Climbing Mount Next: The Effects of Autonomous Vehicles on Society

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THE RISE AND FALL OF TRANSIT AND HIGHWAYS.³

In the US, we have seen a great struggle play out in the twentieth century between what David Jones calls *Mass Motorization and Mass Transit*⁴. The conflict between the modes continues to

³ Comment: The graph shows both linked and unlinked transit trips, as the way transit trips are counted has changed, and there is no continuous series of both over the entire period. Source US Census Statistical Abstract http://www.census.gov/prod/2/gen/96statab/app4.pdf and US Federal Highway Administration: Highway Statistics http://www.fhwa.dot.gov/policyinformation/statistics/2012/vmt422c.cfm

this day, and has become a morality play in the culture wars. While they mostly serve different markets, at the margins they compete for users, roadspace, funding, and the hearts and minds of travelers. They are competing on old turf though, as the graph shows, both modes appear to be in decline, transit for decades, the decline of the conventional auto-highway-system is just beginning.

To develop a metaphor Kevin Krizek and I used in *Planning for Place and Plexus*, the US spent from the late 1880s through the early 1920s climbing Mount Transit. Transit was the most important mode of travel (after walking) in large and medium-sized US cities. The rise of transit was enabled by the electric streetcar, itself a product of electricity, harnessed by Edison and others, and the modern railroad, developed beginning in 1825 with the Stephenson’s steam-powered Stockton and Darlington Railway. Transit peaked in the US in the 1920s, but for a spike during World War II when oil and rubber were rationed, crimping use of the automobile. From the end of the War forward, it began a steady decline from which it has not really recovered. Despite the so-called resurgence of transit, and receiving about a quarter of surface transportation expenditures, transit trips per capita remain below 1990 levels.

The US spent almost the entire twentieth century climbing Mount Auto. From the 1920s onward, the automobile was the dominant mode of travel for Americans, accumulating more miles per capita than other modes. While the Great Depression slowed the auto’s growth, it did not result in decline. There was a brief downturn during World War II, and a few hiccups in the steady rise of mileage. But the later 2000s and 2010s have seen a sharp downturn in motor vehicle use per capita. This drop is greater than the drop during World War II in absolute terms (though the War saw a drop of 23% off the pre-war peak, and the 2012 drop is 7% below 2005). It is complemented by an apparent downturn in total miles of paved roads.

In *The Transportation Experience*, William Garrison and I trace the policy, planning, and deployment of transportation technologies across time. Both car and transit follow the classic lifecycle model or S-curve of birth, growth, maturity, and decline. The S-curve allows us to

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7 These brief slow downs in the inexorable rise in vehicle travel are usually attributed to the oil supply and price shocks in 1973-4 (Yom Kippur War), 1979-1981 (Iranian Revolution), early 1990s (Gulf War), and early 2000s (9/11).


9 One hesitates to say “death”, since so few technologies actually disappear, fixed route streetcars are still with us for instance. Kevin Kelly (What Technology Wants (2010) Viking Press) finds that no technologies actually vanish, though obviously they diminish in importance.
mathematically approximate the process of growth and decline of technologies. It is in many ways natural (if we start with 0 vehicle kilometers traveled (VKT) by car per capita in 1900, surely the number has to go through 5,000 VKT before it reaches 10,000 VKT, and 10,000 before 15,000. One million people must own a car before two million can. Similarly, technologies don’t disappear overnight (although transit really came pretty close). These are long gradual processes, which occur over many technologies which see growth and decline. Transportation is among the slowest of these technologies, as fixed infrastructure is expensive to build and long-lasting.

Is the decline in car use permanent, like what happened to fixed route transit services in the US (which is well below one-fifth of its previous importance), or just a brief digression from the steady march of increasing per capita vehicle travel that has been following the same drumbeat almost continuously from 1910 to 2000?

History will tell us for sure, but the evidence for “Peak Travel” has been mounting. This does not mean there will never be a year in which car travel again rises. The economy and gas prices still fluctuate, and a boom year with low gas prices following a recession with high gas prices might very well temporarily bump traffic upward, but that is really short-term noise. In the absence of external events (technological shifts, demographic shifts, social shifts), the curve appears to have peaked.

The growth curves reasonably fit the data for total system size or total system use for a number of technologies in retrospect. A collection of such curves, and descriptions of the development of the associated technologies can be found at the Transportation Deployment Casebook (https://en.wikibooks.org/wiki/Transportation_Deployment_Casebook), which is the result of student projects for a few years in my Transportation Policy course.

The difficulty is to use such curves in prediction. There are some observations though, the left and right sides of the curve (from the inflection point, where the rate of growth changes from increasing to decreasing) are approximately the same amount of time. (So it takes about as long to go from 10 to 50% of the final market size as it does to go from 50 to 90% of final market size.)

A key issue is the determination of how large will the system get at its maximum? It depends on the system. For instance if we are modeling the number of US states that will adopt some policy, the maximum is 50 (unless the US adds states). If we are modeling the percentage of cars that will have some advanced technology, and we believe it will become universal, then we can say 100%. But if we are modeling a continuous number, rather than a share, it is harder. What is the maximum number of kilometers people will travel in a year? What is the maximum number of trips? We can make guesses; we can even make informed guesses, but we can never know for sure until after the fact. However, if the rate of growth has slowed (we are on the right half of the S-curve), we can make a much better guess than if growth is increasing at an increasing rate (the left half of the S-curve).

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But over the longer term, a significant technological shift could profoundly change how people use the automobile. If there were only one possible significant technological or social shift, this might be predictable, but there are numerous technological and social shifts in play.

While there are many reasons people are not driving more, “saturation” satisfies Occam’s Razor. There is only so much time in the day. For a worker who spends at least 8 hours at the job and 8 hours asleep, how much time is reasonable to actually spend traveling as opposed to the other things that comprise life? Each additional minute traveling is one less minute doing something else. The literature on the travel time budget is rich\(^1\), and while people do want some separation between their home and work lives, most people do not want to spend too much time (say more than 90 minutes per day) traveling on a regular basis. The travel speeds of current technologies limit distance.

Similarly, there are a variety of complementary hypotheses as to why people are driving less per capita in 2015 than 2000, some of the important ones include:

- Price of fuel – higher energy costs diminish travel,
- Size of the workforce – fewer people working leads to fewer work trips (due to both unemployment and labor force participation),
- Telework – people working at home for the day leads to fewer work trips (but more non work trips),
- Online shopping – buying over the internet at home decreases shop trips,
- Virtual connectivity – connecting with friends at home can substitute for visiting.

These last three reasons for traveling less by car (and overall) are due to information and communications technologies substituting for travel. But these are all non-transportation reasons.

Obviously different demographic sectors do these things in different amounts. Just as your grandparents may still receive a physical issue of the newspaper while you read online, Your children are more likely to be early adopters of future technologies than an older you and your parents and grandparents. And the habits formed while young may very well persist over time.

Within the transportation sector there have been small shifts over the past 15 years, which cannot explain much of the decline of travel. There are active transportation modes, like walking and biking, which work well for short trips, and certainly have niches they can grow into if land development intensifies and people reorganize their lives to enable them (for instance, I am one of the 7% of Minneapolitans who walk to work, the numbers are much lower outside core cities, and nationally (3%)\(^\text{13}\)). Transit ridership is up ever-so slightly.

There are a slew of “new mobility options” which use information technologies to allow travel without owning an automobile, but are not yet visible in the transportation statistics. These include peer-to-peer taxi and ridesharing services, dynamic real-time rental cars, and the like.

\(^1\) Mokhtarian, Patricia, and Chen, Cynthia (2004) TTB or not TTB, that is the question: a review and analysis of the empirical literature on travel time (and money) budgets. *Transportation Research A* (38) 9-10 pp.643-675.

While these are useful in their niches, they are not cost-effective to be the main transportation mode for the vast majority of the population with the given technology. Today they are supplements when the main mode doesn’t solve the job to be done. In the future, that might change.

Technologies allow people to do more of the same, and they allow people to do new things. It is easier to predict more of the same than new things.

Mount Next

Autonomous vehicles\textsuperscript{14} appear to be the next profound transportation technology. They bring a series of consequences affecting both the transportation sector and the rest of society.

\textbf{Safety}: Cars, which today kill about 33,000 Americans\textsuperscript{15} and 1.2 million people globally\textsuperscript{16} per year, would be much safer if only there weren’t humans behind the wheel. We might plausibly imagine a reduction to hundreds of deaths per year in the US, as we achieve full deployment.

Autonomous vehicles, powered by sensors, software, cartography, and computers can build a real-time model of the dynamic world around them and react appropriately. Unlike human drivers, they seldom get distracted or tired, have almost instantaneous perception-reaction times, and know exactly how hard to brake or when to swerve.

Autonomous vehicle technology is distinct from “connected vehicle” technology, which allow individual vehicles to communicate with other nearby vehicles (vehicle to vehicle or V2V) and connected infrastructure (V2I) with Mobile Ad Hoc Networks\textsuperscript{17}. If widely deployed, this not only improves safety for those in the vehicle, it improves the safety and environment for pedestrians, bicyclists, and other drivers. Connected vehicles should enable vehicles to anticipate better and negotiate with each other for use of a particular bit of road space and a discrete point in time.

\textsuperscript{14} To describe the new technology, this paper will use the term “autonomous vehicle” throughout, which is taken to be synonymous with automated vehicles, robotic vehicle, self-driving vehicle, and driverless vehicle, and their variants. Just as in the early days of the horseless carriage, it is not exactly clear which term will be the linguistic winner. The terms vehicle includes cars, buses and trucks. The term “auto” is used to mean automobile rather than autonomous vehicle. In the future, autonomous vehicles will probably just be called cars except to differentiate from early instances of the technology.


\textsuperscript{17} Zou, Xi and Levinson, David (2003) Vehicle Based Intersection Management with Intelligent Agents. \textit{ITS America Annual Meeting Proceedings}. 
Both autonomous and connected vehicles are coming. It is important to recognize that cars may be autonomous but not connected or connected but not autonomous, or both (or as today, neither).

Early versions of autonomous cars are anticipated for the 2016 Model Year (Cadillac SuperCruise, which may be described as somewhere between Level 2 “combined function automation” and Level 3 “limited self-driving automation”)\(^{18}\), and NHTSA has a series of levels\(^{19}\) describing degree of autonomy (from Level 0 - “no autonomy” to Level 4 “full self-driving automation”).

The effects of autonomous vehicles are however much more profound than connected vehicles, as connected vehicles are only especially useful in the presence of other connected vehicles, while autonomous vehicles are valuable through the transition period when most vehicles are not up-to-date.

As a rough timeline, it is posited in this paper that Level 3 (“limited self-driving automation”) autonomous vehicles are on the market by 2020, Level 4 is required in new cars by 2030, and required for all cars by 2040 (i.e. human drivers are generally prohibited on public roads).\(^{20}\)

**Capacity:** Because they are safer, autonomous vehicles can have shorter headways. They can follow other each other at a significantly reduced distance.

Because they are safer and more precise and more predictable, autonomous vehicles can stay within much narrower lanes with greater accuracy. Lateral distances can be closer. Lanes can narrower. If skinny cars emerge (designed for one-passenger, or several passengers in tandem) lanes can be narrower still, or be shared with two such cars.

Thus, capacity at bottlenecks should improve, both in throughput per lane and the number of lanes per unit road width. These cars still need to go somewhere, so auto-mobility still requires some capacity on city streets as well as freeways, but ubiquitous adoption of autonomous vehicles would save space on parking (see below), and lane width everywhere.

It follows that if transportation systems require reduced lane width, and have adequate capacity, transportation agencies can reduce paved area and still see higher throughput. Today, most roadscape is not used most of the time, but the road agencies cannot just roll it up when it is not being used.

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\(^{20}\) Once driverless cars become widespread, human drivers will be more widely recognized for the hazard they are, and perhaps like smokers, will slowly be exiled in time and space. For instance, we may see Sunday afternoon Motor-vias, when the old cars, mostly driven by old drivers, make their appearance on selected roads.
With autonomous vehicles and better management, unused roads still cannot be rolled up. However, on freeways the space can be deployed more dynamically to increase either safety (by increasing spacing) or capacity (by reducing spacing), simultaneously adjusting speed and spacing accordingly. On local streets, roadspace no longer needed for movement because of added capacity can be reallocated to other uses (pedestrians, bicyclists, transit, parks and so on).

**Auto-mobility for all:** With autonomous vehicles, the transportation disadvantaged – children, the physically challenged, and others who cannot or should not drive, are now enabled. The “Parent Taxi” days end.

Parents, friends, and siblings need not shuttle children around, the vehicle can do that by itself. The child is securely identified with camera and biometrics, and parents can even monitor their child with an in-vehicle video camera. This is far more secure than the school buses and carpools children are now using. There likely will remain debate about how old a child must be before she is placed alone in an autonomous cars, but the consensus is likely to be, if they are in kindergarten, they can ride alone, as with school buses.

This means that human travel will be much more point-to-point, with far fewer pick-up and drop-off passenger trips required. Deadheading autonomous vehicles, driving around without a passenger to pick up their next passenger will as a result become common, though logistics and shared vehicles can minimize the amount of this.

**Diversity:** Autonomous vehicles along with sharing may bring about a Cambrian explosion\(^{21}\) of new vehicle forms, cars which are designed for specific jobs, since they don’t need to be everything to their owner. For instance, narrow and specialized cars are more feasible in a world of autonomous vehicles. The fleet will have greater variety, with the right size vehicle assigned to a particular job. Today there is a car-size arms race\(^{22}\), people buy larger cars, which are perceived to be safer for the occupant, and taller cars, which allow the driver to see in front of the car immediately in front of them. Both of these advantages are largely obviated with autonomous vehicles. The car-size arms race ends.

Evidence for this is already emerging. Google\(^{23}\) has proposed and built prototypes of a new, light, low speed neighborhood vehicle designed for slow speed (25 MPH (40 km/h) on

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\(^{21}\) The Cambrian explosion was a period beginning about 542 million years ago when many new animal phyla appeared. Many different body types evolved and were tested for the next 20 million years before the environment settled on the forms that became widespread.


The low mass of these vehicles is important as it saves energy but also causes less damage when it accidentally hits something or someone. Combining the low mass with the lower likelihood of a crash at low speed will magnify its safety advantage for non-occupants in this environment compared with faster, heavier vehicles (which privilege the safety of the vehicle occupants).

The Cadillac SuperCruise entrant implies the first market for autonomous vehicles would be the relatively controlled environment of the freeway. However, the relatively controlled environment of low-speed places makes sense as well. These are two different types of vehicles (high speed freeway vs. low speed neighborhood), and though they may converge, there is no guarantee they will, and perhaps today’s converged multi-purpose vehicle will instead diverge.

There has long been discussion of Neighborhood Electric Vehicles, ranging from golf carts to something larger, which are in use in some communities, particularly southwestern US retirement complexes. In Sun City, Arizona, for instance, people use the golf cart not just for golfing, but for going to the clubhouse or local stores (usually as the household’s second or third car, but occasionally as the primary vehicle). They can do this because local streets are controlled by low speed limits, and there are special paths where golf carts are permitted and others aren’t.

Campuses, retirement communities, neighborhoods in some master planned communities, and true parkways are almost ideal for these types of vehicles, as they discourage fast traffic and don’t have high flows.

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To accommodate these low speed vehicles, most non-ideal places will require retrofits. Retrofitting cities for transportation has a long history as cities and transportation technologies co-evolve\textsuperscript{27}. Cities, which had originally emerged with human and animal powered transportation, were retrofitted first for streetcars, and then for the automobile, and in some larger cities for subways. We have also redesigned our taller buildings for escalators and elevators.\textsuperscript{28}

Some places where retrofits might be required and feasible include cities laid out and built before the automobile, where much of the street grid can be retrofitted to disallow high-speed traffic, in much the same way bicycle boulevards are established. Similarly, retrofits are

\textsuperscript{27}Xie, Feng and Levinson, David (2012) \textit{Evolving Transportation Networks}. Springer.

technically feasible anywhere there is space to retrofit a slow network in parallel with the existing fast network, for instance, with barrier separated lanes on wider suburban roads.

Other designs can be found for other situations. Mixing vehicles of different sizes and desired speeds will always remain a challenge. Though in many ways this is transitional until humans are fully taken out of the driving loop, when additional controls can ensure different types of vehicles mix safely.

Vehicle diversity applies not only to a larger variety of motorized vehicles of various sizes, but also to a greater variety of transportation using the existing streets, which today are highly segregated with cars (both moving and parked) dominating the street and pedestrians the sidewalk. Slow speed, light weight vehicles make shared spaces, which don't differentiate between the road and the sidewalk much more palatable.

**Vehicles-as-a-service (VaaS):** Today people keep their personal transportation near their person, parking cars and bikes, which they own, at their homes, workplaces, or other destinations. This is the only way to guarantee point-to-point transportation in a timely way where densities are low, incomes high, and taxis scarce.

Information technologies that are today dubbed part of the "sharing economy" or "collaborative consumption" permit "carsharing" and "ridesharing". Coupling these technologies with autonomous vehicles allows the creation of "cloud commuting".

In this scenario, cars from a giant pool operated by organizations based "in the cloud" would dispatch a vehicle that drives to a customer on demand and in short order, and then deliver the customer to her destination (be it work or otherwise).

The vehicle would have the customers preferences pre-loaded (seat position, computing interface, audio environment). The customer benefits of course by not tying up her capital in vehicles, nor having to worry about maintaining or fueling vehicles. The fleet is used more efficiently, each vehicle would operate at least 2 times or 3 times or more distance per year than current vehicles, so the fleet would turnover faster and be more modern.

Fewer vehicles overall would be needed at a given time. It is likely customers would need to pay for this service either as a subscription or a per-use basis. Though advertising might offset some costs, surely it would not cover them. However retail stores (if they survive) might subsidize transportation, as might employers, as benefits for the customers or staff.

Carsharing companies active in the US in 2015 include Zipcar and car2go, among others.

Ridesharing includes traditional taxi, carpooling, and firms including Uber, Lyft, Gett, Curb, Hailo, Blacklane, Sidecar, Zimride, iHail, and Flywheel. Some of these firms may no longer be in business (or in the same business) by the time you read this, and other new entrants may join the field.

The "cloud" is an early 2000s marketing term referring to computer servers that are located somewhere physically, or maybe multiple places, but nowhere you would actually know by logging into their system.
VaaS will work better in urban areas than rural areas, as the response time will be shorter and size and variety of the nearby vehicle pool will be greater. It will also work better for random trips than work trips, as the regularity of work trips by car increases the value of ownership vs. renting by the trip, or perhaps are (or will be) made by transit in the absence of an owned vehicle.

An interesting aspect of this from the perspective of travel demand is that people will probably pay by the trip (either directly, or through choosing the right plan of service roughly proportional to use) when using “Shared Autonomous Vehicles” (SAVs). While the average cost of car ownership, now a quite significant share of household expenses, goes to zero for those who join this system, the out-of-pocket marginal cost per trip rises quite significantly. The implication is that there will be fewer trips once people give up on vehicle ownership. People paying by the minute or the mile will want to reduce trip distances.

In contrast, if the time cost of traveling per trip declines, the theory of induced demand predicts, all else equal: more trips, longer trips and more trips in the peak period. Induced demand is more likely to apply when people own their autonomous vehicle (and thus have paid for the fixed costs before the trips, and have a low marginal cost), while reduced demand applies when short run out-of-pocket costs rise, as expected for those who subscribe to VaaS. The share of ownership vs. VaaS is thus an important predictor of travel demand.

Migration: While vehicles-as-a-service suggests less future driving, there is an alternative outcome which other travelers may engage. Historically, every increase in mobility (the ability to go faster, either due to new technologies or more connected networks) has increased the size of metropolitan areas, since people can reach more things in less time. Subways drove the expansion of London, while streetcars did the same for many American cities such as

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36 Accessibility is usually measured as the number of opportunities that can be reached in a given amount of time, for instance, jobs within 30 minutes at 7:00 am by transit. See [http://ao.umn.edu](http://ao.umn.edu) for results from the Accessibility Observatory.

Minneapolis-St. Paul. The history of the US Interstate Highway System and suburbanization is well known. The time saved from mobility gains is used mostly in additional distance between home and workplace, maintaining a stable travel time. In short: Speed decentralizes.

Autonomous vehicles should be able to be faster, particularly on freeways, especially after widespread deployment when all other vehicles are also autonomous. This will occur either once human cars are prohibited from freeways, or separate lanes are designated for autonomous cars.

Coupling with just the faster speed, fully autonomous vehicles lowers the cognitive burden on the former driver/now passenger. Modes with lower cognitive burden tend to have longer trip durations. Time is important, of course. What you can do with that time (the quality of the experience) also matters. If you can work while traveling, the value of saving time is less than if you must focus on the driving task. This may also explain the premium people are willing to pay for high quality transit and intercity rail service.

As acceptable trip distances increase, we would expect a greater spread of origins and destinations, (pejoratively, sprawl), just as commuter trains today enable exurban living or living in a different city. More people will live in the suburbs or exurbs, as the pain of travel reduces. This does not mean fewer people live in cities, just that as places grow, this will tend to encourage people to move out rather than up.

Similarly, as the cost of travel decreases, people will be more willing to live in cities far from where they work. The Northeast Corridor of the US already sees people living in one city and commuting to another (for instance from Washington to Baltimore, or Baltimore to Wilmington, or Wilmington to Philadelphia, or Philadelphia to New York, and vice versa). At speeds of 100 miles per hour (160 km/h), the commuting range expands widely.

For a select few, driverless vehicles may bring back the recreational vehicle, as some choose the fully nomadic lifestyle, spending much if not most of their lives in motion, especially if energy costs are low.

Urban Form: At the more local level, the Vehicles-as-a-Service model suggests spaces now devoted to cars can be repurposed. Garages can become accessory dwelling units. Gas stations and parking lots and structures can see a new “higher and best use”. Autonomous vehicles can drop off their passenger at the front door, and then park themselves in far less space than drivers currently require (or move on to their next passenger), and that space need not be so close to the most valuable urban areas. On-street parking is not needed at all, one more aspect of roadspace reconfiguration that was discussed above.

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**Costs:** The capital costs for autonomous vehicles are likely to be higher than traditional cars, at least at first, until driver-facing technologies (like the steering wheel, brake and accelerator pedals, and so on) can be removed for cost savings, as the sensors and computers add some cost compared to existing systems.

Fuel costs on the other hand should be lower, as autonomous vehicles are likely to be more efficient, both due to less congestion, and due to more optimized driving styles (ranging from smoother acceleration to various hypermiling techniques like drafting to reduce drag).

Most importantly, for vehicles such as taxis, buses, and trucks, which today require a driver, that labor cost can go away. Labor is a significant share of costs in transportation, and that will diminish. This lower cost makes benefits taxis, buses, and trucks which had held higher labor costs compared to their competitors.

Delivery services with online purchasing will become even more cost-competitive compared to traditional retail. Transit will either be more cost effective than it is now, or be able to offer lower fares, or some combination of the two.

**Class:** Just as owning a car was once a class signifier in the US, and remains so elsewhere in the world, and as owning a particular model of car persists as a signifier, we can expect that during the transition period owning an autonomous car will be a class-signifier. It indicates at once that you are wealthy enough to own a new car, and technologically sophisticated enough to trust your life to it. While eventually we expect this to be uniform, early adopters will have very different economic and social characteristics from the population at large. Those who cannot afford such cars may come to be vilified as the cause of crashes.

**Conclusions**

I believe the most important technological changes in transportation over the next few decades are those associated with autonomous vehicles. Cars that drive themselves change how people use them.

In “the more of the same” category, we might see more travel. Generally as the cost of travel declines, travel increases. Since fully driverless cars make it easier to drive (by reducing the cognitive burden on the driver) the initial effect, assuming people continue to own their cars, would be that people would travel farther, to places they are less familiar with, and move to places farther from their place of work, to get more real estate for the dollar. Today’s commuter rail passengers travel farther (and longer) than auto users, and autonomous vehicles, where the passenger can do something else while traveling are more like commuter rails than are today’s cars.

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40 This idea is due to Anna Potter (unpublished).
Such cars also can deposit drivers in front of buildings and park themselves, reducing the amount of time that drivers spend parking and accessing and egressing their cars, which would naturally lead to longer distances.

Autonomous vehicles are likely to be safe at higher speeds, since humans won’t be driving, which will also lead to longer distances in the same travel time.

Autonomous vehicles expand mobility for those who are now restricted (the young, the disabled, and so on).

However such cars also make the so-called new mobility options much more useful in cities. Instead of owning a car, vehicles-as-a-service (renting on demand) becomes much more viable. The right-sized car can in principle be summoned at any time. And if a driver is paying by the minute when the car is used, instead of paying for a car loan or lease by the month (whether or not she uses it), the incentive structure the driver faces changes. Travel will be less frequent and more thoughtful. The daily pattern of transit for routine trips and VaaS for special trips becomes feasible. The lack of effective VaaS options now pushes people to owning vehicles, and once they own a vehicle, they are going to use it. This lifestyle model works in cities, where transit can be a mainstay transportation mode, and VaaS are conveniently located.

It works less well in the suburbs, exurbs, and rural areas, where the baseline transportation mode cannot be as expensive on a per-trip basis as the VaaS rental model requires, but the density is not high enough to support fixed route transit on most corridors.

Obtaining better capital utilization out of our surface transportation fleet (like the airlines have achieved with planes that are in motion as much as possible) through VaaS will reduce the lifespan of cars by using fewer vehicles more intensively, and wearing them out sooner. Thus VaaS will on average be newer than today’s fleet. As technology continues to advance with greater rapidity, this becomes increasingly important. The difference between a 2030 and 2020 model likely will be far greater than the difference between a 1970 and 1960 model car.

These are gradual processes. The rapid change in information technology can inform us of the direction of changes in transportation, but the pace cannot be replicated. The lifespan of a car (15-20 years) far exceeds that of a smart phone (about 3 years), so the technology people possess lags far behind the technology that is possible. The technologies are different. Building roads or rails have socio-spatial implications that laying fiber optic cables or constructing cell phone towers do not.

With the emergence of peak travel already, and autonomous vehicles just over the horizon, society needs to think not about adding road capacity but maintaining what we have and what we need. We also need thinking about strategic reductions or rationalizations, or right-sizing. Unfortunately, that conversation is not really taking place.

The mountain analogy implies society cannot climb to the peak of the next technology in the same market niche (for instance, serving daily transportation needs) until it climbs down the first. One can imagine a technological helicopter or zip line, or leaping off the peak (abandoning existing function technology, rather than just deprecating it over time) to accelerate transformation, but such sudden changes are rarely wise and even less politically acceptable,
with entrenched interests having accumulated power desirous of maintaining (or expanding) the status quo.

If the future of transportation does not involve more information technology and more automation, I will be both disappointed and surprised. But the exact shape of what comes next is hard to say. In the 1980s, we had a vision of a future of telecommunications and information that was something like what the internet came to be, all the world’s information at your fingertips. But few foresaw that it would be supported by online advertising. The idea that a collaboratively-built online encyclopedia would displace Britannica, and be of the world’s biggest websites, or that an online bookstore (a bookstore!) would become the world’s largest retailer were all unpredicted and unpredictable. So it is with transportation in the early 21st Century.