Car and Transit Futures in Nashville

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This commentary on the *nMotion* plan for transit in Nashville reflects my career in studying urban issues. I express my own views and do not speak for Vanderbilt University.

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Car and Transit Futures for Nashville

Nashville's *nMotion* plan for transit has five problems. First, transit doesn't reduce traffic congestion. As a consequence, only a small share of the people of Davidson County will benefit from better transit. About two percent of Davidson County's workers go to work by transit today. Although trains may provide a somewhat faster rush hour trip for some transit riders, congestion on nearby roadways will not decrease.

Second, buses provide better service than trains for many transit trips. Buses go to more places.

Third, a train operates at nearly twice the cost per hour of a bus. The capital cost for trains is many multiples of that for buses as well. *nMotion's* proposal for 60 miles of railroads puts a large share of local transit spending in trains.

Fourth, the benefits of transit accrue to certain landowners, not primarily to the people who ride. Fewer people benefit than meets the eye.

Fifth, the good news is that we can deploy express lanes and other digital systems to reduce traffic congestion and improve transit services at the same time.

In short, better understanding of recent developments in transit may reduce enthusiasm for trains and increase support of other ways of increasing mobility. Looking just a few years ahead, makes trains an even weaker bet.

1. Traffic Congestion

A substantial body of statistical evidence demonstrates that better transit does not reduce congestion.[1] Better transit leads to more trips and more residents. The volume of traffic on roadways, however, stays unchanged. Conventional wisdom assumes that the people in a city make a fixed number of trips. Better transit would seek to switch some trips from cars to transit to reduce traffic congestion. Evidence does not support this view. The alternate view, one well supported by evidence, is that the volume of vehicular trips expands to congest whatever space is available for traffic regardless of the level of transit service.

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[1] Giles Duranton and Matthew A. Turner, "The Fundamental Law of Road Congestion: Evidence from U.S. Cities," *American Economic Review* 101, (October 2011) pp.2626-2652.

As illustration, consider Atlanta. After 45 years with a one-cent local sales tax earmarked for transit, 50 miles of quality rails, and an extensive bus service, congestion grew to high levels. Congestion is as extensive on roadways near rail lines as in areas distant from the rail lines. The obvious conclusion from both statistical evidence and the experience of individual cities is that transit does not reduce traffic congestion.

Putting railroads in the middle of major streets, as *nMotion* proposes however, will restrict traffic flow and increase congestion at least until some people and businesses move away. Installing double railroad tracks on major thoroughfares will sharply reduce the flow of traffic at choke points during rush hours. Narrow downtown streets are choke points as are the bridges over the Cumberland. Major intersections will choke as at Gallatin at Eastland, Charlotte at White Bridge, and Nolensville at Thompson Lane.

Although many voters would support more spending on transit if it reduced congestion, such hope is unfounded. Better transit doesn't reduce congestion.

2. Better Rides with Buses

nMotion proposes more passenger rail service. Express buses serve well the five-to-fifty mile range when there are enough riders to justify the service. Limited stop and local bus services address a shorter range. Buses and vans can operate in express lanes (discussed below) at higher speeds than trains and at much lower added cost.

A central problem is that Nashville did not develop rights-of-way in anticipation of future development. Even now, local government rarely lays out rights-of-way ahead of growth. Nashville's roadways are relatively narrow. Existing rail routes are of little help. The CSX freight lines are not available. CSX uses its tracks for a profitable freight service. Rerouting the freight would be quite expensive. Going below ground and in the air is also difficult. The limestone geology multiplies the cost of normal subways. Elevated rail has limited appeal particularly downtown. Other than using two old freight rail lines for the Star and a run toward Clarksville, *nMotion* proposes rail lines in the middle of arterial roadways. This strategy raises problems in addition to causing traffic congestion.

nMotion plans four terminals for rail service in downtown Nashville rather than using a single hub. Rights-of-way to one hub are not available. Through-trips will, then, often involve arriving at one terminal, transfer by bus to another rail terminal, and yet another transfer at the connection. Each transfer involves delays and inconvenience that drives down ridership by about 15 percent for each transfer. A significant reason for the failure of the Star is that the service requires transfers to complete most journeys. *nMotion* considers closing some downtown streets to traffic so that buses can move smoothly among the terminals. The pressure on traffic on other streets would increase. Multiple rail terminals cause dysfunction.

The designer of a rail service faces a tradeoff between speed and number of stops. With one stop per mile, the train will have a scheduled speed of about 24 mph end–to-end. A 34-mile trip from Murfreesboro to Nashville would take about one hour and 20 minutes. With two stops per mile, scheduled speed drops to about 12 miles per hour. That is the scheduled speed of many local Metro buses. The Murfreesboro run then would take two hours 45 minutes. The limited-stop Metro buses run at about 18 mph. The Star has a higher speed with stops about every five miles. With few stops, many more riders must use one vehicle to reach a train stop to transfer to a train. Trains with limited stops in the middle of arterial roads are then neither a speedy commuter rail nor a convenient trolley.

Putting a limited stop train service down the middle of a busy roadway also diminishes access for residents and businesses between stops while most benefits accrue to landowners near the stops. Boston's Green Line fences its tracks from traffic. A fence makes crossing the street more difficult. With no fences, collisions with vehicles and pedestrians are more likely. Buses move more easily in traffic than trains.

nMotion also proposes to give transit operators the ability to flip traffic lights for priority at intersections. Metro has implemented digital systems to resynchronize traffic lights as the level of traffic changes. Some 24 percent increase in traffic flow enhances both transit and traffic. The signal system might link to transit vehicles to give more weight to transit vehicles in the synchronizing algorithm. Manual flipping, however, may not be productive. Cleveland abandoned transit priority at intersections because of the adverse effect on traffic. Better systems account for all vehicles, not just transit.

3. Lower Costs

A recent study estimates the average operating cost for bus service in eleven large cities at $122 per hour.[2] This compares to an average of $233 per hour for operating light rail in the same cities. If a train came every 20 minutes, a bus could come about every ten minutes for the same operating budget. Although a train with more cars could carry more people at a time, the same operating budget would attract more riders to buses with the added convenience from doubling the frequency.

With lower capital and operating costs, bus service can extend for more miles than trains with the same budget. Many cities with trains have, in recent years, added more bus service rather than extend their railroads.

Replacing the limited stop bus service on Gallatin Road with a railroad will reduce ridership for several reasons. The north end of the Gallatin rail line (perhaps

[2] Christopher McKechnie, "The True Operating Costs Between Bus and Light Rail," Thoughtco, June 29, 2016 (https://www.thoughtco.com/bus-and-light-rail-costs-27988520) viewed June 18, 2017.

a temporary end) will be near Briley Parkway, requiring bus travelers from farther north to transfer to the train. The current bus route circulates to several downtown destinations after a stop at a terminal. In contrast, train lines end only at a terminal and require a transfer to reach other downtown locations. For these reasons, the current ridership on the limited stop bus service will decline when the bus service shifts to trains. Spending large sums for a service with fewer riders undermines confidence in the planning.

Car-services like Lyft and Uber are significant alternatives to formal transit for many riders. A car-service driver gains about $21.45 per hour in gross revenue (Uber figure) for an average of 1.2 trips per hour.[3] This would indicate that a bus would need to average about seven riders per mile of bus service for its operating cost to be less than the total cost per hour of the car-service. Note, however, that the car-service moves point-to-point and may use limited access highways or other alternate routes. The cars use about one-third the time of the transit bus for the same trip on average. The bus would then need to average 20 riders for each mile a bus moves in service to have cost below that of the car-service. A train would need to average 40 passengers per mile of train service to achieve a cost per passenger below that of the car service. When the car has double occupancy as with Uber Pool and Lyft Line, the disadvantage of bus and rail doubles. Adding capital costs to the transit costs tilts even further away from transit.

It is difficult to justify supporting a transit service that is more expensive per trip when a better service is readily available. *nMotion* might identify the Metro bus runs where car-services are less expensive per rider than transit buses using its own calculations.

Some transit agencies may offer car-services.[4] A car-service might substitute for conventional bus service in areas of low-rider density as noted above. Deciding whether or under what circumstances to subsidize car-services is an issue. Subsidizing travel in times and locations with low levels of traffic is plausible. Revenues from road-use fees could be used to lower the price of trips from senior centers and public housing. Retailers might underwrite part of the price of car-service travel to their shops with the same motive as providing free parking with deeper discounts off-peak. Employers do something similar for employees. Subsidies for peak-period travel would be costly and avoided.

4. Who Benefits?

The stakes in transit are significant for Nashville's employers. The Mayor's office mentioned a possible half-cent added sales tax as an earmark for transit. Employers will have to increase wages and salaries to compete for workers who face a higher

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[3] Uber Statistics Report 2016. Download from http://www.businessofapps.com/uber-usage-statistics-and-revenue/

[4] Tomio Geron, "Public Transit Agencies Take a Lesson From Uber," *Wall Street Journal*, June 20, 2017,

cost of living with the tax. At the same time, improved access by transit will allow employers to attract workers with somewhat lower wage rates. On net, some employers with improved transit access will gain enough to offset the tax burden. Other employers will face a net loss. Where gains occur, real estate values increases. Net losses drive down real estate values.[5]

People who ride the transit service, then, won't necessarily be better off with the transit program. Rents will tend to increase in areas with improved access with transit. This is an effect somewhat like gentrification. Tenants will see better access offset by higher rents with little net gain. The benefits of transit (net of the tax cost) accrue to real estate in areas with better transit access, not to transit riders. Owners of the core downtown commercial real estate and other destinations will benefit, as will owners of residences near distant transit stops.

With net gains accruing to real estate owners in key areas, the case for property tax finance is stronger than the case for the sales tax. Logically, a special downtown property tax district could bear a significant share of the cost of the transit improvement and yet achieve net gains for commercial landowners in the tax zone. Ironically, Metro has waived property taxes for a number of downtown commercial properties, narrowing a tax base that is well suited to support a transit program.

Seattle and Denver have extensive transit services. Nashville's plan is not comparable. An eight county region in Denver assigned a 0.4 percent sales tax to transit in 2004. It operates on 98 miles of rail with plans to grow to 122 miles.[6] In 2016, a three-county region in Seattle and Tacoma adopted a similar $54 billion plan. Sound Transit's 2017 annual budget is $1.6 billion with a 1.4 percent sale tax plus a property tax and a 1.1 percent annual tax on the value of cars to fund local support for a 62-mile rail expansion.[7] A comparable region in middle Tennessee would encompass at least Davidson, Williamson, Rutherford, and Wilson Counties. *nMotion* does not mention the expected financial role of neighboring counties nor does it forecast State and Federal participation. Who benefits depends on the details of where the money comes from and where it goes.

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[5] The basic ideas here appear in: Malcolm Getz, "A Model of the Impact of Transportation Investment on Land Rents," *Journal of Public Economics*, February 1975, pp. 57-74. Statistical evidence on the effect is difficult to develop because many forces affect real estate values.

[6] Wikipedia, "FasTracks," https://en.wikipedia.org/wiki/FasTracks

[7] Issue Council, "Issue Report: Seattle Sound Transit 3 Referendum," c. October 2016. https://issuecounsel.com/issue-report/seattle-sound-transit-3-referendum/ and SoundTransit, "Regional Transit Taxes," https://www.soundtransit.org/About-Sound-Transit/Taxing-district

5. How Can We Reduce Congestion?

If better transit won't reduce congestion, what will? Express lanes have been congestion-free in SR 91 in southern California since 1995. Houston, Atlanta, and Denver have express lanes as well. Express lanes can allow buses and vans to move at speed at rush hour along with cars. Cars pay for most of the cost of the lanes; transit bears a small share. Nashville could improve both traffic and transit by introducing express lanes. Express lanes, however, are easier to add in suburban areas and are difficult to retrofit in existing lanes.

Express lanes use digital systems to collect tolls that vary with the volume of traffic. As traffic builds, the toll increases to keep traffic flowing. As traffic ebbs, the toll subsides. A driver can put the car in cruise control and glide at the speed limit at rush hour.

An essential and difficult mental shift makes express lanes plausible. See the dynamically adjusting tolls as a tool to manage the flow of traffic rather than as a method of collecting revenues. Here is a basic example. When a roadway is heavy with stop-and-go, speed is low and few people complete their trips per hour. With dynamic tolls keeping speed above 50 mph, more than twice as many people can complete their trips per hour. With dynamic tolls, everyone can leave later and arrive sooner.

The revenue generated by dynamic tolls can finance the express lanes. Tolls can pay to build express lanes and support other transport services. Toll revenue can also replace motor fuel and other taxes. In fact, the Netherlands proposed to replace their high taxes on automobile ownership and fuels with the revenue from dynamic tolls. The total revenue was to be the same with tolls as it had been with conventional taxes. The big gain from the shift to dynamic tolls is that traffic flows all the time.

A digital system collects the tolls. A small radio transponder on the vehicle windshield signals as it passes under an overhead gantry. The system debits the toll from the vehicle's online account. The system collects tolls as vehicles pass under the gantry at full speed. For those who do not have the transponder, the system photographs license plates and sends bills to drivers. The bill based on a photograph is at a somewhat higher rate to encourage drivers to mount the transponder and to compensate for the higher cost of mailing individual bills. The photographic system is not as accurate as the radio transponder. A higher rate adjusts for uncollectible cases.

Buses and vans can travel on express lanes. They should pay dynamic tolls proportionate to the space they occupy on the road. The core idea is that all travellers plan how and when to travel in light of the value of their space on the road at that time. Buses and vans move at speed on express lanes, faster than trains that make stops.

Managed parking reduces traffic congestion. A significant share of downtown traffic comes from people who circulate looking for a parking space. San Francisco introduced dynamic pricing of parking to assure that parking spaces are nearly always available in every area. Here is how it works. Each parking space has a sensor that reports when a car occupies a space. The system connects to meters and changes parking rates by the hour of the day with different rates on each block. Each month, San Francisco reviews the history of parking in each block. In each hour of the week on a given block, when the occupancy rate is below 80 percent, the manager reduces the rate by 25 cents per hour. When the occupancy rate is above 80 percent the manager raised the hourly rate by 25 cents. Within a few months, rates stabilize and about 80 percent of spaces are open in each block in each hour. Occupancy rarely reaches 100 percent in any block. Once drivers see that some open spaces are available in each block, albeit at a price the makes that likely, the driver has little reason to circulate. Downtown traffic congestion decreases. Car-services also reduce the demand for parking because they only drop off and pick up. They often wait for calls at peripheral locations.

Public-private partnerships expand the scope of private vendors in developing facilities. Tennessee has a long-standing aversion to tolls and bonds to finance transportation projects. The Legislature has discussed public-private partnerships. Under such partnerships, private entities borrow funds (that is, sell bonds) to build public facilities. Fees generated by the project pay the bondholders. These schemes often involve both tolls and bond finance, albeit through private entities. If the vendor goes bankrupt, the State may hold the financial liability. The State may, after entering an agreement, discover that a partnership limits the State's ability to respond to new opportunities. California had to buyout its private partner in order regain control of SR91. Express lanes must promise profits to attract a private partner. Some transport facilities create monopolies that are phenomenally profitable like the Ambassador Bridge in Detroit. Monopolies often operate against the public interest. Public-private partnerships can be a disadvantage.[8] Tennessee should do well by exploring opportunities to invest in publicly managed express lanes with dynamic tolls. Judicious use of bond finance need involve no more risk than private partnerships. All-in-all, public-private partnerships appear to be a complex way to work around an aversion to tolls and bonds.

Developing express lanes will begin with limited steps to build experience in the State transportation agency and confidence among travelers. Atlanta converted some suburban HOV lanes to express lanes. The lanes work well except that the Legislature put a cap on the toll rate with the result that congestion occurs when the toll hits the cap. California and Houston left space in the middle of new highways that they developed into dual express lanes in each direction. Denver and Atlanta have added newly constructed express lanes beside existing highways. Note that

[8] Matthew Goldstein and Patricia Cohen, "Public-Private Projects Where the Public Pays and Pays," *New York Times*, June 6, 2017.

many toll roads in the Northeast, Chicago, and California do not vary tolls with the level of traffic and often congest. So far, a limited number of toll roads act as express lanes. There is a learning curve for legislatures, transportation managers, and the travelling public. It is a curve well worth climbing.

Singapore, London, and Milan retrofit a flat daily congestion fee for vehicles that move on downtown streets. The flow of traffic improved along with air quality but significant congestion remained. Stockholm introduced the daily fee and, after the public had six months of experience with it, held a referendum on whether to keep it. The voters approved the system. Mayor Michael Bloomberg proposed a daily fee for part of Manhattan but State legislators from outlying areas blocked the move. Retrofit is challenging because of uncertainty about which real estate values will increase and which will fall. Decisions about using the revenue are also important. Dynamic pricing with tolls varying with traffic by location and time would manage traffic more effectively and allow the system to manage flow over a wider area. Success in suburban areas may build support for retrofitting lanes in downtown areas. Free-flowing traffic may justify reworking entrances, exits, and other elements of the road system. The first city to sustain free-flowing traffic through most rush hours will grow more rapidly than those stuck in traffic.

Can express lanes support the third million residents likely to come to middle Tennessee in the decades ahead? Future growth will come to current employment clusters in downtown, mid-town, the airport, Murfreesboro, and Franklin. New clusters will develop around the region. An urban region with multiple employment clusters allows more people to live near work with lower costs for housing. The old commuting pattern of travel from residential suburb to downtown is already less important than the crisscross patterns to connect multiple clusters. Suburb-to-suburb is now the most common commuting flow.

The best way to prepare for future demand is to layout rights-of-way well ahead of growth. New York laid out the street grid for Manhattan in 1808 that supported growth into the 1890s.[9] The street layout remains in place now and for many years to come.

Broad rights-of-way to connect clusters will have substantial value. Proximity to the airport has some influence on the growth of clusters. A national network of high-speed rail would generate another hub. High-speed rail might substitute for building second airports and wider Interstates over longer distances. New employment clusters with broad roadway access to the airport and rail hub will have advantages. Employment dispersed among ten to twenty clusters with clusters often have modest density do not connect well by rail. Buses, vans, and cars moving in express highways should provide good service.

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[9] Marguerite Holloway, *The Measure of Manhattan: The Tumultuous Career and Surprising Legacy of John Randel, Jr., Cartographer, Surveyor, Inventor*, (W. W. Norton, 2013)

A Better Transit Referendum

The outcome of a public referendum on transit taxes is difficult to gauge. Nashville voters value public services that sustain our urban lifestyles. As the city grows, more sophisticated services become more important. The Chamber of Commerce has supported rail transit for more than 20 years. Their public relations campaign will be potent. Mayor Berry's enthusiasm is infectious.

On the other hand, a succession of civic leaders has supported poorly conceived large transit projects. This time, the plan includes sidewalks, bicycles, and buses. Nevertheless, the bulk of the money will go to rail. The first element of the new plan is a seven-mile double-track rail line on Gallatin and Main Street from Briley Parkway to Music City Central. Phase I engineering is underway. Offering scheduled speeds similar to the limited stop bus service today but with 90 percent higher operating cost, hundreds of millions of capital outlay, and attracting fewer riders, the Gallatin proposal might raise an eyebrow.

In the meantime, we are in the early days of digital systems offering new methods of reducing congestion. Nashville has implemented digital management of traffic signals that automatically synchronize traffic lights depending on the volume of traffic. Car services use digital systems and dynamic pricing to speed response and enhance convenience. Express lanes are working well in a few, forward-looking cities. They can dramatically increase the flow of rush hour traffic and increase the speed of some transit services. Managing parking with dynamic pricing also shows an important reduction in congestion. Although digital systems require innovative management and substantial outlays, they are less expensive than building and operating railways. Digital systems also provide better service and can sharply reduce congestion.

Futures

To go beyond the proven methods discussed above requires some speculation about both how technology will evolve and how the political process will perform. Here are three arenas: maintaining the railroads, global warming, and autonomously driven vehicles.

Railroads are difficult to renew. They obsolesce. Boston's Green Line, for example, with sharp turns inside tunnels can only operate short trains and thereby retains some of its character as a trolley.

Financial plans for railroads typically do not patiently build funds for overhauls. The rail systems in New York, Washington, and Atlanta, for example, suffer from decades of deferred maintenance. They have become unreliable and raise concerns about safety. A passenger tunnel under the Hudson River faces abandonment because it may collapse.

Voters and political leaders are more willing to approve higher taxes for a new service than to fund major replacement of the infrastructure of tracks, power

distribution, signaling, and safety systems. While New York experiences nearly daily breakdowns on the old lines, they are spending $2 billion per mile to add a new line on Second Avenue. They do not deploy congestion pricing for the subway service and use the congestion to justify adding more capacity.

Although the Interstate highways also have deferred maintenance, most of the technology is in the vehicles. Vehicle owners decide when to replace them. Replacement typically includes upgrades in technology as with a shift to electrical propulsion and digital systems.

Global warming is an increasing threat. Here is an example. The Arctic Ocean is likely to be open water during the summer within the next 15 years. Turning the Arctic from white to black in the summer will increase the amount of the solar flux absorbed by the earth. This process will accelerate planetary warming. Such a change may push the planet into irreversible, accelerating change.

When panic comes, voters and leaders will embrace measures to decrease carbon emissions rapidly—at much greater cost than if incremental measures were taken gradually. Prolonged droughts will threaten water supplies for many cities. Coastal cities like New York, Norfolk, and Charleston already suffer from rising seas. Mass migrations from drought and flood plagued areas of the globe already pose challenges.

Nashville is likely to move to all-electric propulsion for vehicles. Metro already operates some all-electric buses. Adoption of a carbon tax (or some facsimile) will accelerate a general shift to electric propulsion. Reducing congestion will reduce energy use and improve air quality even as it saves travel time. Links to a national, intelligent power grid with time-of-day pricing of electric power consumption will lower the overall cost of electricity and enhance the shift to production of electricity with renewables. The cost of the production of electricity will continue to decline exponentially and renewables will become the dominant source of electric power. So far, there has been no urgency.

The cost of the main components of all-electric cars like those in the Chevrolet Bolt will show exponential declines in the decades ahead. The lithium batteries, the sensors and software to support autonomous driven vehicles, and other digital components will show declines in cost.[10] Most major automobile manufacturers have or soon will market all-electric cars with at least a 200-mile driving range on a single charge.

Autonomous vehicles will be available from car services soon. Waymo, Alphabet/Google's car subsidiary, has an agreement with Avis car rental to manage a fleet of 600 autonomously driven Pacifica minivans as an on-demand car-service

[10] Tony Seba, Clean Disruption of Energy and Transportation: How Silicon Valley Will Make Oil, Nuclear, Natural Gas, Coal, Electric Utilities and Conventional Cars Obsolete by 2030," (Tony Seba, 2014)

in Phoenix.[11] Waymo agreed to collaborate with Lyft in 2017 in the development of car-service with autonomous vehicles.[12] Renault/Nissan plans to introduce ten models of autonomous vehicles for sale in the US in 2020.[13] Mercedes expects to launch a car-service with autonomous vehicles in the US early in the next decade.[14] General Motors, Ford, and Volkswagen are also in this hunt.[15] Car-services with autonomous vehicles are likely to be operating in Nashville before a railroad service could launch on Gallatin Pike.

With competition among several car-services in an urban area, the price of an autonomous ride will fall by as much as half of today's price because of the savings in labor. The car service will be responsible for costs and insurance. Generally, autonomous vehicles are ten times safer than human-driven cars because most accidents involve human error. Autonomous vehicles will operate from peripheral staging areas usually close enough (in dense areas) for a five-minute pick-up at the traveler's location. An algorithm will choose the route using real-time information about traffic flows.

Car-services use dynamic time-and-location specific pricing to assure prompt pick-up on demand. In areas of dense passenger flow, the service can offer a pooled service for a reduced price. The Pacifica has three rows of seats. Successful launch of autonomous car-services will reduce the demand for travel by conventional transit by offering faster pick-up, point-to-point service, and around-the-clock availability. The autonomous car-service can accommodate an emergency, a side-trip, luggage and parcels, and fellow travelers with ease.

The autonomous car-service will reduce the demand for personal cars. The substantial fixed costs of owning a car, including the cost of purchase or lease, insurance, fuel, maintenance, and garaging and parking are built into the cost of each ride. With these costs shared among the pool of people using the car-service, the costs per trip are far less overall than ownership. Autonomous car trips will be especially good for people who are unable to drive or who would simply rather not drive.

Introducing dynamic pricing for road use will be easier with car-services because the services already vary prices by time and location. The same pricing

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[11] Micah Maidenberg, "Waymo and Avis Reach Deal Over Self-Driving Cars' Maintenance," New York Times, June 26, 2017.
[12] Mike Isaac, "Lyft and Waymo Reach Deal to Collaborate on Self-Driving Cars," New York Times, May 14, 2017.
[13] Nissan blog, https://www.nissanusa.com/blog/autonomous-drive-car
[14] Alex Davies, "Mercedes Promises Self-driving Taxis in Just Three Years," Wired—Transportation, April 4, 2017. https://www.wired.com/2017/04/mercedes-promises-self-driving-taxis-just-three-years/
[15] Alex Davies, "Detroit is Stomping Silicon Valley in the Self-Driving Car Race," Wired—Transportation, April 3, 2017. https://www.wired.com/2017/04/detroit-stomping-silicon-valley-self-driving-car-race/

philosophy that makes pick-up quick can also assure that traffic flows. The issues in retrofitting dynamic pricing of roads discussed above continue to apply.

Ultimately, autonomous vehicles will be able to communicate among themselves electronically. A vehicle can alert near-by vehicles that it is slowing or turning, allowing the other vehicles to react smoothly. As a consequence, a lane full of autonomous cars can allow vehicles to be close together and flow in phalanx. More cars will fit on a given street, increasing the total flow.

An urban region could move to support autonomous car-services and a range of digital systems to sustain free-flowing travel everywhere at all times. Such a region will offer a better quality of life. Residents and employers will come to the region and welcome a world made better with dynamic pricing. Personal car ownership and conventional transit are likely to have diminished roles.