Transit Leap: A Deployment Path for Shared-Use Autonomous Vehicles that Supports Sustainability

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Abstract The concept of Transit Leap is introduced and explained as robotic, shared-use, multi-passenger vehicle applications that start small, expand by demand, merge, and spread. It is an approach to deploying automated vehicles that is meant to blunt the long-established worldwide trend of ongoing increases in the number of private vehicles. Transit Leap is an alternative to year-by-year automotive feature creep, which is currently the most likely path to ubiquitous robotic mobility, absent public policy intervention. Transit Leap helps bypass the interim challenges of semi-autonomous and mixed-autonomy scenarios, and supports equity in mobility, as well as environmental quality and the financial viability of public transit networks.

Keywords Autonomous vehicles · Disruptive innovation · Driverless · Labor disruption · Mobility as a service · Public transit · Public–private partnerships · Self-driving · Service deployment · Technology forecasting · Transit Leap · Transportation as a service · Transportation policy · Urban economics · Vehicle automation

1 Introduction

Two popular and somewhat utopian views of the future of the self-driving automobile are shaped by vehicle ownership. One is the consumer-friendly, extra safe, super convenient, congestion-busting, personally owned household vehicle that requires no attention to operate and smoothes out traffic flows with tight vehicle spacing and no collisions. The other is an on-demand commercial robo-cab that

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rolls up to wherever you are within a minute of your request via smartphone and zips you to exactly where you told the app you want to go.

How can urban regional governments and nations prepare for one or both of these scenarios as vehicles become more numerous?

1.1 World Vehicle Growth Is High and not Slowing

In 1995 about 625 million vehicles moved about the planet [1]. Twenty years later, this number doubled to 1.2 billion. Despite all the benefits of mobility, the impact of congested streets and highways from growing vehicle counts in an increasingly urbanizing world is widely recognized to be problematic. As *The Economist* magazine states dramatically in a global overview:

> Megacities are seizing up. Surveys of São Paulo suggest that half of all adults spend at least two hours a day traveling. Lagos has such epic traffic jams that an army of street hawkers plies the roads, selling peanuts, Christmas trees and puppies to a captive market of drivers [2].

Traffic measurement in USA and Europe [3] reveals the same growth of gridlock. Recognition of this issue is hardly new. In 2009 transportation scholars Dan Sperling and Deborah Gordon published *Two Billion Cars*, a book detailing reasons to address the growing populations of motorized vehicles [4]. The book's final chapter, "Driving Toward Sustainability," listed 16 policy initiatives to ensure that the two billion vehicles projected for 2030 might have a lighter footprint on the planet. Thirteen of these were directed at alternative fuels and fuel economy, while three focused on reducing vehicle usage. The automated vehicle had not yet mainstreamed, so the book missed it. But now it has become a factor to be considered.

Yet two billion cars are too conservative. In 2013 Bill Ford speaking at the annual Milken Global Conference projected four billion vehicles by 2050, echoing the 2007 analysis by Joyce Dargay at The University of Leeds [5]:

> By 2050, the population is expected to be around 9 billion people. With most of this growth happening in major cities, some 4 billion cars are expected to be on the road by then. If we continue on the path we're on, Ford said, the result will be what he called "global gridlock [6].

An even more startling projection from Dargay: the global vehicle population by 2100 will finally saturate at close to eight billion vehicles. This may seem like scare mongering, but it is the predictable future given the ongoing, rapid, worldwide growth in the automobile population, despite the temporary plateau in automobile use in recent years in developed countries, such as Australia, United Kingdom, and United States.

This chapter suggests a path for automobility that can satisfy the projected demand for worldwide personal, motorized mobility in 2050 with just one billion vehicles, and by 2100 with fewer than two billion. By adding automation concepts to the ideas for more environmentally friendly fuels and trip reduction from Sperling and Gordon, humans can achieve automotive sustainability.

1.2 Humans Will Continue to Demand Motorized Mobility

A significant, per capita, reduction in car travel around the world is unlikely. There is much to commend in efforts to promote walkable and bicycle-friendly communities as a way to reduce driving. Efforts to configure streets to be more complete by including walking and biking as well as motoring are now visible and encouraging. This effort with motor vehicle controls can result in car-free or at least car-limited local environments. But consumption of motorized automobility is a force in the wider world of intercity travel that cannot be turned back.

Powered automobility—provided first by animals—has a 7500-year history supporting a wired-in socio-biological preference that cannot be extinguished. We consider both horseback riding and electric bicycles as forms of powered automobility, although the four-wheel motorized living-room called a car that keeps the traveler dry in the rain is where technology has led us. Individualized decisions as to trip timing, destinations, and route choice are central to powered automobility. A personal, motorized mode is preferred by most humans and in most travel circumstances [7].

The nominal path to the worldwide future is growth in demand for motorized vehicle mobility continuing until a natural saturation of vehicle ownership and use is reached at a level calibrated to wealth. As human population settles at 11 billion over the next century, the trend of vehicle population, pushed by gradual increase in human wealth that correlates with smaller family sizes, will continue to approach eight billion, where it should finally plateau.

Global experience to date shows that all human populations strive in the long run toward the level of automobility achieved in the developed world. The USA is one of a handful of countries leading the trend to ownership saturation, and the current American level of consumption of vehicle miles traveled is indicative of a human tendency rather than a uniquely American behavior.

Current automobility is provided principally by unnecessarily large, collision-prone, and pollution-emitting vehicles equipped with internal combustion engines, even as electric propulsion is now gradually gaining market share. The overuse and abuse of these vehicles has proven difficult to manage; and the problem has largely resisted proposed remedies to date at a scale that is meaningful to the future of nations and the planet. The sheer number of vehicles is a primary characteristic of the issue.

2 Could Shared Fleets Dominate Future Automobility?

The jury is out on the long-run preference for vehicle ownership as motor vehicle automation grows, even though hope-filled forecasts describe a utopia of widespread, electric, crash-proof robo-cab vehicles, kept in constant use, shared by urban customers for all trip types.

Will most automated vehicles be owned as family vehicles are now? Or will the advantages of shared fleets be available and selected by the great majority of travelers so that the population of household vehicles shrinks dramatically as decades pass—by 90% according to the most optimistic projections? Will the car become more of a travel service and less of an accessory—i.e., all about the trip, nothing about status?

Many academics and consultants are on record predicting “few people will own automated vehicles; most will share them,” but there are many reasons—rational or otherwise—why most people reveal a preference for ownership, even while a tiny-but-growing few have found ways to avoid owning a vehicle. The backdrop of culture, habit, status, privacy, and convenience of owning can be stacked against the rational, economic notions of sharing and is used very effectively by automotive marketers. That started long ago.

Zipcar founder Robin Chase has said “no sane person would own a car” when they become automated, but what she says about the non-automated cars of today is nuanced with conditions. Says Chase, a champion of the sharing economy, sharing of non-automated vehicles already offers a distinct advantage over traditional car ownership. “If you are financially smart and you are living in the city and you don’t need a car to get to work, you are insane to own one,” she says, “You will always be saving money by renting them when you need them” [8].

In support of sharing as the rational choice after automated vehicles grow in capabilities, some simulation-based research has been generated for cities such as Austin [9], Lisbon [10], Manhattan [11], Stockholm [12], and others. Consistently, these researchers find that each simulated automated vehicle can replace about ten current, family-owned vehicles (that’s where the above “90%” comes from). But these simulations are realistic only in a constrained context. They have been parameterized using the origin–destination data collected in the simulated cities, but in most cases the researchers imply or reviewers conclude that such figures can be extrapolated to the world vehicle population. Ronald Bailey writes [13]:

> Researchers at the University of Texas, devising a realistic simulation of vehicle use in [Austin] that took into account issues like congestion and rush-hour usage, found that each shared autonomous vehicle could replace eleven conventional vehicles. Notionally then, it would take only about 800 million vehicles to supply all the transportation services for 9 billion people. That figure is 200 million vehicles fewer than the current world fleet of 1 billion automobiles.
>
> In the Texas simulations, riders waited an average of 18 s for a driverless vehicle to show up, and each vehicle served 31 to 41 travelers per day. Less than half of one percent of travelers waited more than five minutes for a vehicle. In addition, shared autonomous vehicles would also cut an individual’s average cost of travel by as much as 75 percent in

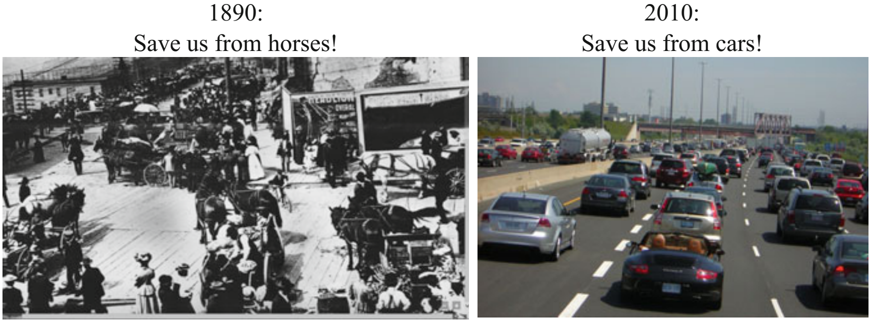
> comparison to conventional driver-owned vehicles. This could actually lead to the contraction of the world's vehicle fleet as more people forgo the costs and hassles of ownership.

There are several problems that often arise with these simulations and the conclusions drawn from them. These studies, constrained by the availability of useable origin—destination data, often propose unwarranted generalizations that cannot be reasonably extrapolated to suburbs and rural areas or work-/service-related vehicles. Extrapolations such as echoed by Bailey may also assume an inevitable and general willingness of all or most travelers to use shared vehicles. While there is much good to be said for a sharing economy, there is no evidence that most humans will engage this way. Barriers are easily found, including social reasons related to privacy, health, and status.

We can find ways to overcome some of these barriers, but it will not "just happen." Humans make many non-rational decisions based on personal, contextual or experiential criteria. In the coming decades, the success of the massive shared fleets these researchers simulate will depend more on revealed preferences and behavioral economics than on the capability of the artificial intelligence software controlling the cars.

An analogy to this occurred 110 years ago, when the car was hailed as the solution to the horse problem, characterized by the stink, flies and disease from manure on city streets. Society dove headlong into full-bore automobile-centric planning and automobile user-preference as horses were pushed out of our cities. There was neither understanding nor mitigation of the eventual global effects, as illustrated in Fig. 1. One-hundred and ten years ago people were largely unable to foresee these effects and paid little attention to the few warnings on offer. Of course humanity is free to repeat this error, and the likelihood of doing so is high, especially as there are payoffs from status quo business models and ownership-thinking.

Robotic vehicles have the potential to make our problems worse, especially congestion, sprawl, and a demand for yet more traditional infrastructure such as



1890:
Save us from horses!

2010:
Save us from cars!

Photo source: Washington Museum of History and Industry

Photo source: Wikipedia Commons

2050: Save us from automated vehicles!

Fig. 1 Will History repeat itself?

roads and parking facilities. They may wipe out any residual value in financially stressed public bus systems. As well, they would tend to entice away from transit those people who own cars but choose to ride transit. Sam "Gridlock" Schwartz warns:

> It can become a vicious circle: the more transit becomes dominated by less affluent people, the more it becomes associated with poverty. And the more it gets associated with poverty, the less appealing it becomes for the affluent. Equity declines [14].

3 Municipal and Regional Governments Can Respond

Regional and local governments could start now to develop policy direction that is more likely to make a desirable outcome of more sharing prevail than just waiting and hoping would do.

If local jurisdictions wait-and-see, they risk the consequences of being swept up by exponential innovation. Governments find private sector innovation hard to track, regulate, and manage. Uber is giving regulators headaches in 2013–16, but the disruption to be wrought by robotics in 2035 will reverberate far more dramatically. Picking winners may work temporarily, but public jurisdictions are prone to commit to consumer choices of the moment and stick with them for too long before being swept away by the next unanticipated innovation. The 20-year transportation future that starts now is harder to predict than any prior 20-year future since 1908, when Ford introduced the Model T.

The only way to escape this conundrum is to innovate and integrate to seek a better way through the technology tsunami. Government agencies must complement traditional notions of infrastructure to go far beyond physical facilities to encompass the methods, business models, vehicle access and use models, data, and labor models that create transportation value. Road surface, train tracks, heavy transit vehicles, schedules, and routes will soon explain less and less of the total picture.

Local governments that fight commercial, robotic, shared fleets—like some fight Uber—will lose. Without paid drivers, the cost per passenger kilometer in flexible, driverless vans, minibuses, and robo-taxis will be a fraction of the cost per passenger kilometer in today's municipal buses, compelling a fleet change based on economics.

Some pundits propose that cities or states set up testing grounds to be leaders and promoters for technology development. Why? City governments do not test pharmaceuticals. States and Provinces do not test new nanotechnologies. Why should they test robotic vehicles? Let corporations and existing standards bodies do that. Instead, have technology suppliers prove the technology.

As their contribution to the future, local authorities should begin thinking through how their communities can encourage or orchestrate the building of large shared, robotic fleets using public–private partnership approaches. Local authorities should plan to disrupt their own public transit agencies head-on as a pathway to creating public robotic fleet services in a way that ensures equitable access for every citizen. Equity is a concept dangerously missing from the young, mid-chic, urban middle-class business model of today's transportation network companies based on smartphone apps [15].

Today, at a time when robotics are still not ready to take over, cities could create the preconditions for the equitable future they want to create.

4 Evolution Toward Robo-Cars

Private ownership of automated vehicles will lead to predictable large vehicle counts, a continuation of present trends, just with more and better technology features. Since newer vehicles with automation would eventually not require a licensed operator, a large cohort of young, old or disabled passengers could then utilize a dedicated vehicle without a chauffeur. Hence some families will see owning one or more additional vehicles as a very rational decision. The marketing forces of the automotive industry will always prefer a high-volume, well-featured consumption model stoked by year-over-year improvements rather than a shared-vehicle model, even while responding to whatever opportunities exist to sell into shared fleets.

Will autonomous vehicles be gradually mixed in with human-operated vehicles or will they be somehow isolated to carefully constrained, perceptually safer applications? There are many operational, social, and liability complexities involved in freely mixing driver-out and driver-in vehicles on the same roadway—the biggest elephant in this room being distracted driving [16].

As this myriad of problems becomes solvable, traditional automotive manufacturers will prefer the mixed-driving model, since it justifies many years of new safety, intelligence, infotainment, status, and convenience features, while nurturing an ongoing preference for ownership. Vehicle turnover is king. Car companies are likely to continue using marketing techniques based on behavioral economics in every conceivable way. And they will mine the rich marketing opportunities across the full spectrum of partial-to-complete robotic enablement, making driving in congestion more comfortable, and taking advantage of the cultural predilection for "my car, my style, my way" [17].

Using increasing automation as a generator of new and compelling features for each model year is an example of the consumer product upgrade practice known as "feature creep." Clearly, automation and safety-related features should not be disparaged, yet the same year-over-year business model of incrementalism stokes consumer envy and sustains sales. Traditional manufacturers are not likely to readily abandon this underlying success formula for creating consumer demand and maintaining competitive advantage.

But new players such as Google that promise full, driver-out robotics sooner than the traditional players see evolutionary feature creep as unworkable in the early stages. Executive Astro Teller of Alphabet, the Google business division overseeing its automated vehicle, in a March 2015 keynote address at the South by Southwest Interactive in Austin, Texas, said this best:

> Even though everyone who signed up for our [self-driving car] test swore up and down that they wouldn't do anything other than pay 100 percent attention to the road, and knew that they'd be on camera the entire time…people do really stupid things when they're behind the wheel. They already do stupid things like texting when they're supposed to be 100 percent in control…so imagine what happens when they think "the car's got it covered." It isn't pretty. Expecting a person to be a reliable backup for the system was a fallacy. Once people trust the system, they trust it. Our success was itself a failure. We came quickly to the conclusion that we needed to make it clear to ourselves that the human was not a reliable backup—the car had to always be able to handle the situation. And the best way to make that clear was to design a car with no steering wheel—a car that could drive itself all of the time [18].

This and the recent stories about Tesla Level 2 drivers [19] suggest that feature creep will fail as a path to vehicles becoming fully automated. Well before creeping toward driver-out, a jump to full autonomy will be demanded. But it is obvious that society cannot move to pervasive road robotics quickly; it will most probably have to creep. Teller's comment also predicts problems for mixing autonomous and non-autonomous vehicles. Until February 2016 [20], collisions involving Google's autonomous vehicle operations have been blamed on drivers of non-autonomous vehicles, who mostly rear-ended Google's cars. It may be that autonomous cars conform to speed limits more consistently or tend to stop more frequently or more suddenly than do human-controlled cars [21].

5 Transit Leap

If driver-in/driver-out mixing is going to be problematic, it would make much more sense to put robotic vehicles to work earlier in constrained, less-mixed applications. Instead of waiting for the fortunes of evolution, leaders should promote an intentional revolution.

For this path to the future, we introduce the concept of *Transit Leap*, which initially focuses on lower risk, partially isolated applications with which to begin cautiously. They start out highly constrained and incorporate extreme oversight, before branching out and eventually disrupting traditional transit. The EU's CityMobil2, a small-vehicle (minibus) demonstration in several cities, is an early example, with vehicles such as shown in Fig. 2. Notably, these trials included research into financial, cultural, and behavioral aspects as well as effects on land use policies and how the new systems mesh with existing infrastructure [22].

There are many other smaller scale, spatially constrained applications available for Transit Leap, such as military, university, and employment campuses. Parking lot shuttles at airports could be serviced by 10- or 12-passenger vehicles running at

Fig. 2 Transit Leap in Europe (*Photo source* CityMobil2)

modest speeds on clearly marked lanes and tightly constrained to regular service on regular routes. Retirement communities could use such vehicles for local on-demand trips including for shopping, entertainment, and worship, with the vehicles beginning to determine best routes, rather than being constrained to fixed routes.

Human attendants, initially in place to provide continuity and comfort to early users and to help address changing labor demands, would be eased out gradually. Such applications are numerous, can start almost immediately, and can be gradually expanded to include longer routes, allowances to handle passenger requests by smartphone (more like a jitney than a shuttle), and to increase route flexibility, length, and detail.

Urban areas could begin with short and simple bus routes at low speeds on constrained lanes at grade and without barriers, treated like reserved bicycle lanes. If adjacent lanes carry driver-in motorcars, they would be traffic-calmed. These city systems would benefit from the experience of the earlier parking shuttles, campus applications, and the retirement communities. This would encourage a degree of local government interest in supporting these earliest systems. City transit routes could expand in number, distance, and flexibility until transit is dominated by multi-sized autonomous vehicles and each is tailored—i.e., scaled to purpose [23]. During the latter half of this shift, true robo-taxi services could be phased in and would merge so that robo-taxi and robo-transit offer a continuous service spectrum.

Figure 3 shows five levels of Transit Leap across five stages of spatial reach, each absorbing the prior stage, and eventually blending into spatially continuous, fully pervasive automation over increasingly larger areas until they all interconnect. Level 1 starts with very small, independent local applications and ends at Level 5—

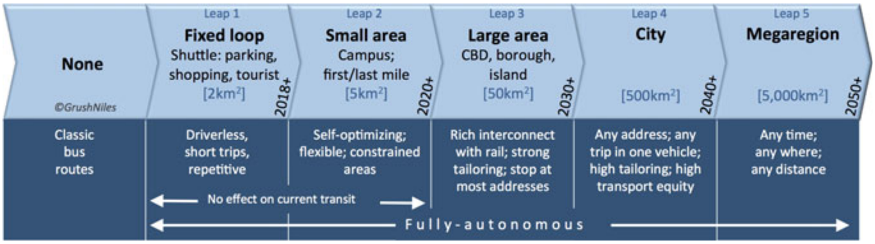


Fig. 3 Five levels of Transit Leap: add by spatial aggregation; encourage transit use, lower ownership and higher density (Copyright, Grush Niles Strategic.)

essentially nationwide. This would take 30–40 years, the same amount of time it took the motorcar to completely displace the horse.

This is distinct from the five Society of Automotive Engineers (SAE) levels of feature creep yielding increasing levels of automation: [L1] driver assistance, [L2] partial automation, [L3] conditional automation, [L4] high automation, and [L5] full automation. The major difference is that the vehicles deployed in the gradually expanding, ridership-growing, spatial applications of Transit Leap would all be SAE level 5 from the outset. The constrained, protected spatial applications allow greater technical autonomy, turning in-vehicle operators into trip assistants and guides from day one.

5.1 Transit Leap and Mobility Digitization

It is important to the workability of Transit Leap that it fits into the larger picture for the direction that society and technology is taking.

As we enter the era of *mobility digitization* the movement of people and goods will experience the effects of digital technologies similar to those we have seen for music, print, broadcast, hotels, entertainment, and hundreds of other aspects of human activity. Part of this will be a move away from ownership toward *usership*—the buying of more trips and fewer vehicles may be expected, or at least hoped for. We can expect an untold number of innovations that will result in new entrepreneurial activity and commercial choices for mobility. These activities and choices can be leveraged to the benefit of cities and urban transit. Transit Leap is one instance of such a lever.

The first stage of mobility digitization was the aggregation of hundreds of thousands of part-time drivers and their underutilized cars by *Transportation Network Companies* (TNCs) such as Uber and Lyft. The second stage, *Mobility as a Service* (MaaS), strengthens that capability by aggregating all forms of transportation—cars, buses, taxis, subway, streetcars, bicycles, carshares, motorbikes—into a single app. MaaS, providing trip coherence with minimal hassle and without car ownership, has already débuted. Maas Global launched *Mobility as a Service* in four cities in Scandinavia in 2016 and expects to launch in more cities soon. MaaS is an instance of the *Mobility Internet*.

These first two app-based mobility digitization technologies tend to reduce the need for car ownership, but the most far-reaching of all digital mobility technologies is vehicle automation. Robotics, far more than just an issue of safety and convenience, is a powerful optimizer of time, space, human attention, and energy. Vehicle robotics will change fundamentally how, why, and how much we travel. It will influence how we sprawl. It will tend to flatten our cities.

Some formats of vehicle automation are expected to reduce vehicle ownership while increasing trip counts and trips lengths, while other formats and circumstances will increase the demand for vehicle ownership. This contradiction alone—driven as much by behavioral economics and choice availability as by technology maturity—will cause more uncertainty in planning and infrastructure over the next few decades than any other single factor of mobility digitization.

Technologies for mobility digitization cannot be stopped, yet surprises in the scope and results of specific developments around the world are already common. Inability to predict the timing, direction, and effects of vehicle automation and mobility digitization now has become the single most troublesome aspect of urban and regional infrastructure planning.

Transit Leap is a deployment system for mobility digitization rather than one of its fundamental technologies. Its value lies in its ability to channel fast-arriving technology developments into *publically available* mobility services. Such services as we described above can preserve and enhance urban transit's roles supporting transportation equity, urban planning, employment skill-mix transitions, congestion abatement, safety, and building livable communities. Critically, Transit Leap can maximize the capability and value of planning in the face of dramatic change.

6 Conclusion: Innovation and Integration

Public jurisdictions can now reasonably begin the process of deciding how robotic mobility technology is to be deployed. They could use vehicle control automation technology to completely transform surface transportation from transit that is cripplingly expensive and used across all trip types for only 5–7% of passenger kilometers in the US and Canada. Shared vehicles (taxicabs, transportation network companies, and carshares), although growing in number now, still produce statistically miniscule passenger kilometers on a North American basis.

Setting and beginning work on a long-run target of 80% of all passenger kilometers to be traveled in shared vehicles—i.e., vehicles that belong to public, private, or co-op fleets and that are busy from 40 to 80 h per week instead of only eight or nine hours—should motivate an urban region to the point where a community of business and government leaders could begin to innovate just how such a fleet could be financed, maintained, managed, and priced. Leaders could begin to

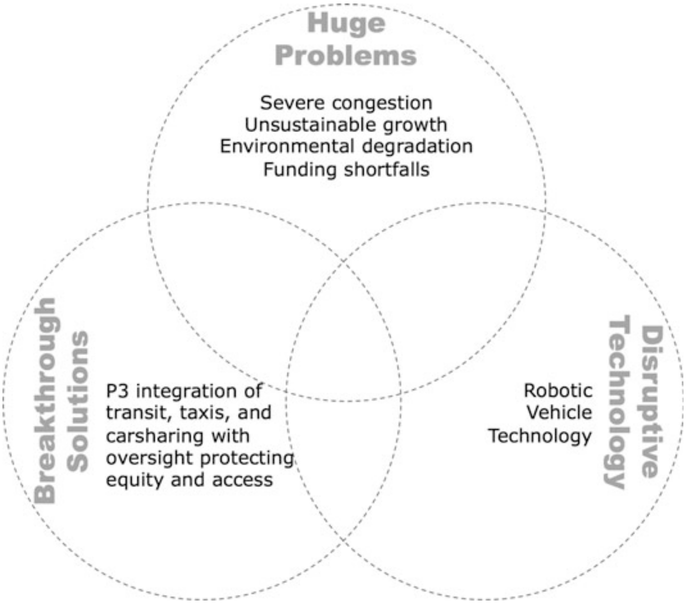


Fig. 4 Public–Private partnerships for innovation

figure out how to park this fleet off peak, how to power it, and how to re-purpose liberated parking areas.

Real estate interests in the community could begin a process to decide how to turn parking garages to other uses or parking lots into parks or building sites. Planners and public works departments might convert street parking into bicycle paths. If community leaders on a market-wide scale do not set such an assertive target and push to implement it, automotive manufacturers will inevitably continue to operate a high, personal-vehicle consumption model for the world's cities.

Public–private partnerships (P3s) for innovation could create opportunities for regions to ensure access and equity to all as well as enormous opportunities for manufacturing and jobs. The approach for moving forward is shown in Fig. 4, derived from the above mentioned online presentation by Goggle (Alphabet) [24].

Urban leaders focused on transportation systems should start thinking now who would be best to deploy such fleets. Which kinds of organizations? With the present pace of technology development, it is not too early for civic leaders to begin forums to discuss the incentive and regulatory structures that would fit community values. Ideas should be considered regarding ownership models. The alternatives of fleets owned and managed by large corporations à la the Wal-Mart company-owned store model or franchised as family-run fleet clusters on the McDonalds model should be put into planning scenarios. Universities and professional groups should be asked to think about a future role in sponsoring affinity fleets run by co-op transportation operators. What kinds of government guides for pricing, service, and response times will be needed to maintain equity, or can the forces of the competitive market include motivations for sustainable social and transportation equity in some unexpected ways? All this, and more, is worth discussing now in government-business forums.

7 Recommendation: Avoiding Ugly Disruption

The difference between the incremental feature-creep model normally pursued by auto manufacturers and the disruptive model of moving directly from driving to not driving as is being pursued by Google, the European Union, and others is the important difference that addresses the vehicle autonomy-mixing. There are numerous problems of mixing robotic-driven and human-driven vehicles at any ratio—whether 1, 50 or 99%. Adopting an incremental, gradual, mixed-traffic model would lead to years of contention regarding traffic rules, overly cautious robotics, insurance liability, ethics conundrums, and new legions of distracted drivers using robotics that operate for 90 or 99 but not 100% of a trip.

If urban leaders emphasized full-solution, Transit-Leap innovation instead of preparing or waiting for household-vehicle feature creep from the auto industry, less contentious, incremental improvements would likely emerge.

If public agencies used innovative business and financing models to replace and grow public transit passenger kilometers in increments safe for passengers and in ways that allow for thoughtful mitigation of inevitable labor disruptions, the subsidization burden of transit could shrink, and ridership could grow. Travelers would be attracted out of household vehicles, expanding the ways TNCs do this now. Rather than resisted, TNCs should be regulated and integrated into a new hybrid solution of privately operated fleets governed for accessibility and equity. However much Lyft and Uber may be good for young, car-less travelers in our cities, TNC services are not designed to be available to low-income, digitally and economically disadvantaged travelers. Cities have a critical role to ensure access and equity, especially as current transit methods and technologies are disrupted.

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

Transportation leaders in the developed world where private automobile ownership is the highest should lead the way in establishing a clear direction toward a preferred future of massively used, massively shared robotic fleets. Benefits will come from demonstrating sustainable, environmentally friendly models of urban style and fashion for the rest of the world to imitate as vehicle automation emerges in practice.

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