Now Arriving: A Connected Mobility Roadmap for Public Transport

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Executive Summary

The form and functioning of cities is defined by transportation. How we traverse them affects everything from our access to opportunities to land uses to energy consumption and pollution. Railroads, streetcars, and automobiles each produced cities made in their respective images, from skyscrapers to suburbs to sprawl.

Today, the state-of-the-art in transportation is the smartphone. Its two-way ability to locate, coordinate, and orchestrate both passengers and vehicles is more important than any one mode, including the automobile. Smartphones and their successors will transform cities once again. The only question is how.

To date, the ones seizing these opportunities have been private actors, whether in way-finding (e.g. Google Maps, Waze, Apple), ride-hailing (e.g. Uber, Didi, Grab, Lyft) or autonomous vehicles (e.g. Alphabet, Tesla, Amazon). This represents both a missed opportunity and a looming threat for public transport, which has struggled to adapt for a litany of historical, political, and technological reasons.

Transit agencies trapped in a downward spiral of shrinking budgets, diminished service, and declining ridership have begun turning to these companies as complements or even substitutes for traditional modes, especially as a first-and-last mile connection to mass transit. This is a dangerous path that practically invites disruption; as on-demand mobility continues falling in price while increasing coverage, transit agencies risk being hollowed out by their would-be partners.

The risk is that a new generation of "choice" riders may choose to forgo both their own cars and public transport in favor of parallel private competitors, consigning vulnerable "captive" riders to increasingly dysfunctional transit systems crippled by a lack of leadership, funding, and political support.

This is not an argument in favor of the status quo, however. Cities are right to encourage innovative services, and residents are right to want them. Regulators cannot restrain new entrants forever, nor should they try. However, they should be proactive about driving the change – and writing the rules of engagement so to speak – rather than have new mobility technology players decide the terms themselves and control the outcome. The only sustainable solution is for public transport to embrace this opportunity to reinvent themselves as mobility orchestrators rather than operators, to supplement high-frequency, high-capacity trunk lines with on-demand services, to recombine and repackage modes in new and appealing ways, and to create new public-private partnerships that create value for all participants while preserving transportation access and equity. No small task, but an imperative goal worth pursuing.

This report is the culmination of the *Connected Mobility Initiative* launched by

the New Cities Foundation in June 2015. The primary aim of the initiative is to explore the triple convergence of "mobility" — physical, digital, and socio-economic — and to propose strategies and steps toward more broadly sharing the benefits of this transformation while ameliorating its potentially corrosive effects on public institutions. To this end, the report is split between brief profiles of four cities — Washington D.C., London, São Paulo, and Manila — facing challenges representative of their respective peers, along with a list of near-, mid-, and long-term recommendations for transport authorities to aid them in their transformations.

Cities

Washington D.C.

Washington became the poster child of America's infrastructure crisis following the "Metropocalypse" — a brief shutdown of the Metro in March 2016, followed by a planned year of emergency repairs. Well before that, a vicious cycle of steadily reduced service and dwindling ridership had created a fiscal crisis that seemingly could only be solved by privatization or federal intervention. Meanwhile, transportation network companies (TNCs) such as Uber and Lyft pounced, offering commuters significant discounts to use their services instead of public transport.

Even in cities that have made substantial investments in new service, such as Los Angeles, ridership declines have continued unabated. Transport officials there and elsewhere are struggling to reinvent

themselves as more agile, entrepreneurial, and willing to partner, alternately inspired by the successful spread of municipal bike-sharing programs and alarmed by would-be disruptors.

In Washington, which was quick to welcome TNCs, there are already signs of how connected mobility is changing the city. New residents are eschewing cars in favor of bike-sharing, car-sharing, and ride-hailing, enabling developers to transform previously undesirable or inaccessible sites into new housing. TNCs' first victims were taxis, and now parking. If transit agencies aren't careful, they might be next.

London

Transport for London is the model of a modern major transport system. It controls the city's trains, buses, cabs, major streets, and congestion pricing. But as big as TfL is, it may not be big enough. It can't afford to develop its own payment system (i.e. Oyster) as Google or Apple can. It can't collect data from every passenger, as Waze does and Citymapper aspires to. And it can't ignore the consequences of flooding central London with 15,000 additional drivers exempt from congestion charges as Uber has done. So, what are its options?

A decade ago, TfL reinvented the city's bus network by partnering with dozens of private operators. While it collects fares and manages the network, the private operators run routes and keep the profits. How might a similar arrangement work with TNCs and their successors? One answer is "mobility-as-a-service," which posits a citywide platform combining multiple modes within

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a single interface. Many of these services begin with a trip-planner and gradually add capabilities such as integrated payment and ticketing (e.g. Moovel and Xerox). Others start as efforts by transport operators to make themselves more attractive by offering multimodal monthly subscriptions (e.g. Hanover's "Mobility Shop," Vienna's SMILE).

Perhaps the most ambitious startup is Finland's MaaS Global, which aims to create a global, open platform on one hand, and city-specific services on the other, starting in Helsinki. Transport for London is one of its first partners.

São Paulo

The largest city in the Western Hemisphere is slowly grinding to a halt. Decades of disinvestment in public transport in favor of building highways has created a spatially segregated city gridlocked at every level. São Paulo is infamous for both its traffic jams and punishingly long commutes by transit, culminating in 2013's protests over a $.09 fare hike.

Unable to add capacity, the challenge facing the city's transit agency is to create enough slack in the system to give passengers room to breathe. That's the aim of MobiLab, a data laboratory and incubator inside SPTrans. Using open source tools to replace expensive software, the lab plows the resulting savings into data-driven experiments and investments.

One goal is to discover how tiny interventions might critically tip congestion.

Researchers have demonstrated how shifting or eliminating even a single percent of trips in very specific neighborhoods can reduce delays across entire cities. This has financial consequences as well. MasterCard estimates that a 5-10% reduction in peak rush hour commutes can help defer system expansion (and capital expenditures) by as many as two years — hopefully enough time for São Paulo to catch its breath and add the capacity it needs to accommodate a growing urban population.

Manila

Nearly half of Metro Manila's 24 million residents ride daily on *jeepneys* — twenty-seat passenger jeeps spewing black exhaust while tracing intricate routes through the city. It's the most affordable, albeit not enjoyable commute for middle class Filipinos, whose more affluent members are fleeing jeepneys *en masse* for private cars — producing the world's worst congestion.

But are jeepneys the problem or the solution? In cities across the Global South — including Nairobi, Mumbai, and Mexico City — informal transport emerged to fill the void left by weak or non-existent public transport. They have in turn been upended by recent surges in auto ownership. Simultaneously, "microtransit" services such as UberPOOL, Lyft Line, Via, and Bridj have appeared to challenge public transport with smaller vehicles making multiple, algorithmically-optimized stops.

Manila's investments in mapping jeepney routes and modernizing vehicles, coupled

with the challenges posed by its fluctuating density and failures to expand mass transit, suggest the megacity may be microtransit's true frontier — if the public and private sectors alike are willing to take the risk.

Recommendations

The key lessons culminating from each of the case studies above yield the following insights and recommendations for public transit authorities on how they can transform themselves to tackle the changing mobility needs of city-dwellers and in the face of technology-driven disruption.

Near-Term Strategies:

1 Create steering committees to assess new technologies. Multi-disciplinary teams should regularly reconnoiter the horizon, identify both promising and threatening developments, and debate the potential impacts of new technologies. Higher-level multi-agency committees should meet regularly to exchange best practices and conduct exercises to concretely imagine future services.

2 Know what data you have, what data you need, and what you can do with it. Sharing data, collecting and making sense of it, and using it to inform planning and decision-making is essential. Public transport must do a better job of taking stock of the datasets they have, what they desire or require from partners and third parties, and adopting open APIs and standards whenever possible.

3 Cross-train staff to build capacity and discover opportunities. Upgrading skills while attracting new talent is critical — and extremely difficult given public sector requirements on hiring. Agencies must strive to re-train staff in data analysis and visualization, cross-train them by embedding staff to-and-from other departments, universities, and partner institutions, and search for opportunities to pool data and expertise across agencies.

4 Leverage, re-use, and repurpose physical assets and infrastructure. Startups may have all the algorithms, but what they don't have are the streets, sidewalks, parking, and curbspace their services rely on. Transit agencies must rethink the highest and best uses for parking and land around stations, while transport officials should seek to leverage broader assets such as libraries and municipal buildings as nodes for connected mobility.

5 Rethink commuter benefits strategies and car-pooling. Transit agencies typically overlook the incentives offered at either end of most commuters, which is usually free parking. Public officials should work with local employers to create carpooling- and rewards networks at the firm-, city-, and regional levels to encourage shared trips, fewer peak rush hour commutes, and less congestion.

6 Explore demand-shaping and peak-shifting through real-time incentives. Singapore and other cities have had great success in using incentives such as free trips and reward programs to encourage commuters to eliminate or defer trips

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during periods of peak demand. Transit apps with integrated way-finding, payment, and ticketing offer new possibilities for individual, real-time incentives to route travelers around service disruptions, balance passenger loads across modes, and offer finer-grained incentives than blanket subsidies.

Mid-Term Strategies

1 Create "connected mobility labs" to assess new technologies. Transit agencies shouldn't go *mano a mano* with deep-pocketed startups when it comes to hiring talent or writing software. But as a number of governments have demonstrated, "living labs" and "innovation teams" can be useful in streamlining procurement, prototyping features and services, and inviting public and private partners to collaborate.

2 Create a mobility-as-a-service (MaaS) roadmap. For public transport to survive and thrive, it must become easier and more convenient than the private modes and services arising to challenge it. Agencies must develop a plan to functionally integrate way-finding, payment, and ticketing onto a single, open platform combining multiple modes — with their own services providing the backbone.

3 Launch a microtransit pilot. Using on-demand microtransit to extend and expand coverage in insufficiently dense areas is one of the biggest opportunities surrounding connected mobility. Unlike better-known TNCs, microtransit services such as Via and Bridj have signaled their willingness to work closely with public transport in licensing their software and data. Agencies should

pursue such partnerships at the earliest opportunity to begin testing service in interested communities.

4 Rethink informal transit. In cities across the Global South, informal transit is transit. Rather than pursue policies to replace them, transport authorities should seek to legitimize and upgrade these fleets with an eye towards integration. Safer and more convenient jitneys may prove to be a bulwark against congestion, while in the long run, upgrading them to microtransit might prove to be an effective solution for sprawling megacities.

5 Rethink parking, zoning, and land-use policies. Given the rise of car-sharing, ride-hailing, and mobility-as-a-service, cities should rethink parking and zoning to encourage creative land uses. Eliminating parking minimums, reconsidering minimum housing lot sizes, and permitting the construction of accessory dwelling units can all help increase the supply of more affordable housing. Higher densities also enhance the efficacy of transit.

Longer-Term Strategies

1 Transition from transport operators to mobility managers. If public transport is to meet the challenges and opportunities posed by connected mobility, it must stop privileging individual modes and instead focus on outcomes such as quality, safety, security, convenience, sustainability, and affordability. This will require combining institutional reforms with innovative tendering, network restructuring, new technologies, and most importantly, strong leadership from the mayoral level down.

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2 **Embrace connected mobility while bridging the digital divide.** Smartphones are not, in fact, ubiquitous. Neither are credit cards or bank accounts. Transit agencies must continue to guarantee access for the most vulnerable, whether that means trip-planning kiosks at stations, basic fare cards or tickets with QR codes, and consolidated call centers for users without phones.

3 **Launch an autonomous vehicle (AV) pilot.** Promote the deployment of AVs as centrally managed fleets complementing transit. Partner with automakers and/or startups to test vehicles under real-world conditions. Collect data on safety and user behavior. Consider the impacts on congestion and whether congestion pricing is necessary.

Introduction

"Cities are always created around whatever the state-of-the-art transportation device is at the time," Joel Garreau wrote twenty-five years ago in *Edge City*[1]. At the New Cities Foundation, we are intensely interested in the forces shaping the development of new and old cities alike, whether social, economic, environmental, or technological. The aim of the *Connected Mobility Initiative* is to explore the triple convergence of "mobility" — physical, digital, and socio-economic — and to propose strategies and steps toward more broadly sharing the benefits of this transformation while ameliorating its potentially corrosive effects on public institutions. In the 1980s and early 1990s, it was the then-cutting edge combination of the personal computer and automobile that spawned the suburban edge cities of Garreau's title. Today, the state-of-the-art in transportation is the smartphone.[2]

It's not just that smartphones are ubiquitous, with annual sales approaching 1.5 billion handsets,[3] compared to a total of 1.2 billion motor vehicles on the roads.[4] They're qualitatively different, doubling as a sensor and pocket supercomputer as well as the focal point of a vast data collection and analysis apparatus churning in the cloud. They're also the locus of 21st century infrastructure spending, as America's mobile carriers have collectively invested more than $500 billion upgrading the country's cellular communications grid — roughly the modern cost of the Interstate Highway System.[5] The smartphone's ability to choreograph transport has supplanted the importance of any one mode, even the automobile. It will remake the city as surely as previous revolutions did.

The most important questions now are "How?" and "For whom?" The advent of mass-produced Model T Fords a century ago had both spatial and political consequences for cities. Jitneys were banned, streetcars demolished, and mass transit became the public's domain to eliminate competition with burgeoning automakers. Federal funds were marshaled to build freeways and finance suburbia. Meanwhile, systematic disinvestment hollowed out cities, requiring decades to repair and recover. Nearly thirty years passed between the judgment famously (though falsely) attributed to British Prime Minister Margaret Thatcher that, "a man who, beyond the age of 26, finds himself on a bus can count himself as a failure,"[6] and Bogota Mayor Enrique Penalosa's more recent assertion that "an advanced city is not one where even the poor use cars, but

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[1] Garreau, *Edge City*, 32.

[2] Goldwyn, "The Most Important Transportation Innovation of the Decade Is the Smartphone."

[3] Gartner. "Forecast: PCs, Ultramobiles and Mobile Phones, Worldwide, 2013-2020, 1Q16 Update."

[4] Navigant Research, "Transportation Forecast: Light Duty Vehicles." 2016.

[5] Townsend, "Re-Programming Mobility."

[6] Bevilacqua, "Maybe Margaret Thatcher Didn't Hate Buses As Much As We Thought."

rather one where even the rich use public transport."[7]

How will we speak of connected mobility thirty years from now? As an enhancement of Penalosa's city, or as the moment public transport willingly began to dismantle itself in the face of smartphone-led disruption? It is critical for policymakers to understand that new technologies and services such as Uber, Waze, and autonomous vehicles are not neutral. They embody values and business models that left unchecked, may run counter to the goals of creating livable and equitable cities — whether intentionally or unintentionally.[8] It's imperative for transit agencies, public officials and their partners to understand the implications of this shift and to reposition themselves as the stewards of a broader, more flexible networked transportation system.

This report arrives at a pivotal time. The International Transport Forum predicts the number of vehicle kilometers traveled will more than double and may triple globally between 2010 and 2050, with 80% of that rise attributed to cars.[9] The result, according to estimates by the International Energy Agency, will be a corresponding 80% rise in global transportation's energy usage, contributing to a six-degree Celsius rise in global temperatures.[10] Even if tighter fuel economy standards and a switch to electric

vehicles reins in some of that growth, the IEA predicts it would still be necessary to pave nearly 25 million kilometers of roads, and a minimum of 45,000 square kilometers of parking. And that's in a scenario in which global temperatures would still rise by four degrees.

Most of this growth will occur in lower- and middle-income cities across the Global South, where a burgeoning middle class is fueling an explosion in private car ownership.[11] There's a good reason for this, as the automobile's point-to-point, door-to-door, on-demand service remains the most personally liberating technology devised so far (with the growing exception of the smartphone). This is why individual auto ownership is, in the aggregate, expected to rise. But in not prioritizing other modes of public transport, these cities run the risk of repeating America's mistakes in prioritizing transport's speed, distance, and efficiency at the cost of accessibility.

The Brookings Institution found that typical residents of an American city are only able to reach 30% of the available jobs in less than 90 minutes using transit.[12] Another study found that nearly half of affordable housing residents spent more than 15% of their incomes on transportation costs.[13] This dilemma is magnified in cities such as São Paulo and Manila, where the

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[7] Penalosa, "Why buses represent democracy in action."

[8] What was good for General Motors in 1953 wasn't necessary good for the country.

[9] UITP. "Public Transport Trends."

[10] International Energy Agency. "Global Land Transport Infrastructure Requirements."

[11] *The Economist*, "Slowly does it."

[12] Tomer, et al. "Missed Opportunity: Transit and Jobs in Metropolitan America."

[13] Hamidi and Ewing. "How Affordable is HUD Housing?"

toxic combination of separate land uses, inadequate transit capacity, and mounting congestion has led to punishing multi-hour commutes.

Ironically, the IEA estimates it would cost less — $50 trillion less spread over forty years — to re-invest in a transit-rich, low-carbon transportation system.[14] As far as transportation experts are concerned, nothing can replace the capacity of a new metro, and they have a point. But new modes of connected mobility, born from data and algorithms and guided by the smartphone, offer transit agencies new tools for reshaping their cities — tools in the hands of startups until now.

This report, intended for transport professionals, public officials, and private companies, seeks to explore the following questions:

- How is connected mobility already changing cities in terms of accessibility and land use? What are the likely impacts on parking, development patterns, transit-oriented development, and value capture?

- What is the role of transport authorities in the era of connected mobility? Should they remain *operators*, privileging some modes while outsourcing others, or should they evolve into *orchestrators*, leveraging their networks and legitimacy to guide and regulate the growth of the system?

- What skills and capabilities are needed internally to achieve this vision, and who are the external actors that will supply new mobility options? How are these partnerships best structured to guarantee mutual benefits?

- How can connected mobility be greater than the sum of its modes? What integrations are necessary to make the most of new combinations? Is the goal to achieve "mobility-as-a-service?"

- Which goals should transport bodies aim to achieve? Is it simply about removing private vehicles from the roads? Or is it more broadly about accessibility, equity, safety, and sustainability? Which modes will help advance (or frustrate) these goals?

- How should transit agencies monitor and develop new technologies and services, recognize threats and opportunities, and pilot projects to test their impacts (e.g. autonomous vehicles)?

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[14] International Energy Agency.

And last but not least: who will own, control, and share the data making all of this possible? Will connected mobility ultimately be provisioned as a public good? Or will it follow the current arc of the greater Internet, in which data — and with it, power — is consolidated in private hands free to enter any industry they like?

Bracing for Disruption

A case in point is Uber Technologies Inc., which has built one of the world's most valuable transportation companies upon a simple proposition: press a button and a car will come. But its real innovations are only made possible by data aggregated from customers and drivers alike, including "surge pricing," matching riders headed in the same direction (i.e. UberPOOL), and even pop-up bus stops (i.e. UberHOP)[15]. Every node in Uber's network is a sensor for tracing otherwise invisible desire lines through cities, for which it offers a service to match.

Uber isn't alone in that respect. Alphabet's Waze subsidiary has begun leveraging its 50 million monthly users to coordinate carpooling pilots in the Bay Area and Israel, while Sidewalk Labs has announced a traffic- and parking-management system built atop Google Maps named Flow. Cities interested in Flow reportedly must agree to exclusively use Google's mobile payment system for transit and parking, and to share their data with Uber.[16]

Are these visions competing with or complementing transit? For now, the answer appears to be the latter. Although only 15% of adult Americans have ever tried ride-hailing services,[17] regular users overwhelmingly tend to be younger, better educated, higher earning, and more likely to live in dense urban areas. (These attributes are important, as American public policy is historically driven by elites' preferences.[18]) They are also less likely to drive and significantly more likely to walk, cycle, and use transit.

After vanquishing most regulatory opposition (with notable exceptions in Europe[19] and Asia[20]), Uber, Lyft, and other transportation network companies (TNCs) have taken a more conciliatory tack with transit agencies. Rather than demonizing transit as public monopolies, TNCs have positioned themselves as first- and last-mile links between stations.

In the last year alone, Uber has partnered with cities and suburbs in California, Florida, and Pennsylvania to subsidize rides to-and-from train stops, and in one case anywhere within city limits.[21] (Separately, Sidewalk

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[15] Hawkins, "UberHop is Uber's latest idea for killing mass transit."

[16] Harris, "Secretive Alphabet division funded by Google aims to fix public transit in US."

[17] Smith, "Shared, Collaborative and On Demand: The New Digital Economy."

[18] Bartels, "Rich people rule!"

[19] Mawad, "Uber Feels UberPop Hangover With French, German Legal Setbacks."

[20] Ramirez, "After getting forced out of South Korea, Uber prepares to fight back."

[21] Uber, "Uber and Altamonte Springs launch pilot program to improve transportation access."

Labs has proposed discounting Uber rides for 90,000 lower-income Columbus, Ohio residents, rather than subsidizing buses.[22]) Uber also integrated its API into bus-tracking software from TransLoc, offering riders in Memphis and Raleigh-Durham the ability to combine trips with Uber pickups to-and-from stops.

Transit agencies have begun warming to TNCs in turn, wondering if they might be better off delegating service on off-hours and at the fringes of networks in order to focus on trunk routes. It's easy to see why. Uber's suburban Florida partners, for example, turned to the company after ballot measures to raise transit funding failed. The curtailing of late-night transit service in Boston has been a boon for TNCs.[23] In Washington D.C. and Los Angeles, declining service levels preceded corresponding declines in metro ridership — and that was before the former suffered a total shutdown of rail service in March for emergency repairs, followed by a feverish maintenance program aimed at compressing years of deferred upkeep into just 12 months, which TNCs have been swift to exploit.[24]

The conventional wisdom is that TNCs and "microtransit"[25] cannot replace the essential role of mass transit. "Even if that does happen, you'll still need transit in dense areas," says Joshua Schenck, LA Metro's chief innovation officer. "There's not nearly enough road space to carry all the people who need to get to the same place."[26] From a purely geometric perspective, this is true — a traffic corridor's maximum capacity is 2,000 motorists an hour, compared to 14,000 cyclists, 17,000 bus rapid transit riders, and 19,000 pedestrians, to say nothing of 80,000 metro riders in the same span.[27]

But to overlook the scale and scope of the upstarts' ambitions is to risk a textbook case of disruption, in which a new, presumably inferior product initially poses no threat to established incumbents, but as it improves in quality while falling in price, the incumbents are forced to retreat into a series of increasingly indefensible niches as their market share is consumed from below. Is this the fate of fixed-route public transit? And if so, what would be lost?

In the worst-case scenario, a two-class system for a new generation of "choice" and "captive" riders might emerge. One is private-but-subsidized for higher- and middle-income residents, and the other a rump system for everyone else. The former benefits from a virtuous circle of falling costs, greater coverage, and a de facto oligopoly (if not monopoly), while the latter collapses into a downward spiral

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[22] Harris.

[23] Bidgood, "Revived Focus on Lagging Night Life as Boston Ends Late Transit Service."

[24] Siddiqui, "Lyft will offer steep discounts to attract commuters during Metro's SafeTrack."

[25] "Microtransit" is the emerging term to describe multi-passenger vehicles larger than a single passenger or party and smaller than a typical 40-passenger bus. Examples of such services include UberPOOL, Lyft Line, Via, Bridj, and Helsinki's late, lamented "Kutsuplus."

[26] Holeywell, "LA Metro's Innovation Policy: Consider Any Good Idea."

[27] UITP.

of service failures, declining status, and disinvestment. As Margaret Thatcher might have (apocryphally) put it, a man who doesn't hail an Uber can count himself a failure.

If this sounds alarmist, let's quickly delineate the differences between transit, TNCs, and other forms of "shared mobility," i.e. bike-sharing, car-sharing, carpooling, and so on. Transit systems are invariably local, politically accountable (to a fault), frequently tasked with operating and maintaining large fleets and infrastructure with salaried, often unionized employees, and subsidized to achieve broader social goals than merely breaking even. Most shared mobility modes are also local and involve managing vehicle fleets, and they can be public, private, or a hybrid of the two (e.g. bike-sharing). Occasionally, they can be monopolistic — the key to "Big Taxi's" undoing in the public eye.

But the TNCs are something else, especially Uber, whose stated goal is to weave what Kalanick once called "an urban logistics fabric in every city in the world"[28] — a parallel, private transportation system. For one thing, the largest TNCs are an order of magnitude bigger globally than any single transport body, which matters when it comes to aggregating and analyzing data.

Uber has more than 400,000 drivers in 360 cities around the world;[29] Lyft has 315,000 drivers in 195 cities.[30] (Uber archrival-turned-partner and Lyft ally, Didi Chuxing claims to have handled more trips in China alone last year than the pair combined.)[31]

They're also flush with cash. Uber has raised $15 billion to date, while Didi has amassed $10.5 billion. The three largest TNCs are collectively worth more than $100 billion on paper. Uber alone is considered more valuable than General Motors or Nissan; Didi is worth more than Hyundai or Renault, and Lyft tops Hertz, Avis, and Enterprise combined. Because drivers don't exist on their balance sheets, they're free to spend copiously on recruitment, market share, and technology.

Third, they're relentlessly efficient. Uber has steadily lowered prices and wages to undercut taxis and bring services like UberPOOL within range of transit. (In July, it briefly offered passes in New York[32] and Boston[33] for less than $2 per trip.) The result is that Uber drivers in Detroit earn as little as $8.77 an hour after expenses — barely more than minimum wage.[34] It's difficult for unionized transit agencies to compete with that. (In fact, some officials privately concede the lure of partnering with Uber is to get around those costs.[35])

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[28] Brustein, "Uber's Workforce Is Built to Do More Than Chauffeur."

[29] Uber. "Find a City."

[30] Alexandra LaManna, e-mail message to the author, August 1, 2016.

[31] Alba, "Didi Kuaidi Announces 1.43 Billion Rides in Challenge to Uber."

[32] Griswold, "Commuting with Uber in New York is cheaper than taking the subway this summer."

[33] Uber. "July POOL Pass: Ride for a penny all month long."

[34] O'Donovan and Singer-Vine. "How Much Uber Drivers Actually Make Per Hour."

[35] Tsay, et al. "Private Mobility, Public Interest."

Finally, they're accountable only to themselves. Uber and Lyft angrily withdrew from Austin, Texas in May 2016 after voters passed a referendum requiring their drivers to submit fingerprints as taxi drivers must. Despite following similar regulations in New York City, the pair elected to spend $9 million lobbying against the referendum before leaving. That kind of deep-pocketed intransigence, coupled with their opaque use of "surge pricing" during periods of high demand and even during emergencies,[36] should make any city think twice about handing over large swaths of their system to them.

That said, what are public transport bodies to do? Clearly, banning potentially disruptive new technologies and services doesn't work, at least not in the long term. The only solution is for transport bodies to embrace and extend those same technologies to better connect with customers, buttress existing modes, and extend the reach of their systems with the help of new partners — on their own terms.

In a best-case scenario, public transport and planning agencies might be able to:

- Promise riders an on-demand "bus" arriving within minutes a few blocks away and deliver them within walking distance of their destination — all for a single fare.

- Lure drivers from their cars with a monthly membership combining unlimited public transport with car-sharing or ride-sharing at the edges, all running on the same platform, accessible through a single app.

- Use the data from these services to customize the experience for each rider, using combinations of carrots and sticks to shape demand across modes or even shift the rush hour peak.

- Encourage residential developers to subsidize memberships in these multi-modal services for tenants, thus reducing the need for parking while spurring denser growth beyond traditional transit corridors.

Taken together, these might not only lessen auto dependence and reduce congestion, but also increase the public's faith and support in transport — provided, of course, that transit agencies can successfully remake themselves into vastly more flexible, innovative, customer-centric entities. It won't be easy. (After all, there's a reason they're being disrupted.)

This report, made possible with the generous support of the Toyota Mobility

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[36] Ries and Ryall. "Uber intros surge pricing during Sydney hostage siege, then backtracks after user outcry."

Foundation, draws upon a year of research and more than one hundred interviews with public officials, CEOs, NGOs, researchers, drivers, and riders in dozens of cities to focus on four whose challenges and opportunities are representative of those facing transit agencies and private stakeholders around the world.

The first half of this report explores the issues surrounding each of these cities in turn, highlighting their responses to the questions below. The second half gleans lessons from these examples and offers recommendations for public transport officials and private stakeholders for how to maximize connected mobility's potential.

Washington D.C.

America's test bed for shared mobility for more than a decade, thanks to the first in a new breed of more entrepreneurial transport officials. With the District's Metro facing a funding and maintenance crisis, how is connected mobility already reshaping the city?

Washington DC. © tchamber236.

London

Transport for London is one of the world's best-and-brightest transit agencies...and it's been flummoxed by TNCs. What can TfL's approach to public-private partnerships teach us about incorporating new mobility players into existing systems?

London. Flickr / Christian Schreiter

São Paulo

Its trains are jammed, its buses packed, and its streets hopelessly gridlocked. Can Brazil's biggest city use data to discover a tipping point in lowering congestion, giving commuters and public officials alike enough room to breathe?

São Paulo. © Connection Consulting.

Manila

The archetypal Global South megacity suffers the world's worst traffic. Would mapping and networking the city's infamous "jeepneys" help solve a lack of formal investment? Is algorithmically-guided microstransit a better fit for these cities than fixed-route service?

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A Tale of Four Cities

Washington D.C.

Gabe Klein had a confession to make. The former director of Washington's District Department of Transportation (DDOT) hadn't taken the train in six months. "I find it to be unreliable and unpleasant," he said over breakfast in January 2016. "So, if I can ride my bike instead of taking it, I will."[37] This was shocking but not surprising — Metrorail ridership and service had fallen into a tailspin, with the former plummeting to levels not seen in a decade,[38] despite a population boom over that span. In Klein's case, "my bike's replaced trips; I also drive, and Lyft in particular has displaced trips. I would have ridden the Metro less anyway, because I was dissatisfied with it."

Klein was proven prescient on March 16, 2016 when the Washington Metropolitan Area Transit Authority's (WMATA) general manager ordered a system-wide shutdown for emergency repairs.[39] Things would get worse before they got better, with years' worth of delayed maintenance compressed into twelve months, shutting down entire lines for days at a time. Officially named "SafeTrack," it quickly became known as the "Metropocalypse."

Overnight, Washington had become the national test bed for connected mobility, as more than half of the District's working population wondered how they would get to work. By June, Capital Bikeshare had reported record ridership,[40] buttressing earlier research that found it to be a substitute for short train and bus trips.[41] Uber and Lyft pounced, offering capped fares as low as $5 on their shared ride options, UberPOOL and Lyft Line. Smaller players like Split and Via went even further, with the latter offering a flat fare of $2.15 — the same price as a Metro ride. Meanwhile, Bridj offered pop-up bus routes between neighborhoods poorly served by transit.

That the city had a wealth of options at the ready is testament in part to Klein, a transport Zelig who launched Zipcar in Washington in 2002 before stints running DDOT and Chicago DOT. More recently, he'd written a book, Startup City, detailing lessons from his time spent in government, during which time he became the prototype for a new generation of transport czars more inclined to experiment.

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[37] Klein, interview with the author.

[38] Thomson, "Metro ridership continues to plummet along with service."

[39] Fandos, "Inspections Will Close Washington, D.C., Metro on Wednesday."

[40] Giambrone, "Capital Bikeshare Sees Record Use During First Week of Metro's SafeTrack Maintenance Plan."

[41] Martin and Shaheen, "Evaluating public transit modal shift dynamics in response to bikesharing: a tale of two U.S. cities."

Perhaps Klein's most notable accomplishment was Capital Bikeshare (CaBi), a multi-jurisdictional public-private partnership that was the nation's first municipal bike-sharing program when it launched in 2010, and has since tripled in size to more than 350 stations city-wide. Using this as his model, Klein's advice to transit officials is to fight disruption with disruption by reforming regulations, focusing relentlessly on customers, and "failing fast" before delivering polished projects like CaBi with marketing campaigns worthy of any startup.

Transit agencies have only themselves to blame, he said, for stubbornly thinking of themselves as fleet operators rather than entrepreneurial stewards of a broader mobility ecosystem. As a cautionary tale, he pointed to the Washington D.C. Taxi Commission (DCTC), which waited until early 2016 to launch a unified taxi app, then watched helplessly as the commission was

dissolved and reconstituted in June as the Department of For-Hire Vehicles in an effort to weaken the influence of local operators.[42] "Why aren't transit agencies functioning as a travel agent?" Klein asked rhetorically. "They're relegating themselves to a corner by saying, 'All we do is operate buses.' And they have the customer base! Whoever owns the customer is going to win. So, if you own the customer base, you should be expanding your service platform, and you should be taking a cut of everything that runs on it. And let me tell you something: if they had an app with every [mode] on there, with mass adoption, I'd guarantee you Lyft would be paying them a fee for every ride from the platform — and then they could use that to fund transit. The problem is they're living in an era that doesn't exist anymore."[43]

In Washington D.C.'s case, that era was when the Metro opened in the 1970s. Today, the system Klein studiously avoids

Capital Bikeshare. Photo left: Flickr © DDOT DC. Photo right: Flickr © Mr.TinDC

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[42] Giambrone, "Cabbies: Commission's Rebranding as 'For-Hire Vehicles' Department End of the Road."

[43] Klein.

is facing a maintenance Metropocalypse, blistering criticism from the FTA and National Transportation Safety Board, and a $100 million budget shortfall[44] that has led WMATA chairman Jack Evans to muse publicly about asking the Federal government to step in, or else privatizing the system altogether.[45]

How is an organization tasked with making trains run on time (literally) that is too busy putting out fires (literally) supposed to transform itself into a more agile agency prepared to make better use of the assets it has, let alone the assets it wants? This is the question facing transit agencies and transportation officials around the world: how do you compete with much-nimbler startups that have all of the goodwill and none of the obligations?

Learning from Los Angeles

Los Angeles makes for an interesting juxtaposition with Washington's travails, given Mayor Eric Garcetti's unflagging efforts to coax Angelenos out of their cars. Despite its recent declines in ridership, in November 2016, Metro[46] will ask voters to pass a half-cent sales tax increase that would raise as much as $120 billion for Los Angeles County transportation projects, including five new rail lines. Eager to reinvent itself as an organization closer to what Klein has in mind, in 2015 the LA Department of Transportation created

the role of a "transportation technology strategist" — a connected mobility czar tasked with charting the department's internal transformation.

Reporting to both LADOT general manager Seleta Reynolds and city CTO Peter Marx, the post was awarded to former Kansas City (Missouri) chief innovation officer Ashley Z. Hand. Many of her recommendations, published in August 2016, concern data — what to do with it, where to find more of it, and most important, how to train LADOT staff to make the best use of it. "If we don't do it, somebody else will," Reynolds said.[47]

Data is the shared obsession of transport officials around the world, as the rise of Uber, Google and their various competitors have underscored both how little they know about their cities compared to these entities with sensors in every pocket or mounted on every dash, and how little their staffs know what to do it with. In conversation after conversation, discussions of how to better use data became a proxy for how to accelerate internal change — with few concrete answers.

Some of Hand's suggestions along these lines are painfully, necessarily basic: inventory available data, make it easier to share and use within and across departments, dig deeper into what partners like Waze[48] and Xerox have already shared,

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[44] Stolberg and Fandos. "Washington Metro, 40 and Creaking, Stares at a Midlife Crisis."

[45] Freed, "Metro Chairman Tells Congress to Chip in $300 Million Per Year. Congress Yells at Metro."

[46] The Los Angeles County Metropolitan Transportation Authority.

[47] Seleta Reynolds, telephone interview with author.

[48] Hamilton, "Waze, L.A. to share data on traffic, hit-and-runs, kidnappings."

and add new capabilities to old platforms like ATSAC[49], the traffic management system built for the 1984 Summer Olympic Games. Others include re-assessing the technical skills required for new hires, cross-training staff across different agencies, including Metro and Caltrans, and contracting with on-call consultants to supply analytic capabilities the department lacks.

The difficulty in attracting, training, and retaining cutting-edge talent is one of public transport's steepest disadvantages in the face of disruption. "Most people would be shocked to learn just how far behind cities are when it comes to using technology," Reynolds said. "We don't have a 'data scientist' classification, and it would take us a year-and-a-half to create one — and then a civil service exam." Needless to say, that's not how startups function.

Partnerships will be crucial. Another of Hand's suggestions is to explore the feasibility of testing on-demand microtransit in neighborhoods seeking expanded bus service. LADOT already has a local, affordable, fixed-route service (albeit with low frequencies), but lacks the technical resources to execute microtransit on its own.

Faced with a similar dilemma, in March 2016 the Kansas City Area Transportation Authority (KCATA) partnered with the microtransit service Bridj to launch a one-year, $1.3 million pilot connecting several underserved neighborhoods with downtown. In this instance, KCATA

provides the strategic direction, funding, and unionized drivers, while Bridj supplies software and analytics while sharing data within tightly defined criteria. With this data in hand, the authority has been able to iterate service deployment, with one expansion of coverage already.[50]
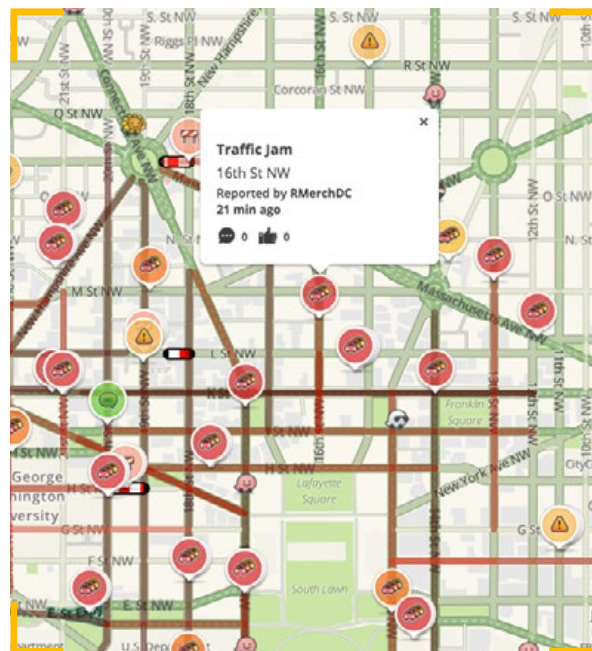

Photo above: Waze Application. © Waze.

Photo above: ATSAC. Flickr © LADOT.

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[49] Automated Traffic Safety and Control.

[50] Kansas City Area Transportation Authority. "RideKC: Bridj Expands Service to the River Market."

One of Hand's more intriguing proposals is the elimination of parking minimums for new residential developments, accompanied by relaxing the rules concerning "accessory dwelling units" and the conversion of garages into living spaces. If the rise of connected mobility increases the demand for alternative shared modes of transport, as many expect, it will in turn reduce the need for residential parking. Given that Los Angeles lags far behind on affordable housing units[51] while boasting an estimated 200 square miles of parking spaces, changing these requirements could lead to denser, more affordable[52] housing that is in turn more amenable to transit.
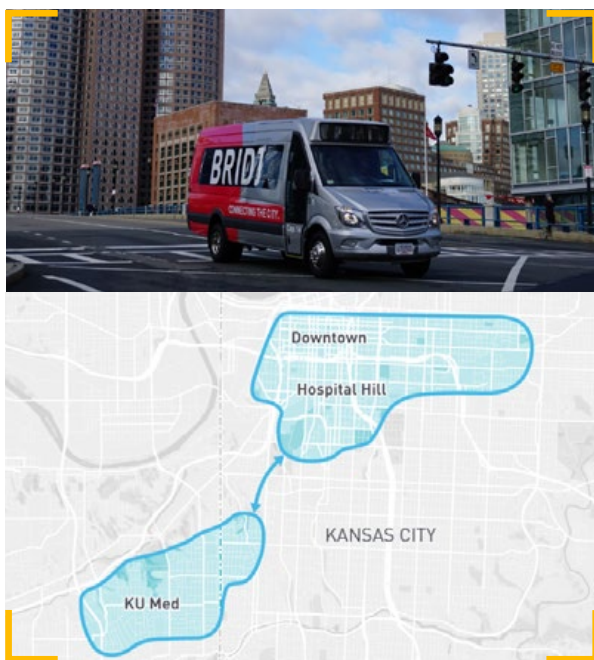

Photo above: Bridj - Kansas City. © Bridj

Connected Transit-Oriented Development

Back in Washington D.C., Klein pointed to transit-oriented redevelopments such as Columbia Heights[53] and Waterfront Station[54] as signature examples of catalyzing growth around Metro stops by pairing them with new modes such as bike-sharing and circulator buses. But more recently, a new pattern has emerged of what might be called "connected transit-oriented development."

One instance is a 45-unit building planned for 1326 Florida Avenue, Northeast, in Washington D.C.'s Trinidad neighborhood, where the nearest Metro is more than a mile away.[55] Developed by local firm Ditto Residential, the complex offers one- and two-bedroom apartments aimed at the city's influx of young residents. Building enough underground parking to meet the city's zoning requirements would have nearly doubled the $2,300 monthly rent for a two-bedroom.

Ditto appealed to DC Zoning for fewer spaces on the grounds that its intended residents were less likely to own cars. The city agreed, on the condition that it provided them with car-sharing or bike-sharing memberships for free, as well as a lobby TransitScreen with real-time updates on buses, trains, and available car2Gos. For its

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[51] Hand, "Urban Mobility in a Digital Age," 49.

[52] London and Williams-Derry, "Who Pays For Parking?"

[53] The District's first big-box retail hub within its borders.

[54] A Forest City/Vornado conversion of a former shopping mall into several million square feet of office and retail in addition to hundreds of housing units.

[55] Freed, "Amazon Prime and Uber Are Changing the Map of Your City."

next project at 301 Florida Ave — an eight-story building a block from a Metro stop — Ditto plans to forgo parking altogether in favor of bike racks, CaBi memberships, and even partially underwriting a nearby bike-sharing station.

It seems certain that developers will seek to increase the attractiveness of existing projects and unlock value from previously negligible sites using connected mobility. In May 2016, Uber announced a partnership[56] with the owners of Parkmerced — an 8,900-unit master-planned development on the edge of San Francisco — to supply car-free residents with a $100 monthly transportation stipend, $30 of which must be spent with Uber.[57] Given the state of the city's housing market, Parkmerced's developers are understandably eager to minimize parking to maximize developable land.

The newest addition to D.C.'s menagerie of connected mobility options hits the sidewalks in September 2016 — rolling delivery robots from Estonia's Starship Technologies.[58] New rules for testing delivery drones passed this summer by the city council again makes Washington a test bed for new technologies. And if Starship or its competitors succeed in lowering the cost of delivering groceries to less than a dollar per trip, how will they remake the city once more?

Photo above: Transit Screen. Flickr © Ted Eytan.

Photo above: Starship Technologies. © Starship Technologies

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[56] Salzberg, "Living Car-Free in the City."

[57] UberPOOL rides to nearby BART and MUNI stations are capped at $5.

[58] Fung, "It's official: Drone delivery is coming to D.C. in September."

Key Lessons

1 Transit agencies and transport authorities must reinvent themselves as entrepreneurial managers of an urban mobility system, rather than operators of a few primary modes.

2 The only way to achieve this will be through partnerships with adjacent jurisdictions and public-private partnerships. Agencies should take the initiative in creating these partners and maintaining a relentless focus on customers (and the customer relationship).

3 Internal transformation will be hard. (It always is.) Public transport should seek to leverage past investments as much as possible, draw upon outside expertise, and partner with interested parties to begin testing "microtransit" and other projects using pilots that do not detract from existing service.

4 Transport authorities should work closely with colleagues involved in land-use planning to understand the impacts of new mobility services on parking minimums, transit-oriented development, development patterns, and future transit investment.

Photo: Washington DC. Flickr © Daimon Eklund

London

In June 2016, Transport for London (TfL) updated its regulations for private hire drivers and vehicle license-holders, a category including traditional car services such as Addison Lee and TNCs — notably Uber. The list of changes included new insurance requirements, English-language proficiency for drivers, and the promise that passengers could call someone to complain. Most controversially, it also required private hire operators to disclose any changes to their business model before making them, including (but not limited to) payments, booking, and ride-sharing.[59]

Two months later, Uber sued.[60] By then, the battle lines had been drawn, with TfL, new London Mayor Sadiq Khan, and Addison Lee defending the regulations against Uber and its allies in the financial and technology sectors.[61] But the lawsuit was merely the culmination of a year-long struggle by London's mayors to make Uber play a productive role in the city's mobility mesh, rather than trying to disrupt it.

Any benefits the service once delivered in taking private cars off the road had long since been subsumed by its sheer number of drivers. The number of licensed private hires had mushroomed from 59,000 in 2010 to more than 110,000 by the middle of 2016.

Things were worse in central London's congestion pricing zone, where private hire vehicles are exempt from the toll. There, their numbers had soared from 448 in 2012 — when Uber arrived— to 13,151 three years later.[62] Congestion charges had removed roughly 60,000 cars from the roads since its introduction in 2003. In short order, Uber had put nearly a quarter of them back.

Unlike New York, where a thinly sourced report had concluded that TNCs weren't the problem,[63] London had the facts and a clear objective — to improve the quality of life through fewer cars and less road space. The mayor's critics in the tech sector didn't understand that, complained Isabel Dedring, deputy mayor for transport under Boris Johnson. "All of the externalities from something like Uber, they don't think about any of that stuff," she said last fall. "They see it as 16,000 more cars for consumer choice. No, that's 16,000 more cars clogging up the center!"[64]

This was the dilemma TfL has been wrestling with ever since — how do you disentangle disruptors from the rest of the system?

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[59] Transport for London, "Changes to private hire regulation."

[60] Hodges, "Uber Sues Over TfL Rules Making Drivers Take English Exams

[61] Murgia, "Businesses call on London mayor to rethink onerous Uber rules."

[62] *Ibid.*

[63] Fitzsimmons, "Uber Not to Blame for Rise in Manhattan Traffic Congestion, Report Says."

[64] Isabel Dedring, interview with author, London, October 14, 2015.

The Problem of the Adjacent Incumbent

That TfL found itself in this position was remarkable. Formed in 2000 by the Greater London Authority, the agency not only controls the Underground, the Overground, and the city's network of double-decker buses, but also many of the most important streets, congestion pricing, and oversight of black cabs, private hires and cycling. It long ago completed the transformation Washington D.C.'s Gabe Klein had envisioned, tendering the majority of its system to private operators. TfL seamlessly plans and manages the network, collects fares, and sets standards in exchange for covering any losses. Passengers are none the wiser.

TFL could also innovate. It had introduced integrated ticketing across most modes with the launch of the Oyster fare card in 2003. And when the costs of maintaining 40 million proprietary cards rose to consume 15% of fares, TfL partnered with the banks to create an open payments system around contactless bank cards and digital wallets like Apple Pay.[65]

It's also one of the best transit agencies at collecting, analyzing, and sharing its data. Working in tandem with researchers at MIT, its analysts had determined how to stitch together multimodal trip chains from a few taps of riders' Oysters. They had calculated real-time Tube congestion from the weight of cars at a handful of stations. But the more they learned, the more they understood how much data they didn't have.

Photo above: Black Cabs. Flickr © Sergio.

Photo above: Oyster Card Machine. Wikipedia © Romazur

Asked what new problem she would most like to solve, Lauren Sager Weinstein, TfL's head of analytics, thought for a moment. "At what point do people decide it's worth taking a car instead of the Tube or bus?" she said. In other words, could you pinpoint the moment someone gave up on public transport, and why? Was it crowded carriages? Delays? Inconveniently located stops and stations? Asked what she would need to know that, she replied: "When we don't see people on the network, for example, on the weekends, are they traveling? Do they stay home? Do

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[65] Walsh, "'Data helps us provide better transport': TfL on Oyster cards, big data and contactless payments."

they drive? What do they do when they *don't* take us?"[66]

Others might learn with TfL's help. The agency has liberally shared its data with more than 6,000 apps and services, eschewing its own in favor of meeting its customers wherever they are. This tradeoff means that TfL has little direct contact with passengers through their phones. Meanwhile, the London-based startup Citymapper has raised $40 million for a route-mapper and journey-planner built on the bedrock of TfL's real-time feeds.[67] But that only gets you so far, Citymapper CEO Azmat Yusuf explained. "Open transit data isn't sufficient for building a business."[68]

He'd invested heavily in tools for filling gaps and adding informal modes and paths left out of London's and other cities' official transport systems.[69] And he had no intention of telling them what they'd overlooked. TfL's data flowed into the app, but Citymapper's new-and-improved version did not flow back out again.

Meanwhile, Uber continuously collects data from drivers and passengers alike, even when the former are in between fares.[70] By contrast, London's black cab drivers long resisted accepting credit card payments — a change that will finally go into effect in October 2016.
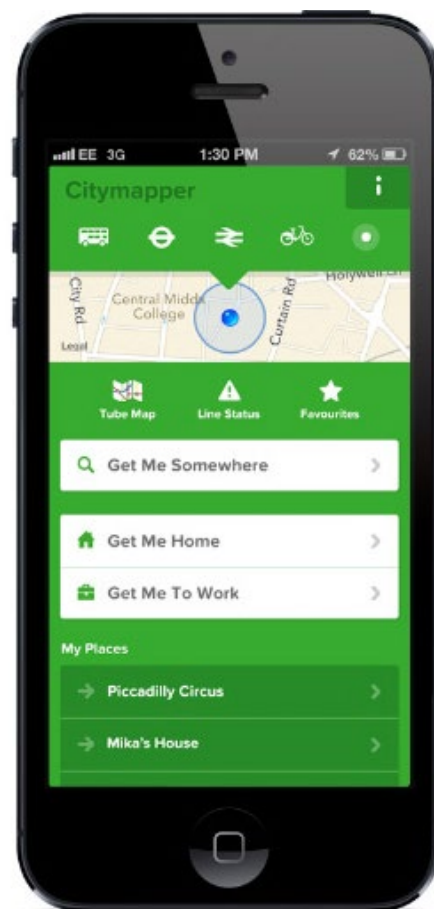

Photo above: Citymapper Blog. © Citymapper.

This difference is what TfL's head of business development, Matthew Hudson, had described earlier as "the overhead you pay for being a public body."[71] As private connected mobility companies grow in scope and scale, just how steep will this penalty become? Arup associate director and former Future Cities Catapult chief design officer Dan Hill has described this predicament as "the problem of the

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[66] Lauren Sager Weinstein, interview with the author.

[67] Lomas, "Urban Transport App Citymapper Snags $40M From Index, Benchmark, Yuri Milner, Others."

[68] Azmat Yusuf, interview with the author.

[69] See the Manila section for more on informal transport.

[70] Cassano, "How Uber Profits Even While Its Drivers Aren't Earning Money."

[71] Matthew Hudson, interview with the author.

adjacent incumbent."[72] "It could be that Uber, et al. seriously destabilise existing public transport agencies," he wrote, "simply by working an adjacent patch to them, mopping up bits of their business without having to work with their constraints like universal service."[73]

The question debated within TfL over private hire regulations might best be summarized as: how do you internalize the externalities would-be disruptors represent? Rather than banning them — or capping their numbers, or otherwise restricting them as many European cities and nations have done — how can they be folded back into the larger system? Just as TfL had transformed itself once before from a transport operator into a mobility manager, could it do so again, this time as a total network orchestrator?

Mobility-as-a-Service

In Washington, Klein had imagined a public transport app so compelling, Lyft would happily pay a cut for every ride sourced through that system. This is the aim of "mobility-as-a-service," a platform taking Klein's idea and incorporating every available transport mode — including bike-sharing, car-sharing, ride-hailing, and microtransit — as a solution to the adjacent incumbent problem. Although only a few such services have made it past the prototype stage, their proponents envision replacing single rides on single modes with all-you-can-eat monthly subscriptions modeled on streaming media services such as Netflix and Spotify.
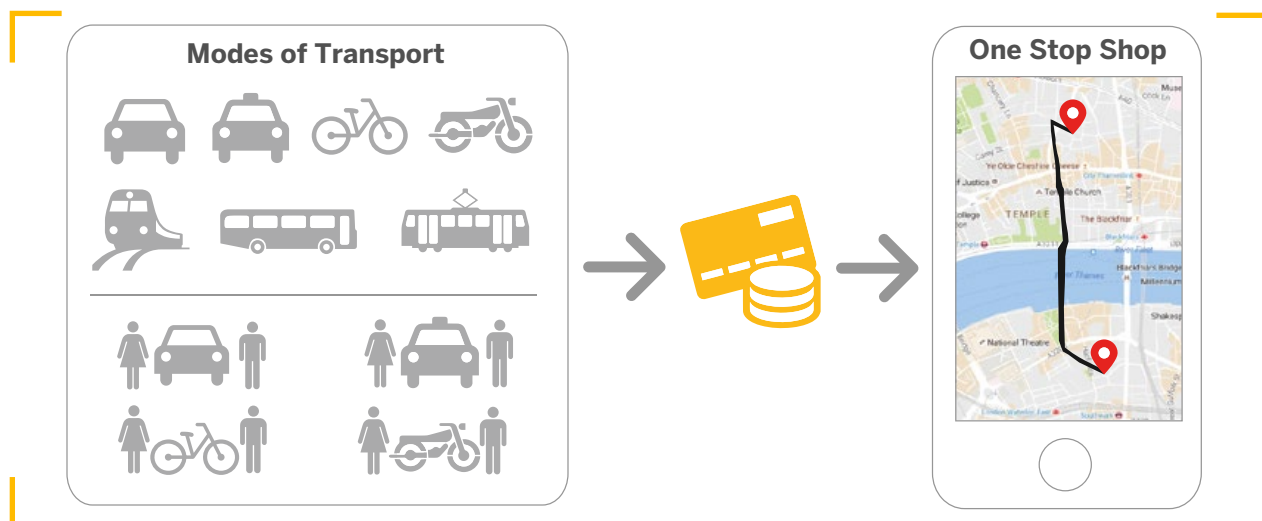
Above: Mobility-as-a-Service. © New Cities Foundation

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[72] Hill, "Essay: Clockwork City, Responsive City, Predictive City and Adjacent Incumbents."

[73] *Ibid*: "Here, we might describe universal service as the delivery of a consistent transport service at a consistent, affordable price to everyone in the city, irrespective of net worth or location… Transport for London, for example, has to deliver that, whilst innovating; Uber, for example, simply gets to pick off the low hanging fruit in the middle of town, moving freely as a 21st century mobility business, floating across taxi-likes, hire-cars, delivery services and ultimately minibuses and privately-owned cars generally. Essentially, given half a chance, Uber's trajectory will envelop most mobility in the city, not merely taxis."

Roughly a dozen MaaS-style systems exist, mostly in Europe, each with a different mix of modes, digital sophistication, and institutional integration. Their capabilities might include, in ascending order of complexity:

· An intermodal trip planner with real-time data about the location and availability of modes along each path;

· Integrated booking and payment mechanisms able to seamlessly access multiple ticketing systems while presenting users with a single fare;

· Personalized mobility packages bundling trains, buses, taxis, and so forth to help drive and shape demand;

· Predictive analytics to both anticipate users' preferences and to balance supply in the aggregate.

In addition to possessing some or all of these features, MaaS systems might usefully be sorted into top-down and bottom-up. Top-down efforts typically start with the interface — such as trip-planning features like Citymapper's — and drill downward, adding features and modes as they go. Bottom-up networks are more systematic, seeking to integrate a critical mass of partners and modes before launch, lest they disappoint users.

A top-down example is Daimler's Moovel Group, which operates MaaS-style services in Germany and the United States. In April 2016, the company integrated the Hamburg Transport Association into its app, not only giving local users the option to book and pay for public transport, but also pre-existing taxis (Flinkster; mytaxi); car-sharing (car2go), and intercity trains (Deutsche Bahn).[74] In May, Moovel North America (a merger of RideScout and GlobeSherpa) released a new version of Portland's TriMet Tickets app integrating car2go and Lyft.[75] Other examples include Xerox's Go LA and Go Denver apps in the United States, and the Berlin-based Ally.

Bottom-up systems include Hanover's "Mobility Shop," a joint partnership between local transport providers üstra and GVH (Greater Hanover Transport Association) to offer subscribers custom bundles of mobility options, with a single monthly bill. Although originally aimed at holders of annual transit passes, the newest version of the service includes a standalone plan incorporating heavily discounted car-sharing, taxi, and inter-city Deutsche Bahn pitched to car owners. Vienna's experimental SMILE platform combined Wiener Linien (Public Transport Vienna), Citybike, car2Go, and taxis with ÖBB (Austrian Railways) and a national charging network for electric cars.

But perhaps the most ambitious project is Whim, announced in Helsinki in June 2016 by parent company MaaS Global. Integrating public transport, taxis, and car-sharing at launch, Whim adds several wrinkles to the standard MaaS formula.

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[74] Moovel, "One-stop-shop for urban mobility in Hamburg."

[75] Moovel N.A. "moovel N.A. Launches RideTap Pilot in Portland, OR."

One is that Whim is a private, for-profit service working closely with – and not in competition with – public transit. MaaS Global founder and CEO Sampo Hietanen describes Whim as the first of potentially many "mobility operators" positioned between transport providers and subscribers, purchasing trips from the former at wholesale prices and repackaging them at retail for the latter.

Another difference is the all-you-can-eat model. To offer subscribers unlimited mobility, Whim will agree to assume the risk, betting that it can refine its predictive algorithms to the point where it can model on-demand usage efficiently enough to turn a profit on monthly packages priced between 300-600 Euros — less than the total cost of car ownership.

Finally, MaaS Global is already trying to define open APIs and network standards to guarantee interoperability across multiple cities and regions. Just as Nokia once built a multi-billion dollar mobile phone business on the back of standards it helped create and was first to deploy, MaaS Global hopes to do the same for a different type of mobility. To that end, it has formed the "MaaS Alliance," a public-private consortium including several universities, ministries from the Finnish and Swedish governments, Ericsson, Xerox, the International Railways Union, and Barcelona's Autoritat del Transport Metropolità.

As far as public transport is concerned, the logic of MaaS is simple: instead of competing with TNCs, outflank them by building a bigger and broader platform that is so compelling for partners and passengers alike, they'll eagerly opt-in. Because transit will most likely comprise the backbone of these services if not run them, MaaS operators would happily play along when it comes to policy. In a best-case scenario, freely sharing data between partners will lead to a rapidly evolving and improving system in which analytics wring the inefficiencies out of transit, making it more competitive versus other modes.
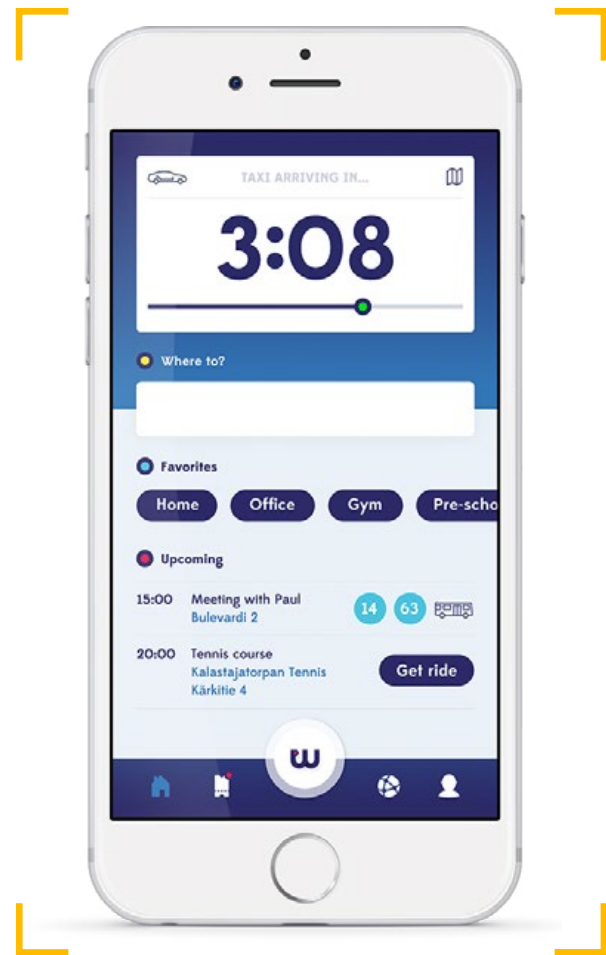

Photo above: Whim Application. © Maas Global - Whim.

Given this vision, it's safe to say many in public transport hope MaaS will prove to be the one-app-that-rules-them-all. It's even safer to say that many are skeptical that it can.

The first question is whether consumers even want mobility-as-a-service, or is this an answer in search of a question?[76] Data on this issue is understandably scarce, but one source comes from yet another pilot in Gothenburg, Sweden named UbiGo, which ran for six months starting in 2013. Half of the respondents in after-the-fact surveys reported using public transport more often while the service was active, and nearly half reported a decline in private vehicle usage. (Small sample size caveats apply.)[77]

Encouragingly, nearly four-in-five said they would be interested in becoming a regular customer if the service resumed, although responses from non-participants reveal the most common reason for declining was that UbiGo was more expensive than their current transport solutions.[78] Clearly, the pricing of these services will be critical in their reception.

Beyond costs to the consumer, there are obstacles at every turn. Simply integrating ticketing schemes at both a technological and institutional level have proven enormously difficult due to legacy costs, proprietary hardware, and differing jurisdictions. Aligning terms of service, resolving public service obligations, and determining passenger liability and customer service issues all need to be resolved before MaaS systems can scale.

Data may prove to be the biggest sticking point — will participants agree to share it?

If so: how much, with whom, and what data will they receive from the MaaS operator in return? Customer privacy, legal transparency, and open standards for data provisioning will all be crucial — and as of yet are still largely undefined.

Disputes over data and who controls the customer relationship may lead to the biggest competitive stumbling block, which is the refusal of key mobility providers to participate. TfL's Matthew Hudson argued that a truly open system would be irresistible to startups, as they could never achieve such scale on their own. This naturally assumes it's in their best interest to collectively benefit from network effects, but that isn't always the case.
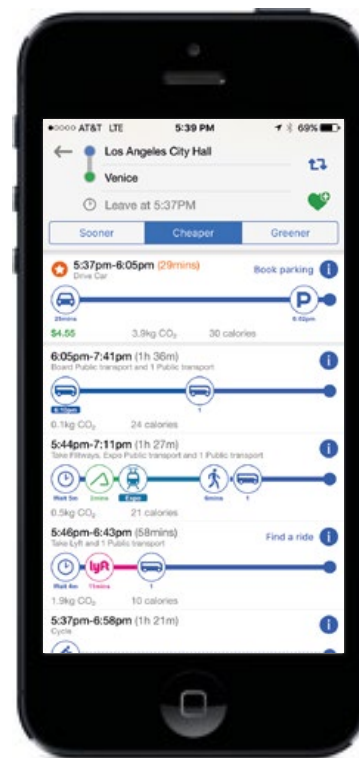

Photo above: Go LA Application. © Go LA.

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[76] With apologies to Cedric Price: "Technology is the answer… but what was the question?"

[77] Sochor, et al. "Travelers' Motives For Adopting A New, Innovative Travel Service."

[78] UbiGo intends to relaunch in 2016 with technical support from Ericsson.

In Los Angeles, for instance, Xerox originally sought participation from both Uber and Lyft in its Go LA app. Initially, both companies agreed to make their services visible within the app, albeit not simultaneously — users would have to toggle between one or the other. Even this ultimately proved to be too much for Uber, which withdrew shortly before launch. Wrangling partners unwilling to co-exist may prove difficult, especially when they are many times your size.

One solution might be to designate a third party to safeguard participants' data and to broker requests under the terms of service. The U.K.'s public-private mobility incubator, Transport Systems Catapult recommends the creation of a "data provider" role independent of the MaaS service and its partners.[79] In the SFMTA's Smart City Challenge proposal, the University of California Berkeley's Transportation Sustainability Research Center fulfills this function, responding to requests from the city and its partners and returning answers with the narrowest possible scope.[80]

The biggest threat to MaaS isn't Uber, but the transit agencies themselves. As Transport Systems Catapult noted in its report, officials may refuse to participate or fatally drag their feet on changing business models. The intense discussions at TfL suggest that even an agency of its size and sophistication may not be big enough to survive disruption. Embrace and extend may be the only way.

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[79] Datson, "Mobility As A Service: Exploring The Opportunity For Mobility As A Service In The UK."

[80] SFMTA. "City of San Francisco: Meeting the Smart City Challenge."

Key Lessons

① Use data to define metrics and set unambiguous policy goals. In London, the congestion pricing zone has made it both possible to track Uber's influence on the number of private hire vehicles and to galvanize a response from Transport for London.

② Not even TfL is large enough to internalize the costs of proprietary technologies, as it eventually discovered with the Oyster card. Industry consortia are needed to define open standards for payment, ticketing, ride-hailing, and other pieces of the software stack so as to more widely share the costs (and benefits) of their development.

③ Open data has proven to be an effective, low-cost method for seeding real-time scheduling and service disruption data in popular apps like Citymapper. But transit agencies should also work with partners (e.g. LADOT and Xerox) to receive at least a measure of trip planning and other user data in return.

④ Think carrots, not sticks when it comes to regulating TNCs and others. MaaS promises to create a platform so broad and so compelling that competitors will happily play along. Only by using all of the modes at their disposal, and in new combinations, can transit agencies internalize emerging threats as partners.

São Paulo

São Paulo commuters switching lines at rush hour between the Paulista and Consolação metro stations must endure what is locally known in Portuguese as the "march of the penguins." The phenomenon takes its name from passengers' involuntary shuffling from side-to-side as they slowly squeeze through the subterranean tunnel linking the stations. Once on the far side, many riders elect to sit for a while on the immaculate concrete platform, occasionally glancing up from their phones as crowds fruitlessly press against the doors of arriving trains. They're waiting for the peak to subside, wondering when it will finally be safe to board the train.

For decades, São Paulo has been slowly grinding to a halt. The military regime that ruled Brazil through the 1980s neglected public transport in favor of building highways gutting the urban core. For years, the percentage of overall trips has inevitably tilted in favor of cars. Today, the city's passenger rail system is less than half the size of London's or New York's despite serving a significantly larger area.[81] The results were predictable — São Paulo's average commute of 43 minutes was the world's second-highest in 2013,[82] while the World Bank estimated that congestion had cost the city USD $17.8 billion a year earlier, equal to nearly a percentage point of Brazil's GDP.[83]

Making the situation worse is São Paulo's structural and spatial inequality. Even after residents fled downtown, employers stayed behind — today, the core contains 17% of the city's jobs, but only 4% of the population.[84]

Photo Above: Rush hour at Estação da Luz . Breaking Borders © Walker Dawson

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[81] Biderman, "São Paulo's Urban Transport Infrastructure."

[82] Bevins, "The Sao Paulo commute: Walk, bus, train, train, train, bus, walk. Repeat."

[83] World Bank, "Changing Commuters' Choices Helps São Paulo Reduce Traffic Congestion."

[84] Holmes, "São Paulo Is Betting Better Urban Planning Can Solve a Housing Crisis."

Rural migrants have tended to settle in the south and east, leading to punishing multi-hour, multi-modal trips. Rush hours are a maelstrom, as epic numbers of commuters pass through the system in a massive peak.

All of this comes with a cost. Paulistanos earning the minimum monthly wage spend nearly a quarter of their incomes on commuting,[85] which explains why a $0.09 fare hike in June 2013 triggered protests that swelled into the millions and spread across the country, becoming a referendum on the high taxes Brazilians paid for abysmal public services.

Following the protests, the debate over transport switched focus to the policies of Mayor Fernando Haddad, a left-wing economist who pledged to "humanize" the megacity. His policies converted large swaths of roads into 250 miles of dedicated bicycling lanes.[86] Efforts to calm traffic and transform streets into public spaces succeeded in reducing air pollution and pedestrian deaths while earning the ire of drivers.[87]

But the real work of moving of the city is done by its buses. The failure of the metro to keep pace with the city's growth means that two-thirds of residents rely on SPTrans, including 175 km of BRT lanes that carry 3.5 million passengers daily — the busiest system in the world.[88] In April 2016, Haddad's administration announced it was seeking a $614 million loan to finance construction of another 150 km of bus lanes before his term ended later that year.[89] A 2030 master plan ratified in February calls for building thousands of affordable housing units along these corridors in an effort to lessen commutes through transit-oriented development.[90]

Photo above: Bicycle Lanes, São Paulo. Flickr © Dylan Passmore.

The decision to focus on BRT is a political as well as pragmatic one, as SPTrans controls the city's buses while the rail networks are administered by the state, whose current governor bitterly opposes Haddad's Workers Party.

The challenge facing the city and SPTrans isn't losing passengers to new mobility services — it has gridlocked streets, packed trains, *and* crowded buses — but whether it can use data to identify just enough savings and slack in the system to buy it time to add

[85] Ferdman, "Brazilians Spend as Much as 26 Percent of Their Income to Ride the Bus."

[86] Johnson and Jelmayer, "Mayor Fernando Haddad's Pro-Bike Push Polarizes São Paulo."

[87] Romero, "Fighting Resistance, a Mayor Strives to Ease Gridlock in a Brazilian Megacity."

[88] BRTData: Brazil.

[89] Pinho, "Haddad tenta empréstimo de R$ 2 bi para obras de mobilidade e drenagem."

[90] Cavalcanti, "São Paulo's new master plan prioritizes sustainable urban development."

capacity. The clock ticks faster as Haddad's prospects for re-election dim.

MobiLab: Faster, Cheaper, Better?

The person charged with creating that slack is Ciro Biderman, formerly chief of staff at SPTrans and now the head of innovation at SP Negocios, the city's business development arm. He's also the founder and director of MobiLab, a data laboratory started in 2014 in which teams of traffic engineers, students, and resident startups are invited to experiment with SPTrans' trove of more than 30 million data points arriving daily from fare cards and the buses' GPS units.[91]

Biderman had originally pitched the lab as part of the city government's commitment to transparency, but his ambitions were broader. Could small teams, using open transit data and open source tools, innovate faster and less expensively than the standard procurement process? Under SPTrans' current contract with Microsoft, for instance, the system is "outdated and very slow, and doesn't give us the information we want," he said in his office at SP Negocios. "Support costs [$610,000] per year for a closed system." Using MobiLab's methods, "I can have the information I want for half that, and you can do dozens of things with it."[92] Done right, he would end up with a virtuous circle, plowing the savings from each project into the next batch of experiments.

And what information did he want? "How much it costs me on each route," he replied. "I don't know that right now. And how much I get from each route — we know some are very, very profitable, and some aren't profitable at all. But I don't know which." With more precise data, he explained, SPTrans could dial down service on some routes during off hours and dial it up during peaks. It could redraw routes altogether, or crowdsource new ones — all in an attempt to wring additional capacity out of an overtaxed system.

Photo above: SPTrans, Trolleybus. Wikipedia © Rafael-CDHT.

Biderman and his team are playing at the margins of São Paulo's gridlock, but the margins might be all he needs. As it turns out, traffic congestion isn't linear. Using cellphone data, in 2013, a team of researchers at MIT found that canceling or delaying the trips of 1% of all drivers in Boston or San Francisco would reduce delays from congestion by only about 3% percent. But when they delved more deeply,

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[91] Zottis, "How technology can transform urban mobility: A Q&A with São Paulo's Ciro Biderman."

[92] Ciro Biderman, interview with the author.

they discovered that by shifting the peak by 1% in a handful of select neighborhoods and suburbs, you could reduce commutes across the entire network by 14-18%.[93] A similar experiment by Japanese researchers in 2009 revealed that by shifting slightly more — between 2-5% — they could reduce delays by as much as 35%.[94]

These savings have implications that go far beyond shorter commutes. "You have to size transit systems for the peak of the peak,"[95] said Hany Fam, president of MasterCard Enterprise Partnerships, which is working with C40 and cities including London and Chicago to implement what he calls "active demand management."[96] "The peak typically lasts 25-30 minutes in a 24-hour day," he continued. "If we can push 5-7% of commuters off that, this has the effect of pushing the [capital expense] curve out by two years." In a city like London or New York, he said, the savings on interest alone amounted to $150-$200 million per year.

And in cities that can't or won't make infrastructure investments immediately, like São Paulo, shifting the peak can provide critical breathing room. In observing this phenomenon, *Smart Cities* author Anthony

Townsend has provisionally coined Townsend's Law: "A ten-percent reduction in peak urban system load allows for twice as much growth to be accommodated at the same level of service and corresponding overall quality of life."[97] Seen in this light, MobiLab's projects act as a sort of urban acupuncture, searching for pressure points capable of alleviating stress across the entire system.

Soon, MobiLab may have a new storehouse of data to analyze — the granular details of every TNC trip taken in the megacity, the result of a regulatory scheme designed by Biderman and approved by Haddad in May 2016. The regulation stipulates that Uber and local rivals such as 99Taxis must agree to pay the city an average fee of $.03 per kilometer, which Biderman expects will raise around $11.5 million per year. Perhaps more important, the city will guarantee compliance by collecting its own origin and destination data from software embedded in drivers' phones — bypassing the need to ask Uber or any other TNC to share. "We need the trip details, otherwise, how can I charge them per kilometer?" Biderman asked rhetorically. Perhaps it might yield the pressure points he needs.

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[93] Wang, et al. "Understanding Road Usage Patterns in Urban Areas."

[94] Xing, et al. "Mitigation of expressway traffic congestion through transportation demand management with toll discount."

[95] Hany Fam, telephone interview with the author.

[96] MasterCard, "MasterCard and C40 Partner to Rally Megacities Around Sustainable Mobility."

[97] Townsend, "Peak City."

Key Lessons

Most public transport strategies focus on bolstering supply. But in financially- and capacity-constrained cities such as São Paulo, the most effective short-term solution may lie in managing demand. Using clear communication and carefully designed incentives, transit agencies should explore tactics for shifting or eliminating some trips.

Not all trips are equal. Academic research has demonstrated how managing demand in only a handful of areas can have systemic effects on surface congestion. Discovering and addressing these bottlenecks may offer the highest short-term ROI on collecting traffic data.

Transit agencies can't compete with Google or Uber when it comes to writing software, but they don't have to. Small teams addressing discrete problems with clear benefits can produce savings that more than justify the investment, setting the stage for the next round of experiments. Partner with universities, startups, and other departments to leverage talent and data.

The standard software procurement model is insufficient, if not broken. Agencies should embrace open standards, open data, and open source software — all of which require a greater up-front investment in building internal capacity, but in the long run offer a lower total cost of ownership.

SPTran's mutually satisfying proposal to regulate TNCs was the result of negotiating from a position of strength and taking the initiative. Cities should strive to do the same when confronted by future upstarts, neither capitulating to their demands – unless they offer concrete counter-proposals that hold the possibility of a win-win – nor indefinitely obstructing them.

Photo: São Paulo. Flickr © Marcelo Druck.

Manila

Rush hour in Manila at times resembles a scene from *Mad Max*. Weaving between the cars, taxis, motorcycles, and private buses are *jeepneys* — aging, gaudily decorated passenger jeeps seating twenty.[98] Festooned with chrome and painted with names like "Cold Fusion" and "Soldier of Fortune," the first were hacked together here 70 years ago. Their name is a portmanteau of "jeep" and "jitney," the latter referring to early automobiles repurposed as transit — a mode that has returned with a vengeance in the form of TNCs.[99]

Nearly half of Metro Manila's 24 million inhabitants take one of its 45,000 jeepneys daily,[100] more than double the number of passengers riding buses and trains.[101] That's changing rapidly, however, as Manila continues its economic and population boom. The addition of 6 million new residents since 2000, coupled with an emergent middle class, has led to an explosion in private vehicles — new car sales in the Philippines practically doubled between 2013 and 2015.[102] The logic is undeniable: why breathe a jeepney's black exhaust when one can opt for a comfortable, air-conditioned commute instead?

This line of thinking guarantees additional traffic. Cars presently account for less than a third of all passengers on Manila's roads, but comprise nearly three-quarters of congestion[103] — the world's worst, according to users of Waze.[104] That congestion carries a cost in lost time and productivity: $57 million a day, according to the Japan International Cooperation Agency, which predicts it may nearly triple by 2030.[105]

Photo above: Jeepneys. © Greg Lindsay

The challenge facing Manila and its jeepneys is a common one in cities where public transport is scarce or non-existent. First, a shadowy network of informal transit flourishes, followed inevitably by a surge in private cars.[106] Whether the cities and

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[98] Dancel, "End of the road for Manila's jeepneys."

[99] Kalanick, "Uber's plan to get more people into fewer cars."

[100] Sherielysse Reyes Bonifacio, interview with the author.

[101] Francisco, "Fixing traffic: Jeeps eyed as feeders to bus routes."

[102] *The Economist*, "Jam today."

[103] *Ibid.*

[104] Alba, "In The City With The World's Worst Traffic, Uber Is An Awkward Fit."

[105] Rodis, "Manila's traffic jams cost $57 million a day."

[106] Gao and Zielke, "A road map to the future for the auto industry."

vehicles in question are Nairobi (*matatus*), Mexico City (*pesero*), Mumbai (auto-rickshaws) or Bangkok (*songthaew*), informal transit has proven to be an unsustainable substitute for public transport when owning a car becomes an option.[107]

Complicating things further are land use patterns. Unlike Western cities' dense urban cores and outlying suburbs — or even the polycentric edge cities of mature suburbia —Manila exhibits a pattern known in urban geography as *desakota*. Coined from the Indonesian words meaning "village" and "city," the term describes the commingling of urban and rural settlements cheek-by-jowl.[108]

Desakota's fluctuating density and development (e.g. skyscrapers next to open fields) defies planning and hinders the efficacy of transit. For example, Jakarta's aggressive sprawl and congestion have outpaced the growth of the city's equally ambitious BRT system carrying 370,000 passengers daily over 129 miles along a dozen lines.[109]

In Metro Manila, desakota has made congestion worse by funneling the majority of traffic from residential enclaves in the north to the city's main business districts in the south along just a handful of trunk routes. Commuters must choose between riding a jeepney to an overcrowded train to *another* jeepney, or else drive or ride on a perpetually clogged highway.

Photo above: Manila. Wikipedia © Patrick Roque

The playbook in many cities (such as São Paulo) would call for digging more trains and building dedicated BRT lanes anyway. And that's exactly what the Philippines' Department of Transportation (DOTr) has called for. The job of designing such a system fell to assistant secretary for planning and finance Sherielysse Reyes "Booey" Bonifacio, who was tasked in 2014 with the impossible mission of restructuring the government's dysfunctional PPP on its most critical rail line while identifying the most promising bus corridors — all in just

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[107]Vidal,"'There is no escape': Nairobi's air pollution sparks Africa health warning."

[108] Moench and Gyawali, "Desakota: Reinterpreting the Urban-Rural Continuum."

[109] BRTData: Jakarta.

Photo above: Clogged Highways, Manila. © Greg Lindsay

two years[110]. The former is still tied up in the courts,[111] but Bonifacio and her team chose seventeen candidates for BRT.[112] Aquino approved one before leaving office.[113]

What role does connected mobility have to play in megacities like Manila, where institutions are weak, sprawl confounds transit, and efforts to build high-capacity systems have faltered? In these places, a rich mobility mesh already exists, but is invisible to most residents beyond a handful of local links. A third of the 100 largest cities in the world lack complete maps of their transit networks, including nearly all of the 25 largest low and low-middle income cities.[114] The simple ability to visualize these systems could be transformative for citizens and transport officials alike.

The challenge, then, is to understand these systems and use the resulting data to either reformat them as feeders to more formal modes such as BRT, or more audaciously, to make Metro Manila the front line for microtransit. Given mounting congestion, could a cleaner, safer, connected jeepney compete with owning a car? And if so, could algorithms chart a course through the city where planners could not?

Learning from Nairobi: Mapping Nairobi's Matatus

The answers to these questions begin in Nairobi, where matatus — fourteen-seat minibuses analogous to jeepneys — emerged to carry a third of the city's commuters after bus service collapsed in the 1990s.[115] In 2011, a team led by

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[110] Cupin, "Catch up: The DOTC's race to 2016."

[111] Camus, "Gov't buyout of MRT-3 dims."

[112] Francisco.

[113] Calica, "P-Noy OKs P4-B Manila-Quezon City bus rapid transit system."

[114] Krambeck, et al. "Completion Report Urban Transport and ICT Capacity Building."

[115] Klopp, "Cities in motion: how we mapped the matatus of Nairobi."

researchers from New York's Columbia University and the University of Nairobi resolved to definitively map the illegible network whose schedules are "in many, many heads, but fragmented," according to Columbia's Jacqueline Klopp.[116]

The "Digital Matatus" project employed a team of students riding matatus for months, taking care to log each of the city's 130 routes using smartphones and GPS units. The coordinates for each stop were translated into data compatible with the General Transit Feed Specification (GTFS). Originally developed by Google, GTFS has become the lingua franca of transit data thanks to the ease of integration with open source tools like Open Trip Planner and the ubiquity of Google Maps.[117]
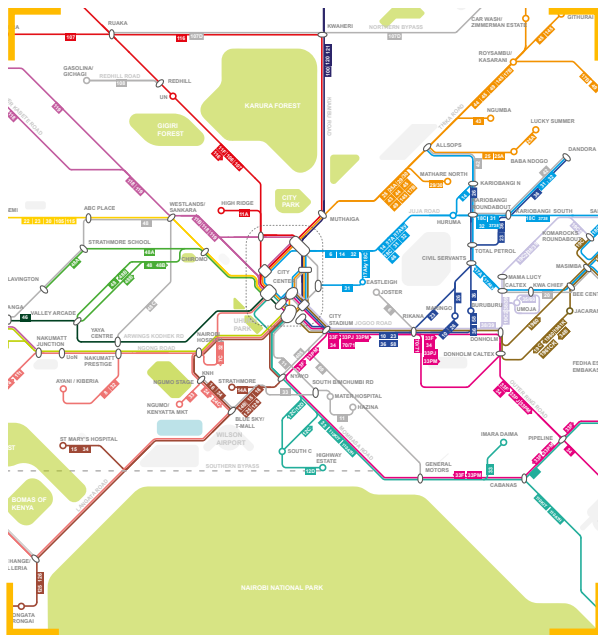
Above: Digital Matatus Project Map. © Digital Matatus

This data was used in turn to print maps, define routes, and spur interest in apps like Ma3Route — i.e. Waze for matatus. It also served to legitimize matatus in the eyes of government policymakers who had never incorporated them into official planning.

Mapping Manila's Jeepneys

The Nairobi project quickly caught the eye of researchers at the World Bank, who embarked on a similar project with DOTr in 2012 to trace Metro Manila's jeepneys. The Bank's team discovered no one had ever mapped the megacity's overlapping transit systems — despite jeepney routes being licensed. The reasons, they wrote in their report, were alternately cultural (would anyone use them?), institutional (five agencies couldn't agree on one database), technical (a lack of in-house expertise), and financial (no one would pay for it).[118]

What the Bank and DOTr found shocked them. There were more than twice as many jeepney routes as they expected — more than 900.[119] That helped explain the system's staggering redundancies — Manila jeepneys and buses drive six times as many passengers-per-kilometer as cities with comparable populations, such as New York and Beijing.[120] Working with partners like the Japanese International Cooperation Agency (JICA), DOTr used the data to help draft its new transport master plan, including the BRT corridors. One piece of that plan was to

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[116] Jacqueline Klopp, interview with the author.

[117] Canales, "Why Developing Cities Should Standardize and Open Their Transit Data."

[118] Krambeck, et al.

[119] Holly Krambeck, interview with the author.

[120] Krambeck, et al.

rationalize the number of jeepney and bus routes by nearly 90%, with a corresponding 23% decrease in greenhouse gas emissions, according to the Bank's estimates[121] — the equivalent of removing 105,000 cars from Manila's roads.[122]

All it would take is 20 billion pesos ($43 million), Bonifacio estimated, to purchase and retire its existing jeepney franchises. For less than half the cost of starting the city's first BRT route, the government could draw a new map and tender new routes linking neighborhoods to future train and bus lines.[123]

Integral to her plan was reinventing the jeepney itself. During the waning days of the Aquino administration, she and her staff were busily drafting the reference specification for a modernized version — one with windows, air-conditioning, seatbelts, doors, and less air pollution. When it was ready, they would solicit proposals from vehicle manufacturers with experience in the region (e.g. Kia, Tata, Isuzu).[124]

Local entrepreneurs weren't waiting. One of them was Congressman Sigfrido "Freddie" Tiñga, whose startup GET Philippines is marketing an American-made electric jeepney named the Comet. Rather than disrupt existing franchises, Tiñga intends to sell them his jeepney-as-a-service; in exchange for an upfront purchase of $35,000 to $40,000, GET will hire the drivers, collect fares and sell ads. He believes jeepneys aren't a bridge to BRT, but their replacement. "The world will best be served by these twenty-seat electric vehicles in a fleet-managed system," he predicts.[125]

Something is missing from both visions: data, software, and connections. In a city where Waze is ubiquitous and both Uber and Grab are wildly popular, the unquestioning assumption of fixed route-service is out of step with the capabilities of widely affordable smartphones. Rather than chain together trips to overcrowded trains and non-existent buses, what if a fleet of Tiñga's electric jeepneys permanently traced dynamic routes through the city, delivering riders just close enough to their destinations to satisfy all of them?[126]

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[121] *Ibid.*

[122] The Bank estimates GHGs would decline by 500,000 metric tons. According to the Environmental Protection Agency's GHG Equivalencies Calculator, a 500,000 metric ton reduction in Carbon Dioxide emissions is equivalent to removing 105,617 cars from the road. Calculator available at: https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

[123] Sherielysse Reyes Bonifacio, interview with the author.

[124] Bonifacio.

[125] Sigfrido Tiñga, telephone interview with the author.

[126] This is precisely what Tesla Motors CEO Elon Musk was alluding to in July 2016 when he published Tesla Motors' "Master Plan, Part Deux," which included his thoughts on buses: "With the advent of autonomy, it will probably make sense to shrink the size of buses and transition the role of bus driver to that of fleet manager… It would also take people all the way to their destination."

Photo above: The Comet. © Global Electric Transport. http://getevee.com/

It would also bring fledgling microtransit services such as Via and Bridj full circle. The Israeli founders of Via, for example, were inspired by *sherut* — Tel Aviv's answer to the jeepney. "One way to use our technology is to allow cities with large informal systems to centralize their jitney services and gain insight on how they're performing," said Zachary Wasserman, Via's vice president of strategy. "We're talking to people in South America and have had conversations in Africa about how our technology could upgrade jitneys and optimize them."[127]

Arguably the most important debate in connected mobility circles — one subsuming both TNCs and autonomous cars — is whether bits can ultimately substitute for atoms. Would Manila and its sister cities across the Global South be better off trying to leapfrog over BRT with algorithmic jeepneys? This is the flipside to arguing whether TNCs are undermining transit in the Global North — that is, for cities that lack strong systems, would their time

and energy be better spent yoking together the transport they have?

Is the Future "Stream Mobility"?

One answer to the leapfrogging question comes from São Paulo, where a logistics platform named Loggi has harnessed a growing fraction of the megacity's estimated 300,000 motorcycle messengers into a real-time, continuous delivery service. Its messengers rarely delivered their 8,000 daily packages from A to B; more often, they are asked to stop by C and D along the way. For the most part, Loggi substitutes algorithms for warehouses to keep goods moving in what co-founder and chief technical officer Arthur Debert described as "stream logistics."

Just as Global South cities had leapfrogged over fixed telephony in favor of mobile phones and voice-over-IP, so too, would they bypass centralized distribution networks in favor of decentralized intelligent

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[127] Zachary Wasserman, telephone interview with the author.

ones that were more flexible, supple, and resilient. "Brazil has totally missed the boat on traditional logistics," Debert explained. "We can't do a Fedex or UPS here. But we don't need it."[128] Neither would megacities in Southeast Asia or anyplace else where *desakota* is the norm.

Debert didn't think stream logistics would work everywhere, but he might be wrong. In 2015, Uber's Travis Kalanick outlined a feature named "Perpetual Trip"[129] amounting to an UberPOOL that never ended — or a jeepney ride. If Debert (and Kalanick) are correct, UPS-style hub-and-spoke mobility may be the equivalent of copper wire to every home — a once-transformative technology now too difficult and too expensive to install.
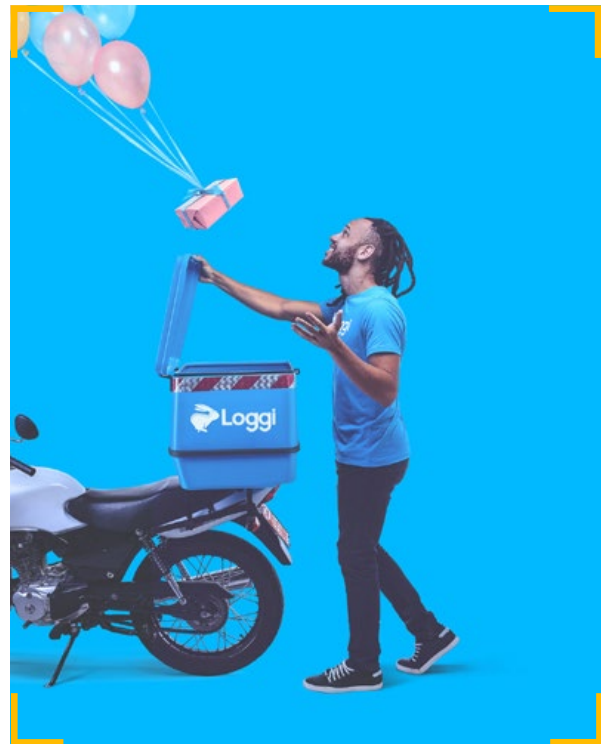

Photo above: Loggi Motorcycle. © Loggi.

[128] Arthur Debert, interview with the author.

[129] Buhr, "Lyft Line Gets Into Perpetual Ride Territory With Triple Match Service."

Key Lessons

1 In many cities, informal transit is transit. Public officials should recognize and better regulate these systems, either as part of a path to their replacement, or as the first step toward augmenting them.

2 Next, map these systems using open source data formats (e.g. GTFS) and software (TransitWand). Make these databases free and open for use in route-planning and other transportation apps. Visualize existing routes in the context of cities' larger transit networks.

3 Use these maps to rationalize existing systems for greater efficiency and accessibility by weeding out redundant routes and identifying underserved areas (if informal transit operators can be convinced to serve them).

4 "Microtransit" services such as Via and Bridj are essentially networked, algorithmically-guided transit. Transport officials in cities with a critical mass of informal transit should explore piloting microtransit services using jeepneys, dollar vans, matatus, etc.

5 Automotive OEMs may have an opportunity to create a new form of transit with six-to-twenty seats, depending on operating costs and local contexts. They should aggressively explore this niche ahead of potential competitors (e.g. Tesla Motors).

Recommendations

The second half of this report distills lessons from the four case-study cities presented above — as well as examples from Los Angeles, Helsinki, Singapore, Nairobi, and many more — to offer concrete recommendations for transit agencies, public transport authorities, city officials, and the private partners needed to make these proposals a reality. The following sections are divided into near-term, mid-term, and long-term goals; above all, public officials must learn to assert their role as the managers of an emerging connected mobility ecosystem. Doing so will require strong leadership from mayors, thoughtfully designed public-private partnerships, and most of all a commitment from within the organizations to re-imagine how they might provision urban mobility in the era of the smartphone — and whatever comes next.

Near-Term Strategies:

1 **Create a multi-disciplinary, multi-agency steering committee to reconnoiter new technologies, services, and socio-economic developments to explore and assess potential impacts on transportation service and policy.** "Horizon scanning" is a term used in strategic foresight groups to describe the systematic examination of new developments and weak signals to identify future risks, threats, opportunities, and responses. This analysis is then used to explore scenarios imagining potential impacts on the current landscape. Government bodies using this practice include the U.S. National Intelligence Council[130] and the U.K. Cabinet Office.[131]

If such an exercise had been held inside transit agencies in 2010, the advent of Uber, the mainstreaming of smartphones, and early bike-sharing successes might have pointed transport officials toward future developments in real-time GPS wayfinding. A similar exercise held today might take its cues from wearable technologies (e.g. HoloLens, Oculus Rift), augmented reality (Pokémon Go), and peer-to-peer networks (Ford Smart Mobility, Getaround) to imagine how a simple glance at cars in the street would reveal which are available for how much and how long. If so, what would the impacts be?

Transport authorities should create multi-disciplinary teams and higher-level steering committees comprised of multiple departments (e.g. ticketing, customer experience) and agencies (e.g. planning, zoning, parks, public health). Their job is to regularly scan the social and technological landscape for signs of disruption. The goal

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[130] U.S. National Intelligence Council, "Global Trends 2030: Alternative Worlds."

[131] U.K. Cabinet Office. "Horizon Scanning Programme Team."

isn't to "predict the future," but to build internal awareness and the capacity to respond more quickly to change.

A horizons steering committee could meet formally to exchange ideas and best practices, or consist of a more ad hoc group convening irregularly to debate. Ideally, there would be some combination of the two, with a task force of mid-level staffers from multiple agencies passing thoughts and recommendations to a senior group including external partners. Their insights would ultimately be channeled into design charrettes and similar exercises to concretely imagine future services and their impacts on operations and policy.

2 **Know what data you have, what data you need, and what you can do with it.** Data is the lifeblood of connected mobility. Understanding how well a city's moving, where it isn't, who has access, who doesn't — and why — is essential to building a more prosperous and equitable one. Simultaneously, the data collected by third parties ranging from the TNCs to Google and Waze to automakers and bike-sharing systems is unprecedented in its granularity. Sharing this data, making sense of it, and using it to inform decisions, planning, and pilots is an essential task for transport officials moving forward. They should think carefully about:

- **Taking an inventory** of the data they already have. What is it? How valuable is it? Who owns or manages it? And who has permission to use it?

- **Identifying useful datasets** compiled and controlled by other departments; creating

a centralized repository where all staff can find it.

- **Defining standards and templates** for documentation and sharing. Building APIs for sharing and querying.

- **Adopting open standards** for future data collection, such as GTFS and GBFS (Global Bikeshare Feed Specification).

- **Partnering with other departments**, agencies, governments, universities, and non-profits to leverage analytical capabilities.

- **Renegotiating the terms and conditions for sharing data** with commercial trip planners and other potentially valuable sources of data. Xerox, Moovel, Moovit, Citymapper and others have built businesses around real-time transit data. Agencies should require at least some degree of data sharing in turn, as LADOT does with Xerox.

- **Carefully defining** what data you desire (or require). Uber's data-sharing deal with the city of Boston was touted as the de facto industry standard when it was announced in January 2015. As the city quickly discovered, however, quarterly trip reports aggregated at the zipcode level isn't especially useful for planning. A better model might be Bridj's partnership with KCATA, which clearly defines what's to be shared, including: total trips; trips per hour; the number of passengers per hour per vehicle; the average number of stops, and average walking distance to and from the vehicles. In general, public officials should push hard for essential "breadcrumb" data

such as origins-and-destinations, vehicle miles traveled, and the cost of operations.

· **Disarming private mobility providers' concerns** about sharing data. Uber, Lyft, and other TNCs have been cagey about sharing data with regulators. Uber's data-sharing deal with Boston, for example, includes provisions forbidding the city from releasing its data in response to Freedom of Information Act requests[132], while Lyft shies away from such deals altogether. The SFMTA's Smart City plan proposes to solve such conflicts by storing this data with a trusted third party (i.e. the University of California Berkeley's Transportation Sustainability Research Center) that would only share data in response to specific queries[133]. It won't be that easy. According to Uber's own "Transparency Report," the company tried to negotiate a narrower scope in response to regulatory data requests in 79% of cases — and succeeded in more than half.[134]

3 **Cross-train staff across different skills, departments, and partners to bust silos, build capacity, and discover opportunities and savings.** A common refrain in interviews with public transport officials was the pressing need to upgrade the skills and talent of current staff while attracting new talent — tasks made difficult by public sector requirements. LADOT's Reynolds and the Philippines DOTr's Bonifacio had nearly identical laments about the bureaucratic

constraints on their ability to hire data scientists, forcing them to contract with consultants.

In addition to creating new multi-disciplinary leadership teams, it will be necessary to re-train staff in such necessary skills as data analysis and visualization, as well as cross-train them within other departments to better understand connected mobility's impact on land-use regulations, for example. Doing so will require an audit of expected and desirable skills for each position; creating internships, fellowships, and other opportunities to cross-train staff with universities and other partner institutions; and identifying which departments might fruitfully work together and how to share data and expertise relevant to both.

4 **Leverage, re-use, and repurpose physical assets and infrastructure.** Startups may have all the algorithms, universal brand awareness, and a seemingly inexhaustible stream of cash, but what they don't have is infrastructure — streets, sidewalks, parking, and curbspace, not to mention the rights to use them. Transit agencies must make better use of physical assets under their direct control — including the areas around stations — while transport authorities determine how to leverage the larger city to enhance connected mobility options and as a bargaining chip with potential partners.

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[132] City of Boston. "Boston/Uber Data Sharing Agreement."

[133] SFMTA.

[134] Uber. "Transparency Report."

A precedent already exists for parking. When Gabe Klein launched Zipcar in Washington D.C. in 2002, making spaces available in and around Metro stops required convincing reluctant public officials through the use of pilots.[135] Today, WMATA formally invites competitive bids from various car-sharing services for 170 spaces around 42 stations. One of the requirements is an equitable distribution throughout the network, rather than concentrating around the busiest stations.[136] Elsewhere, Seattle's Department of Transportation has made on-street parking available to car2Go's floating vehicle network in exchange for city-wide distribution. In these and other cases, access to parking became the means for securing equity in addition to revenue.

Parking is only the beginning. Given its financial difficulties, WMATA has begun experimenting with additional uses for stations, including a six-month pilot with the online grocer Peapod to make commuters' orders available for pickup at a handful of stations.[137] Transport operators should explore partnerships to enhance and expand services through the flexible re-use of space. And given the potential for a secular decline in parking, they should rethink the highest and best uses of their lots and how best to financially structure these arrangements.

For example, a McKinsey report commissioned at WMATA's request in April 2016 recommended offloading its parking assets to private developers.[138] But before engaging in straight asset sales, operators should solicit proposals from developers' potential re-use and greater value capture.

On the flipside, transport officials should think more broadly about leveraging public assets such as libraries, community centers, and city-owned buildings as nodes for connected mobility. LADOT is already pursuing the implementation of "integrated mobility hubs" at transit stations combining car-sharing, bike-sharing, and bicycle-parking with trip-planning and reservation kiosks.[139] Transport authorities should partner with other departments, municipalities, agencies, and communities to explore making similar hubs available on public land.

5 **Rethink commuter benefits strategies and car-pooling.** Most transit strategies overlook the incentives offered by employers at either end of commutes, which is typically free parking.[140] When these incentives change, however, so does their employees' behavior. After Panasonic moved its North American headquarters to downtown Newark, New Jersey in 2013, the company offered 50% discounts on transit

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[135] Klein, *Startup City*, 137-143

[136] Tsay, et al.

[137] Lazo, "Coming to a Metro station near you: grocery delivery."

[138] McKinsey, "Financial management and operational effectiveness Board Readout."

[139] LADOT Bike Blog. "Mobility Hubs in Los Angeles."

[140] TransitCenter and Frontier Group. "Subsidizing Congestion."

passes (the legal maximum), eliminated free parking, and briefed employees accordingly. Two years later, the share of solo commutes had fallen from 88% to 36%, cutting vehicle miles traveled in half, while the share of Panasonic's employees taking transit to and from work had soared from 4% to 57% — more than double the city's average.[141]

At the same time, the advent of connected mobility has the potential to transform carpooling. In 2015, Waze released an app in Israel pairing commuters with drivers heading in the same direction. Careful not to run afoul of local regulations, Waze limited drivers to two rush hour pickups daily. Driver compensation was limited to the legally defined cost of the ride, with Waze receiving a 15% commission. A year later, the company's parent Alphabet brought Waze Rider to the San Francisco Bay Area for a closed beta test involving as many as 25,000 commuters, including many belonging to other firms such as Wal-Mart and Adobe Systems. Interestingly, Alphabet has said it doesn't plan to vet drivers, relying instead on the trust of employers. Reportedly, the company's next step is to expand the service to include every Waze user in San Francisco — with no background checks.[142]

Waze wasn't the first, although its app offers cities and employers instant scale. In São Paulo, the carpooling service Caronetas boasts 50,000 monthly users drawn from 1,800 local employers. Drivers are paid in a virtual currency redeemable for goods and services from participating retailers.[143] In Seattle, a startup named Luum builds what are essentially private carpooling platforms on behalf of such clients as the Gates Foundation, for which it created the Commute Tool — an app guiding and rewarding employees who take sustainable modes of transportation.[144]

Cities should work with local employers to create their own carpooling and rewards networks, either as a single city or region-wide opt-in service for employers, or many such smaller networks and single firms. Used in combination with strategies and tools to incentivize commuting at off-peak hours, these programs would not only reduce vehicle miles traveled and congestion, but also provide cities with a powerful source of data — a miniature version of Waze — while steering new riders toward transit, and perhaps eventually to mobility-as-a-service platforms.

6 **Explore demand-shaping and peak-shifting through real-time incentives.** Much of the discussion around connected mobility has focused on increasing supply, whether through new modes, multimodal combinations, or greater efficiency. Less discussed, although potentially as powerful,

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[141] Jaffe, "How Panasonic Turned Car Commuters Into Transit Riders."

[142] Nicas, "Google Takes On Uber"

[143] Marcio Nigro, Skype interview with the author.

[144] Mackie, "Bill & Melinda Gates Foundation cuts solo driving with employee programs."

are opportunities to guide, shape, and curb demand. Big Data can't replace a metro, but MasterCard's Hany Fam asserts that flattening the peak by a few percentage points may save hundreds of millions of dollars in interest costs on deferred capital expenditures,[145] while Townsend's Law posits that a strategic ten-percent reduction of the peak allows for doubling growth within current constraints.[146] If they're correct, relatively small nudges in passenger behavior could yield outsized benefits for cities and commuters alike.

The best example of a win-win scenario may be Singapore Mass Rapid Transit's early bird program, launched in June 2013. Passengers leaving one of eighteen high-traffic stations before 7:45 AM on weekdays ride for free. Within the first year alone, transport officials estimated a 7% reduction in the peak.[147] MRT has since partnered with the Google-backed startup Urban Engines to create a commuter rewards program awarding points for trips at off-peak hours, redeemable for cash.[148] Elsewhere, Milan offers unlimited public transit on smoggy days for the cost of a single fare[149], while in Finland, the city of Turku offers €20 in free bus fares to drivers (and only drivers) applying for a new transit card, in hopes they might ride more often.[150]

As effective as these programs are, they're also relatively static. The introduction of transit apps with integrated way-finding, payment and ticketing creates the possibility of offering individual, real-time incentives in response to current system conditions. Service disruptions or acute congestion might prompt an offer for discounted travel on alternate lines or modes — or to wait an hour, after the peak passes. Similar offers could help rebalance the supply of such modes as bike-sharing or car-sharing by incentivizing riders where to park, thus reducing the need for manual rebalancing.[151] They'd also offer officials finer-grained policy tools than blanket subsidies.

In London, for example, Mayor Saddiq Khan's pledge to freeze fares will cost Transport for London an estimated £450 million to £1.9 billion in lost revenue over four years.[152] Perhaps a better approach would have been to raise the base fare while offering individual subsidies to qualifying riders — in effect using the fares paid by city bankers to underwrite their fellow passengers.

Transit agencies should explore creating their own rewards programs as a means for increasing ridership, collecting data,

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[145] Hany Fam.

[146] Townsend, "Peak City."

[147] Jaffe, "Singapore's Early Morning Free Transit Program Has Been a Huge Success."

[148] Land Transport Authority of Singapore. "Travel Early, Travel Free, Travel on the MRT."

[149] O'Sullivan, "Milan's Quick Fix for Bad Smog: Cheap Public Transportation."

[150] O'Sullivan, "A Finnish City Is Giving Drivers Free Fares to Take the Bus."

[151] Jaffe, "Balancing Bike-Share Stations Has Become a Serious Scientific Endeavor."

[152] *The Economist*, "Going underground."

and spurring passengers to reconsider traveling at peak hours. They should also study successful experiments in Singapore and elsewhere, partner with universities and private firms to study how incentives might enable peak-shifting and resource-rebalancing, and keep these capabilities in mind when evaluating whether to partner or build apps of their own.

Mid-Term Strategies

1 Create a "connected mobility lab" to assess and explore which technologies to buy, build, and share. It's a given that no transit agency should try to go head-to-head with deep pocketed startups when it comes to data analysis, software development, and user interface design. But many government bodies have notched successes in streamlining procurement, prototyping new features and services, and building capacity through the creation of internal "innovation teams" and labs separate from front-line staff. These teams take many forms and can serve many functions:

- São Paulo SPTrans' MobiLab resides within a single transport agency, tasking small development teams with specific problems — such as analyzing BRT data to identify traffic bottlenecks and suggest new or alternate routes.

- Bloomberg Philanthropies deploys external "innovation teams"[153] to act as big-picture consultants striving to solve intractable problems spanning multiple departments and silos.

- The U.S. General Services Administration's digital services consultancy, 18F, works with federal agencies to not only implement discrete projects, but also introduce more agile development methods and processes.[154]

All of these models are useful; so is the "living lab" approach adopted by Finland's Living Lab Bus Project, which makes the electric buses acquired by Helsinki Region Transport available to businesses looking to build and test features on top of them. A partnership comprising multiple cities, agencies, startups and the VTT Technical Research Center, which coordinates the project, the aim is to make public transport more appealing by making it a hardware platform for new services.

Cities and transit agencies should create connected mobility labs for all of these reasons, and also to lure talent from Google, Facebook, LinkedIn, and Twitter — all of which have lost staff to 18F.[155] Agencies should seek to leverage both local partners — as SPTrans' MobiLab does in working with universities and even high schools — and regional or even national funding streams.

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[153] Bloomberg Philanthropies, "Innovation Teams Solve Intractable Problems By Bringing Innovation To Life."

[154] Shueh, "The Case for 18F."

[155] Former SFMTA director of innovation Timothy Papandreou has suggested employees of TNCs will later find careers in transit agencies. Timothy Papandreou, telephone interview with the author.

(For example, Arlington, Virginia's Mobility Lab receives funding from Arlington County Commuter Services, U.S. DOT, Virginia DOT, and Virginia's Department of Rail and Public Transportation.) Those unable to secure such streams on their own should explore regional or even state-level partnerships to create and share a connected mobility lab more broadly.

2 Create a mobility-as-a-service (MaaS) roadmap. Former Washington DDOT director Gabe Klein said it best: "Whoever owns the customer is going to win." Transit agencies can't outrace deep-pocketed, well-managed startups such as Uber, and they can't out-scale them, either. Owning the customer in an era of smartphone-mediated mobility will require outflanking challengers instead. That will require bringing multiple modes to bear. Mobility-as-a-service represents the most comprehensive (if still-untested) approach toward creating a compelling customer proposition along these lines. The tradeoff is unprecedented complexity. In practice, creating a MaaS framework will require careful planning to coordinate the seamless integration of trip-planning, payment, and ticketing across a network of partners. Fortunately, there's value to be found in each of these steps along the way.

There are essentially two models for building a MaaS service: top-down and bottom-up. Top-down versions begin with an interface — usually a trip-planner — and add both features and modes as they evolve. Examples of this approach include CityMapper, Transit App, and Moovel. The latter has built white label apps for Hamburg and Portland (OR) offering booking and payment for taxis, trains (Deutsche Bahn), car-sharing (Flinkster, car2Go), and TNCs (Lyft). Xerox intends to do much the same with its Go LA and Go Denver apps, the former of which launched in early 2016 with a trip-planner capable of combining multiple public (buses, trains, bike-sharing), private (bicycles, cars, motorcycles), and shared modes (taxis, Zipcar, Lyft) into the fastest, cheapest, or most sustainable trips. The apps are free; Xerox's plan is to manage these "mobility marketplace" on behalf of the cities by taking a small percentage of each transaction.[156]

The best-known bottom-up example is MaaS Global's widely anticipated but still-in-beta service, Whim. Reflecting CEO Sampo Hietanen's belief that users would reject a half-baked offering, this approach marshals commitments from mobility providers before launch to offer customers packages tailored to their needs. The intent is to quickly build a critical mass of users (and data) enabling a profitable balance of supply and demand. To achieve scale beyond its launch market of Helsinki, a public-private "MaaS Alliance" will lobby to define open standards and dismantle regulatory barriers in hopes of establishing interoperability across Europe.

Practically speaking, most cities interested in MaaS must choose between working

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[156] David Cummins, telephone interview with the author.

with a white label development partner or allying themselves with a larger player like the MaaS Alliance. Either way, there are several principles they should follow in drafting their own mobility-as-a-service pilot:

• **Commission a trip-planning app to collect data.** Users of Xerox's Go LA, for example, may elect to share their anonymized searches with the company (and in turn LADOT). This data — the mobility equivalent of Google searches — may prove helpful in planning for future demand and service improvements.

• **Pay close attention to your partners' partners.** Many top-down services already have agreements with third-party providers, whether TransLoc's partnership with Uber, Moovel's sharing a corporate parent (Daimler) with car2Go, or Transit App's close integration with Motivate's Divvy bike-sharing system in Chicago. The advantages of these arrangements are obvious — plug-and-play providers and instant scale. But they also create possibilities for conflicts-of-interest and the potential for lock-in. Tranist agencies must take care to orchestrate their partner mix before their partners do it for them.

• **Avoid exclusivity.** Resist the temptation to work solely with a partner in any given mode, such as Google Maps' and Citymapper's defaulting to Uber for ride-sharing. Occasionally, this may be unavoidable. Uber withdrew its participation in Go LA shortly before

launch in evident discomfort at sharing the platform with Lyft. Transport officials should think carefully about the full size and scope of their broader mobility "ecosystems" and actively solicit partners to fill gaps or provide competition.

• **Use technology to drive deeper integration.** Xerox, Moovel and other white label developers aspire to provide ticketing and payment integration through the careful brokering of differing rate structures (single-use, daily, monthly, etc.), ticket media, and geography. While this can be useful, it's ultimately unsustainable. Transit agencies should use technology as a lever to pursue more systemic integrations. These services should serve as reasons to move forward, not a stopgap measure.

• **Carrots or sticks?** What happens if your partners decide they need you less than you need them? A mix of carrots and/or sticks will be necessary to create the critical mass of participants for a mobility-as-a-service system. But what will prove most convincing? The SFMTA's Smart City proposal suggests the carrot of making transit-only lanes available to partners to make their offerings more attractive. Another idea is to trade lanes for data. Yet another option — this one a stick — is to make their legal operation contingent upon participation, a strategy available only to officials who have successfully denied access to TNCs and others before now.

3 **Launch a microtransit pilot.** Unlike leading TNCs such as Uber and Didi, two of the standard-bearers for microtransit — Via and Bridj — have signaled their willingness to work closely with public transport. Bridj is well into its one-year pilot with KCATA to provide demand-responsive trips through its app aboard dedicated 14-seat Ford minibuses, while Via has partnered with Mercedes-Benz Research and Development to test a similar service in exurban Orange County, California.[157]

Using on-demand microtransit to extend and expand coverage in insufficiently dense areas is one of the biggest opportunities surrounding connected mobility. Transit agencies should seek to partner with microtransit providers at the earliest opportunity to begin testing service in interested communities.

In Kansas City, Bridj has worked with KCATA to overlay their pilot on top of neighborhoods with under-utilized fixed-route service. The partners hope to galvanize latent passenger demand while comparing Bridj's passenger-per-mile costs with existing routes. "We're demonstrating reduced bus costs by 80% and providing more service," Bridj CEO Matt George reported in May.

Meanwhile, LADOT transportation technology strategist Ashley Hand has recommended starting microtransit trials using the department's DASH circulator buses. The city would work with underserved neighborhoods to test coverage as a means of gauging demand for future fixed-route service.[158]

Partnering with firms willing to license their software and share data should be a no-brainer for transit agencies, which would struggle to build such capabilities on their own. But a number of questions and caveats remain. The most important is adequately balancing supply and demand. The original microtransit experiment — Helsinki's late, lamented Kutsuplus — failed in part because it tried to serve a hundred square kilometers with only 15 buses. The long distances required increased costs to unsustainable levels, while the correspondingly long response times depressed ridership.

Another issue is determining the appropriate vehicle size for such pilots, which, depending on whom you ask, ranges from six seats to twenty. Careful testing must be done in each market to determine what's needed to achieve breakeven passenger-per-mile costs. This is also a potential opportunity for automotive OEMs to introduce a new vehicle type optimized for this level of service, as Tesla's Elon Musk has vowed to do.[159]

Finally, both Bridj and Via provide service through their own branded smartphone apps. This not only raises questions around accessibility and equity — especially when testing service in lower-income neighborhoods — but also as to who will control the customer experience. Agencies

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[157] Heuer, "Building a seamless network."

[158] Hand, 58.

[159] Musk, "Master Plan, Part Deux."

should consider commissioning white-label versions of the app in the event of a successful pilot.

4 **Rethink informal transit.** What's now called "microtransit" is neither new nor novel. Manila's jeepneys, Nairobi's matatus, and even New York's "dollar vans" already carry hundreds of thousands of passengers daily.[160] In cities across the Global South, informal transit *is* transit. Rather than pursue policies to ultimately replace them, transport authorities should seek to legitimize and upgrade these fleets with an eye towards integration. In the short run, safer and more convenient jitneys may prove to be an alternative to auto ownership. In the longer run, 14 to 20-seat algorithmically-guided minibuses might prove to be ideal for navigating desakota-like land-use patterns.

First, focus on safety and regulatory compliance. In 2015, the Philippines passed the world's first national regulations for TNCs such as Grab and Uber. The rules require screening drivers, installing GPS, and banning vehicles more than seven years old — none of which currently apply to jeepneys. DOTr has drafted plans to phase out older jeepneys and extend financing to owners to help them buy new ones, but winning support has been difficult. (Drivers comprise a large and vocal voting bloc.)

Next, use open data standards and open-source software to map routes, stops, and schedules (assuming they exist) to produce an accurate map of a perhaps otherwise invisible system. As Digital Matatus, the World Bank/DOTr initiative, and other efforts have demonstrated, inexpensive projects to understand the true scope of these networks can have huge payoffs when it comes to revising transport policy. Although the GTFS standard isn't perfect, free, simple tools such as TransitWand (which is available for download through Github) make it easy to get started.

Once a map exists, the question becomes what to do with it. In both New York and Manila, many dollar vans and jeepneys ply the same heavily trafficked routes, bypassing underserved neighborhoods. Rationalizing routes and offering concessions as first-and-last-mile feeders to trains and buses may require some level of subsidy, but it could prove more sustainable for all parties in the long run.

An alternative is to convert informal transit into microtransit through a partnership similar to the one described above. In New York, for example, Via claims to make as many as 125,000 trips per week paying hourly wages to independent drivers with valid For-Hire Vehicles licenses. In theory, it would not be that difficult for cities that have adopted regulations for TNCs to create a similar program for jitneys.

5 **Rethink parking, zoning, and land-use policies.** Free parking is never free, especially for renters, who pay an average of $246 per month in Seattle and $225 nationwide to subsidize construction of their mandated parking spot — whether

[160] Goldwyn, "A Transit System Hiding in Plain Sight."

or not they own a car.[161] This trend has important consequences for cities worldwide, especially those struggling to build affordable housing with access to jobs and transit, such as São Paulo.

In 2012, researchers at New York University's Furman Center for Real Estate and Urban Policy found that parking minimums — i.e. the mandatory number of spaces defined by the city's 1961 zoning code — had artificially inflated the supply of spaces in New York City, and presumably elsewhere. A year later, newly elected mayor Bill de Blasio made affordable housing his signature initiative. One of his proposals, approved by New York's City Council in June 2016, is the creation of an outer-borough "transit zone" with a half-mile radius around subway stations in which off-street parking is no longer required for public, senior, or subsidized housing.[162]

New York is hardly alone in recognizing that parking minimums contribute to higher residential constructions costs, which lead in turn to higher rents. Cities must rethink land-use policies in the context of connected mobility, starting with parking. They should reduce, if not eliminate, parking minimums (or local equivalents), at least in areas designated for affordable housing or demonstrating a preference for transit and shared-use modes. São Paulo's master plan through 2030, which calls for concentrating growth along transit corridors, abolishes

parking minimums altogether — making it the world's first megacity to do so.[163]

Simultaneously, cities should reconsider minimum lot sizes and other restrictions on the repurposing and reuse of garages and parking spaces. For example, attached residential garages can be converted into accessory dwelling units (ADUs) to densify housing without significant new construction.[164]

For their part, commercial developers are eager to convert parking into more lucrative uses. Cities should at the very least codify standards and create programs encouraging developers to subsidize bike-sharing stations, transit passes, and mobility-as-a-service memberships in exchange for parking exemptions. And they should also consider the creation of "connected mobility zones" in which these exemptions would be the default.

Longer-Term Strategies

1 Transit agencies and transport authorities must rethink their roles as operators and reposition themselves as managers of an integrated urban mobility system. This message echoed in conversations from Los Angeles to London to Manila — if public transport bodies are to meet the challenges and opportunities posed by connected mobility, they must stop privileging individual

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[161] London and Williams-Derry.

[162] Miller, "This Map Shows Where de Blasio Wants to Reduce Parking Mandates."

[163] Benicchio, "São Paulo's Path to Sustainable Transport."

[164] Weeks, "San Francisco Supervisors reach agreement on accessory dwelling units."

modes and focus on outcomes. LADOT's list of measures includes quality, safety, security, convenience, sustainability, and affordability.[165]

This is easier said than done, of course. Local politics, labor contracts, and institutional inertia have all conspired to inhibit change, even within agencies possessing strong leadership and a broad remit, but there are models officials might follow. Transport for London, São Paulo's SPTrans, and the Seoul Development Institute all successfully overhauled their cities' bus networks more than a decade ago through holistic strategies combining institutional reform with innovative tendering, network restructuring, new technologies such as GPS-equipped vehicles and integrated ticketing, and dedicated infrastructure.[166]

One way forward might be to adapt these approaches for connected mobility, designing new systems marrying seamless coverage with maximum flexibility in tendering. Another is the mobility-as-a-service model advanced by Finland's MaaS Global, in which public transit operators (e.g. Helsinki Region Transport) supply services to private mobility platforms.

A more pressing question is: who should lead this transformation? Strong political support is a given, especially at the mayoral level. Internally, the shift from thinking modally to a more holistic view may require empowering ticketing and customer experience groups to lead the way toward a customer-centric offering. Leaders should also explore hiring designated change agents along the lines of the "transportation technology strategist" fellowship created for LADOT's Ashley Hand. Although such figures run the risk of marginalization, they can provide fresh perspective and a framework for where to begin.

2 Embrace connected mobility while bridging the digital divide. Smartphones are not, in fact, ubiquitous. Neither are credit cards and bank accounts. This isn't a problem for TNCs, nor for car-sharing, bike-sharing and other shared-use systems that aren't burdened with the duty to be universally accessible. As transit agencies experiment with digital wayfinding, trip-planning, and integrated payment and ticketing, they run the risk of making themselves opaque to many of the riders who depend on them the most.

"What I fear is that the legibility of the system becomes invisible to those don't have it or who fall out of the system," said Timothy Papandreou, the SFMTA's former director of innovation. Those without phones or credit cards or bank accounts — "How are they supposed to navigate this invisible terrain?"[167]

This problem is more pronounced in the Global South, where informal transit networks of jeepneys and matatus operate on a cash basis rather than farecards.

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[165] Hand, 20.

[166] Pai, et al. "Decision Making Process In Successful City-wide Bus Reforms."

[167] Papandreou.

Google's effort to create a contactless transit card for Nairobi named BebaPay has met with stiff resistance from drivers.[168] What was presented to the public as a means of reducing thefts and corruption has been received by the industry as another form of corruption — a transparent attempt by the government and its partners to disrupt their businesses.

Whether in San Francisco or Manila, transit agencies and their partners must chart a course to the future while guaranteeing access for the most vulnerable. A few commentators have half-seriously suggested underwriting smartphone ownership as part of transit subsidies.[169] But more likely, they will need to rethink baseline levels of redundancy, whether trip-planning kiosks at stations, basic farecards or tickets with QR codes, and consolidated call centers for users without smartphones. (Even Uber has begun taking requests by SMS message and by phone.)

③ Launch an autonomous vehicle pilot. In 2014, Zipcar founder Robin Chase asked whether a future of autonomous cars would be heaven or hell.[170] Heaven, she argued, would be a world in which autonomous vehicles are centrally managed, highly efficient taxi fleets.[171] Hell would be cars endlessly circling the block — because parking frequently costs money, while roads are free.

Chase's point was that autonomous vehicles won't happen in a vacuum. How they're deployed and who deploys them will be the product of public policies and private actors. Transport officials shouldn't wait to see if hell comes to pass, but must act swiftly to ensure autonomous vehicles are perceived and deployed as an extension of transit. Several cities, ranging from Singapore to Beverly Hills, have already announced plans or begun testing AVs as first-and-last-mile feeders to transit, while Daimler recently unveiled autonomous BRT.[172]

Assuming local regulations allow it, launching an AV pilot will require necessary funds, partners, and test beds. In the former's case, the race between cities, states, and nation-states to be seen on the cutting edge of mobility has created a groundswell of funding, including U.S. DOT's pledge of $4 billion over ten years to test connected and autonomous vehicles.[173]

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[168] Gettleman, "Transit Cards to Replace Cash on Kenyan Minibuses Are a Hard Sell."

[169] Anthony Townsend made a similar suggestion at the MIT Media Lab's "Disrupting Mobility" conference in November 2015.

[170] Chase, "Will a World of Driverless Cars Be Heaven or Hell?"

[171] Fagnant, et al. "Operations Of A Shared Autonomonous Vehicle Fleet For The Austin, Texas Market."

[172] Hammerschmidt, "Daimler demos semi-autonomous city bus."

[173] U.S. Department of Transportation. "Secretary Foxx Unveils President Obama's FY17 Budget Proposal of Nearly $4 Billion for Automated Vehicles and Announces DOT Initiatives to Accelerate Vehicle Safety Innovations."

While the most notable AV collaborations to date have paired automotive OEMs with TNCs (e.g. Toyota-Uber, GM-Lyft, Volkswagen-Gett, etc.) there are many more opportunities to partner with specialized players. For example, the open-source vehicle manufacturer Local Motors is exploring a collaboration with Florida's Miami-Dade County to test its artificially intelligent minibus, "Olli," on public roads.[174] The trickiest part will be structuring pilots in such a way that they are safe while testing operations under real-world conditions, and avoid raising issues around labor and automation. The latter is a sticking point — care must be taken to communicate with employees that such a pilot would be a learning exercise for future interactions with AVs, not a labor-saving measure.

The prospect of Chase's hell full of zero-occupancy vehicles also raises the specter of unintended consequences stemming from poor policies and a lack of regulation. Congestion pricing for AVs must be weighed carefully. As the veteran technologist George Gilder once observed of Google's power-hungry data centers, "in every era, the winning companies are those that waste what is abundant… in order to save what is scarce.[175]" It isn't hard to imagine how a near-future combining electric AVs with abundant solar energy, untolled roads, and minimal attention spans could pave the road to hell. Transport authorities should be forecasting potential impacts of autonomous vehicles as part of their regular horizon scanning.

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[174] IBM. "Local Motors Debuts "Olli", the First Self-driving Vehicle to Tap the Power of IBM Watson."

[175] Gilder, "The Information Factories."

Conclusion

This should be the best of times for public transportation. The ascendancy of the smartphone has finally made it possible to marry the ease and convenience of the automobile — through car-sharing, ride-hailing, and (someday) autonomous vehicles —with the reliable capacity of mass transit. As we've seen in the United States, this combination has already proven liberating for affluent urbanists, while providing newfound leverage for residents of suburbia and other less dense, transit-starved environments.

But as this report has argued, it's not enough to close one's eyes and wait for TNCs, technology companies, and other private mobility operators to remake the world in their image. Without leadership, relentless customer focus, the right combination of carrots and sticks, and a visceral understanding of connected mobility's implications, public transport runs the risk of fatal disruption — just as they did in the decades following the first flowering of private mobility.

The case studies and recommendations offered in this report are meant to demonstrate the new possibilities available to cities, public transport, and the public itself. The state-of-the-art in transportation isn't the smartphone, *per se*, but in how we use it. It's time for us to use it wisely.

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