# Re-Programming Mobility

# Trends & Signals Report

August 14, 2014

**NYU**Wagner
**rudin
center**
for transportation policy & management

*About the Re-Programming Mobility Project:*

# About This Report

These research notes are a compendium of trends and signals about the ongoing and future transformation of mobility in the United States as a growing wave of innovation employing digital technologies and services take hold between now and 2030.

These observations were collected as part of a comprehensive horizon scan of current debate over the nature and impact of these new technological innovations. Our analysis draws on hundreds of documents – research articles, case studies, news reports, and opinions and essays – produced by transportation experts, technology experts, journalists, and amateur observers. (A complete source bibliography is available at http://wagner.nyu.edu/rudincenter/2014/08/re-programming-mobility-a-bibliography-of-source-materials/). From these source materials we have identified many more new technologies, new scientific discoveries, forecasts and speculation, and emerging conflicts. Some of these documents helped us identify patterns in the emerging discourse and speculation around trends in transportation; others provided expert insights and recent research findings with major impacts for future cities.

These notes are organized according to four alternative future scenarios we are developing which will be published in early September 2014. They are intended as a sneak preview of the key themes of each scenario, a supplement to the scenarios themselves, as well as an informational resource for the research community.

# GROWTH

## technologies and services

Virtual currency offers safe carpooling for corporate employees. (RITA)

- "The primary innovation of Caronetas Caronas Inteligentes deals with informal carpool services in Brazil. Caronetas created a virtual currency that allows passengers to participate in carpool services without the need for exchanging (or carrying) cash. Caronetas also increases the trust level in the system by allowing only individuals with valid corporate email addresses to join the system. The virtual currency can also be used in stores and shops. Caronetas sells the service to Brazilian companies. Companies that opt in must authenticate their employees' email addresses to use the service, reducing concerns about safety of carpooling with other unknown passengers. The email certification allows people to ride-share within one company or across multiple companies that have been vetted and authorized employees to participate. More than 900 businesses in Brazil registered for the virtual currency carpooling service during Caronetas' first year of operation. Based on the model's initial success, Caronetas now plans to expand operations to Mexico and the United States."

Dynamic Eco-Lanes encourage drivers to use low emission vehicles. (RITA)

- "Dynamic Eco-Lanes: Dynamic Eco-Lanes are similar to current high-occupancy vehicle (HOV) lanes; however they would be optimized for the environment and encourage use by low emission, high occupancy, freight, transit, and alternative fuel or regular vehicles operating in eco-friendly ways (i.e., eco-speed limits, vehicle platooning). The Eco-Lanes application supports the operation of Dynamic Eco-Lanes including establishing Eco-Lanes criteria and defining or geo-fencing the Eco-Lanes boundaries. Eco-Lanes criteria may include the types of vehicles allowed in the Eco-Lanes, emissions criteria for entering the Eco-Lanes, number of lanes, and the start and end of the Eco-Lanes. The application also conveys pre-trip and en-route traveler information about  Dynamic Eco-Lanes to travelers. This includes information about criteria for vehicles to enter the Eco-Lanes, current and predictive traffic conditions in the Eco-Lanes, and geographic boundaries of the Eco-Lanes."

Vehicle-to-Vehicle communications make roads safer by alerting drivers of possible danger with other drivers. (RITA)

- "Potential V2V safety applications include safety warnings for drivers, such as:        -Emergency electronic brake lights warning -   Forward collision warning -Intersection movement assist warning -Blind spot warning       -Lane change warning -     Do not pass warning     -Control Loss Warning -Bus Driver Warning — vehicle making a right-turn-in-front- of-bus"

Vehicle-to-Infrastructure makes roads safer by alerting drivers of possible danger with highway infrastructure. (RITA)

- "Potential V2I Safety Applications crash scenario mitigation opportunities include:
  Intersection safety    Roadway departure prevention    Speed management    Transit safety and operations    Commercial vehicle enforcement and operations    At-grade rail crossing operations    Priority assignment for emergency vehicles"

Mercedes plans to integrate google glass into its automobiles. (Lavrinc)

- "direct-current battery charging stations of a"Door-to-Door Navigation" - Mercedes and Google Glass integration "I put the car in park, unplug the phone, and put Google Glass on my face. Within seconds, I've got step- by-step directions to a coffee shop down the street beamed directly to my eyeballs. This is what Mercedes-Benz has planned for the future, and not only do they have a functioning prototype, they're working with Google to make it a reality.... Jungwirth makes it clear that Mercedes has every intention of integrating some form of Google Glass functionality into its future products."

IndoorAtlas company allows customers to use phones to determine the exact location of desired products as they walk through stores. (Hardy)

- "A Finnish company called IndoorAtlas has figured out that all buildings have a unique magnetic "fingerprint" — and has solved how to use that to determine locations inside a structure to within six feet. That is enough to take a consumer to a product in a crowded supermarket, or figure out the location of, say, a half-dozen  workers in a building full of them. It's also much better than cell phone towers can do... shoppers can load their week's shopping into their phones, and get interior directions about where every product is located,  and how to efficiently walk through the store to get everything."

Long-haul trucking is transformed by intelligent tracking devices. (Janson)

- "Electronic On-Board Recorders (EOBRs) are transforming trucking by using intelligent systems to collect data and communicate in real time to ensure groceries arrive unspoiled, drivers are less fatigued, and highways are safer. EOBRs track driving hours, fuel-efficiency factors, location, and even events such as hard braking or the activation of a truck's trailer roll stability controls.... Three million truckers today still use paper log books, although it's widely acknowledged that information in driver log books is often less than truthful."

The new section of the San Francisco Bay Bridge is instrumented, and tunable (Rose)

- "Sensors allow for continuous monitoring of the bridge, and its structure can be adjusted for various loads and stresses. The bridge is robust, resilient, repairable, and responsive."

The Leap Transit shuttle service in San Francisco provides a transportation alternative, featuring Wi-Fi and a cashless payment app. (Sankin)

- "Boasting leather seats, Wi-Fi, a cashless payment system and comparatively fewer Epic Beard Men, San Francisco's Leap Transit is looking to provide a private alternative to the city's public transportation system."

StreetLight Data - big cell phone data analytics for site selection analysis (Leber)

- "The company, which aggregates and analyzes the signals from cell phones and dashboard GPS navigation systems, makes it easy for just about anyone to do what Schewel had long envisioned—see detailed maps of where, when, and how people travel through cities... With software that she and her team developed, Schewel can type in an address and find the demographics of the people who drive by or stop near that location. The system shows when they drive by, how frequently, and even what neighborhoods they're coming from. (Importantly, Schewel's algorithms analyze the movements of groups of these devices, rather than individual units. That means StreetLight's analytics can't be reverse-engineered to reveal any given individual's movements.)"

SchlauerParken uses light pole mounted sensors to measure parking availability, eliminating the need to put sensors in road bed.  (source)

T-Drive, a navigation service powered by machine learning from analysis of historical travel routes of 33,000 taxi drivers in Beijing over 3 month period (source)

CITYLOG's delivery system uses telematics to create the most traffic-friendly route. (source)

- "CITYLOG researchers conceived of a three-tiered telematics solution to optimize delivery routes. First, a pre-trip planning application maps the most traffic-friendly sequence for drivers to deliver their packages. On the road, a dynamic navigation application keeps the route up-to-date, altering it as necessary to reflect real-time changes in traffic conditions. A last-mile parcel tracking system then automatically sends customers a text message to inform them of imminent delivery. The idea is to have customers meet couriers at the door, minimizing the time that a truck has to be double-parked at the curb."

# forecasts

As a result of improved cell phone technology, consumers in the future will have an expectation of immediate gratification with their cars as well.  (Lev-Ram)

- "In an era in which consumers have become accustomed to regular, over-the-air updates and upgrades of their consumer electronics products, they'll expect the same kind of service from their cars."

Cars no longer hold the same appeal for teens as they once did. (Lev-Ram)

- "The car is no longer the gateway purchase to adulthood," says Sheryl Connelly, Ford's global trends and "futuring" expert."

Self-driving cars will eliminate most traffic stops by police (Sottek)

- "Forty-two percent of involuntary encounters with police in the United States happen in cars, and many of these encounters lead to searches."

Forum for the Future predicts four possible future mobility scenarios. (Forum for the Future)

- Planned-opolis: high energy costs dictate a strict planning regime and heavy investment in public transit
- Sprawl-ville: unplanned expansion and high energy costs isolate the poor and impose high mobility costs
- Renew-abad: transition to alternative energy allows for more distributed neighborhood-level hubs for energy and mobility networks
- Communi-city: sustainable, chaotic, lots of private modes of transport compete for road space

The first autonomous vehicles on the road will likely be long-haul trucks. (Geeting)

- "Even at $100,000 — the upper estimate of the Google car's autonomous platform — AVs will become cost-effective investments for certain business uses, like delivery vehicles, long before they become affordable for households. Ümit Özguner of Ohio State University's Center for Automotive Research told TechHive that the first AVs to hit the road would most likely be long-haul trucks."

Volvo plans test of putting a fleet of 100 autonomous vehicles on the road at once. (Geeting)

- "Volvo awake at night. The Swedish carmaker plans to do the world's first large-scale test of driverless cars in 2017, putting 100 on the road. For a venue, the company chose its native Gothenburg."

Self-driving cars will hit market starting in 2020 (Geeting)

- "Closely watched by the auto and insurance industries, the next-day headlines focused on a 2020 delivery date for driverless cars announced by Nissan executives and more uncertain timelines from other carmakers, notably GM."

Impact of self-driving cars will begins in 2030 (Geeting)

- "The driverless, or more accurately, self-driving car is widely predicted to revolutionize mobility by knocking humans out of the driver's seat as soon as 2030."

Planning for growth (RITA)

- "Vision: Imagine - Planning for growth patterns as if you could see complete traffic patterns around development."

Taxis will be gone by 2030, as autonomous vehicles will be able to beat them in price per mile. (Zmut et al)

- "(Taxis went out of business fairly quickly when aut-Vs could beat them in price per mile; a few remain, but, over the protest of driver unions, most cities stopped issuing new taxi medallions by 2024.) The more affluent use private aut-Vs to commute, but, for many people, the main purpose is errands or going out in the evening, for which they use shared aut-Vs."

Super-commuters will be early adopters of fully autonomous vehicles. (Zmut et al)

- "Finally, a third group, albeit the smallest, were the "super-commuters," people who did not mind driving 90 minutes or more each way when they could turn their vehicles into a true mobile office. Mobile devices allow them to carry work everywhere and seamlessly, from home to car to

office with almost no disruption in e-services. Early predictions that aut-Vs would allow people to live and work anywhere proved to be exaggerated, not unlike the dream that computers would eliminate paper."

The elderly will be early adopters of fully autonomous vehicles (Zmut et al)

- "The elderly made up another key group, seeing a chance to keep living the suburban dream even as their doctors revoked their driver's licenses. Aging baby boomers, now in their 70s and 80s, have been able to remain independent because loss of a driver's license no longer means relying on grown children or expensive taxis for rides."

Affluent teens will be early adopters of fully autonomous vehicles (Zmut et al)

- "A few key and fairly affluent groups were early adopters. First, parents bought them for their teenagers. Teen- agers still needed to get to school and work, and stricter licensing standards and stiffer penalties for texting while driving meant that fewer teenagers were driving themselves. By 2028, the percentage of 19-year-olds without a license passed 50 percent, continuing a trend that started in the early 2010s. A skill that used to be nearly universal—the ability to drive—is fading among this generation."

Even in the most optimistic scenarios, no more than 15% of vehicles will be fully autonomous by 2030. (Zmut et al)

- "Today, in 2030, about 15 percent of all vehicles are aut-Vs—enough to have changed, but not revolutionized, transportation. Some services have been transformed, especially in the cities, but the majority of Americans are still driving themselves and over similar distances."

Regulations will allow autonomous vehicles pushed by interest groups: elderly (AARP?), transit planners and operators, car mfgs (Zmut et al)

- "It was still nearly a decade before autonomous vehicles were allowed in most states because of insurance and licensing regulations. Many states with heavily urbanized populations were reluctant to change their regulations, especially after several early and heavily publicized crashes caused by malfunctioning sensors. In the late 2010s, autonomous vehicles—or aut-Vs, as they are now commonly known—were legal only in the sparsely populated western states. By 2022, however, more than half the states allowed aut-Vs on the roads, and the last holdout legalized them in 2026. Several groups were instrumental in pressuring states to legalize them. Advocacy groups representing the disabled and the elderly were the most vocal, pointing to the increased quality of life for people who would be able to travel independently, not to mention the cost savings of allowing people to live more easily at home. The auto manufacturers themselves pushed for them. Even transit agencies, which had concluded that some types of service could be provided more cheaply through aut-Vs than conventional transit, wanted to see them on the roads."

2030 self-driving penetration: no more than 5% of fleet (Zmud et al)

2030 is the threshold of self-driving vehicles (Zmud et al)

- "The share of autonomous vehicles (both partly and fully autonomous) remains very low (not more than 5 percent) in 2030, but the expectation has been that it will expand significantly in the 2030s and 2040s."

Advanced driver-assist vehicles will allow the elderly to keep driving later in life. (Zmud et al)

- "The "young elderly" (age 65–75) have continued to take work, shopping, and leisure trips by vehicle to the extent that they can afford, given the high cost of fuel and prevalence of road pricing... They purchase ADAS-equipped vehicles to drive longer and qualify for the steep discounts given by insurance companies."

90 percent of new vehicles will have advanced driver assist in 2030 (Zmud et al)
- "The share of new vehicles that have been equipped with ADASs has increased from 20 years ago, when only premium vehicles were equipped with ADASs, to nearly 90 percent of all new vehicles today. "

Metro areas will see a boom in transit use. (Zmud et al)

- "In most metro areas, transit agencies have responded by adding about 35 percent more miles of service than they provided in 2012."

Road pricing will rise to expand and maintain the system. (Zmud et al)

- "Road pricing will be prevalent as a source of needed revenues to maintain and expand the surface transportation system and as a disincentive to use the system, which will have caused tangible reductions in congestion."

The monitoring of cell phone data will increase. (Airsage) _____.

- "Employees are monitored in their places of work, and a new generation of planners will embrace big data for transportation planning "
- "The next generation of planner will no doubt embrace digital studies because they accept the credibility and cost of the new technology.""
- ""There's no question that cell phone data will replace all other surveys.""

Millennials will want more digital amenities in public transit (APTA)

- "Millennials would like to see in the next ten years:
  1. 61% more reliable systems,

  2) 55% real-time updates,

  3) 55% Wi-Fi or 3G/4G wherever they go,

  4) 44% a more user-friendly and intuitive travel experience.

  Fully leveraging technology, through real-time transit applications that connect users with community amenities, through smartphone fare payment, and the provision of WiFi and 3G/4G, will allow transit users to be more spontaneous, thus addressing the key competitive advantage of the car."

Growing senior 75+ driving population will become a growing safety risk (Shaheen et al)

- "In contrast, since the 1980s, older adults have increased the length of time they retain their driver's licenses. In 1983, 55% of people over 70 maintained a driver's license, but by 2008 that percentage increased to 78% (16). This increase in older drivers introduces a safety issue, as people over 75 have the highest collision fatality rate of 11.5 deaths per 100 million miles (16). Fewer than 10% of seniors walk, bike, or use public transit as their primary transportation mode."

Uber will not be a monopoly (Mims)

- "Unlike Apple and Google, which own much of the ecosystems on which their respective marketplaces are built, Uber doesn't own anything, other than its apps and dispatch service. That means Uber can only ever be a participant in a much larger and more diverse ecosystem — transportation — in which both drivers and riders can opt for the non-Uber option at any moment. I'm sure Uber has convinced its investors that its future includes myriad ways to both differentiate and dominate the market it's in, but getting from point A to point B is not, nor has it ever been, the kind of winner-take-all market that allowed Facebook to reach its current size."

In Germany 2005-2025, regional disparities in cost of living will drive weekend commuters (Feige)

- "Growing number of weekend commuters due to significant regional differences in the cost of living."

Passive tracking of drivers helps build and validate crowdsourced maps, like the one used by Telenav, the first ever based on OpenStreetMap (Quain)

- "Increasingly, however, mapmaking is becoming a more passive pursuit. Simply by driving, users are automatically submitting information over their phones about their routes and the roads they travel. It's the collection of such data that acts as a check on possible crowdsourcing errors."

Carshare fleets will need to be replaced far more often. (Plumer)

- "Cars might need to be replaced more frequently. If car-sharing became widespread, then driverless cars would be on the road and in motion far more often. This might mean cars would have a lifespan similar to that of police vehicles, about three to five years, rather than their current 11 years. It's hard to say what this would mean for energy use — cars could be upgraded more quickly as new technology became available — but it's another angle here."

Buildout of EV charging network will continue to be a chicken-and-egg issue as range increases only gradually. (Berg)

- "The availability of charging stations will likely become less important over time, as battery technology improves and range increases. Tesla's 265-mile range lithium-ion battery packs are leading the field, and the company is hoping to extend that dominance with a recently announced plan to invest about $5 billion between now and 2020 on a new battery factory. But for now, those longer-life batteries are expensive, and most electric or hybrid electric vehicles are limited to the much more modest ranges. 'Range will be an issue for a very long time, unless a miracle battery shows up that is safe and cost effective,' says Britta Gross, who heads the electric vehicle infrastructure program at General Motors. She says cost is why the battery in GM's $35,000

Chevrolet Volt only has a 38-mile range. Additional range would make the car more expensive than GM prefers."

Mandating the sharing of private mobility data with planners. (Shaheen and Christensen)

- "Central to the development of an intelligent transportation system is open data. To understand and monitor the complete network of available transportation modes, each modal provider must be willing to make their data available to an aggregator. The closer that data is to real time, the better for the system.
- While it is widely expected that the public sector will support open data policies, the private sector is generally more hesitant to share data. Many private-sector mobility providers see a competitive advantage in keeping data proprietary. This may be the case in certain situations, but there are many benefits associated with a private company opening its data: these include increasing system efficiency, expanding the market of users, fostering innovation ancillary to the service, and other benefits associated with transparency (e.g., emission and fuel-use reductions).

Google cars will have to slow down to deal with complex urban environments = limiting their use? (Markoff, May 29)

- "Recently at a press event held to showcase Google's research in self-driving vehicles, project leader Christopher Urmson said that the problems posed by driving on city streets are between 10 and 100 times more difficult than freeway driving. Robot vehicles confronted with other vehicles, pedestrians and bicyclists do seemingly random things, and the roadway can change at a moment's notice. By dramatically slowing the speed of its robot car – limiting it to 25 miles per hour – and by removing the human driver entirely, Google is attempting to simplify the problem as well as mitigate any damage that the machines might cause should they fail."

Self-driving cars will unlock land at fringes of metros for development (Romem, June 11, 2013)

- "self-driving cars will make locations beyond the current urban fringe feasible places to live. In fact, such locations will become at least as attractive as today's outermost suburbs as they will typically bundle lower housing costs with a shorter commute than is available at the urban fringe today."

Indoor tracking will power advances in asset management. (Hardy)

- "'The world is going to be incredibly optimized,' said Simon Thompson, the director of commercial relations at Esri, a company specializing in geospatial analysis. It already uses maps for predictive policing, forestry management and disaster preparedness. In the future, he said, 'indoor knowledge will become a resource. Hospitals will manage equipment better. Sports stadiums will know where to put the beer taps.'"

Self-driving cars will allow people to live further from work, because the commute will not interrupt people's days, as commuters are constantly connected to the internet. (deChant)

- "But self-driving cars could reverse that trend. As people's commutes are freed up for other tasks, including work, they'll stretch their daily trips, once again allowing them to live where they want. And as we've seen, people want to live where they have more space.[1] Compounding the problem

is the fact that most early adopters are likely to be wealthy, the same people Baum-Snow says will be looking to drive less."

Suburbs will be powered by sustainable energy and eco-friendly technology. (Romem)

- "Contrary to the intuition that associates rapidly advancing sprawl with environmental disaster, persistent progress in sustainable energy could ultimately dissociate the suburban lifestyle from the greenhouse gas emissions it implies today, severing an important link between sprawl and climate change."

Self-driving cars will drive exurban expansion. (Romem)

- "Cities will greatly expand, again: Faster and more efficient transportation will convert locations that are currently too remote for most users into feasible alternatives, abundant with space. Like suburban rail in the early twentieth century and the mass consumer automobile that followed, driverless cars will generate a gradual, but dramatic expansion of cities."

The use of self-driving cars will reconfigure parking. (Romem)

- "Buildings and parking will be uncoupled, freeing up valuable land: After dropping off passengers, driverless cars will independently seek parking (or their next car-share customers) and they will show up for the return ride at the tap of an app. As soon as driverless cars are common enough, the demand for adjacent parking will dwindle and parking lots in areas where land is sufficiently valuable will be ripe for conversion to other land use. As parking in high-value areas is thinned out or altogether purged, the micro-structure of cities will change – you guessed it – dramatically!"

Self-driving car sprawl will be driven by reduced opportunity, cost of time spent travelling, and also speed improvements through higher vehicle speeds and coordination of traffic. (Romem)

- "Driverless cars will make it less "costly" for people to travel a given geographic distance, partly because they will be free to engage in other activities while travelling, but primarily because of reductions in travel time. Unlike human drivers, autonomous vehicles will follow optimal routes given real-time traffic conditions without fail. More crucially, as soon as suitable roads such as freeways (or lanes thereof) are declared off limits to manual driving, driverless cars will travel – safely – at much higher speeds than we do today. Gains in efficiency will follow from coordinated traffic management protocols, too. Once vehicles communicate with each other traffic through intersections and merges will flow much more smoothly than permitted by today's traffic signals, stop signs and merging lanes, leading to substantial gains in travel time (a partial, human-mediated step in this direction is explored in this article)."

Expansion of cities will be tied directly to travel time reductions (Romem)

- "The extent to which cities expand will be determined by the extent to which travel times are reduced. The more efficient traffic flow becomes the broader the geographic range in which living and working becomes feasible."

Separated infrastructure more difficult but huge ROI. (Romem)

- "Most estimates suggest that the arrival of the fully self-driving car on the consumer market will occur within a decade. Provided that it will be possible to install these systems in existing

manually driven cars – much as hands-free cellphone devices can be installed today – then there will be no need to wait for the entire stock of cars to gradually be replaced, and a much faster process of adoption will ensue. The speed of the process will be determined by people's willingness to give up the driver's seat, and by the adaption of the legal environment, first to permit driverless cars and then to secure them an exclusive right of way (a separate lane on the freeway). Google and the automakers will go to great lengths to ensure that legal barriers are removed and that the driverless car is adopted quickly. The devotion of a separate right of way may be a more challenging feat, but it will be difficult to reject in light of the gains it will offer."

For decades, cities will undergo changes to their structure, as well as expansion. (Romem)

- "Following these developments, the gradual process of city expansion will take place over many decades, much as the ramifications of the mass consumer automobile continue to play out almost a century after its arrival."

Self-driving vehicles will transform the in-car social and productivity experience. (Alter)

- "The implications of the self-driving car become apparent when you watch this video. You see a kid alone in the car, you see a mom playing with her son. This changes everything about what the car does and how it is used.... Grandma isn't stuck in the house all day; the kids get driven to school and to soccer practice; mom can work while the car drives to the office. Parking lots and garages disappear as the cars are shared and always on the move. It's less Andrés Duany and more Woody Allen."

Shared autonomous vehicle networks will emerge around 2030 (Jaffe, February 13)

- "The big market question is when this world will begin to emerge. Levinson subscribes to a timeline in which autonomous cars enter the luxury market in 2020, the technology trickles down into the affordable mid-level range over the next several years, and by 2030 every car on the road is driverless. (Other cars would be banned a decade later.) Since car- and ride-sharing operations tend to rely on smaller cars, that would peg SAV networks closer to 2030 — about 16 years from now."

SAVs will be a cheaper option for low-demand transit corridors (Jaffe, February 13)

- "At the same time, SAVs might even represent an upgrade to existing transit service in many low-demand corridors. A few SAVs perched outside such neighborhoods might provide the area more cost-efficient and reliable service than a few buses running every half hour or hour."

SAVs will serve as feeders boosting transit ridership (Jaffe, February 13)

- "Could an SAV network perpetuate car travel so much that it eliminates public transportation? For sure, it means a greater reliance on roads and automobiles. But Kornhauser points out that an SAV network also has the potential to enhance transit ridership on existing commuter routes. After all, a convenient ride to and from the station could increase demand enough for transit agencies to run even more trains or buses."

Shared autonomous vehicles, metered by time/distance will encourage people to move closer together. (Jaffe, February 13)

- "Skeptics have also charged that autonomous cars will disrupt any city-based travel models, since people freed from the need to drive will move even farther away from the core. That might be true for people who own their autonomous cars, says University of Minnesota transport scholar David Levinson, but a strong sharing system could promote the opposite movement. "If you're paying for the car by the minute, then you're not going to want to move farther out," says Levinson. "You're going to want to move closer in.""

As transportation alternatives become cheaper and easier, car ownership could vanish. (Jaffe, Feb 13)

- "It's a game-changer," says autonomous car researcher Alain L. Kornhauser of Princeton University. "What I think is going to happen is that nobody will own a car. … If you can get [mobility] by the drink, you won't buy the bottle."

Self-driving shared cars will be pre-positioned in areas of high demand (Jaffe, Feb 13)

- "You wake up and get ready for work, and a few minutes before it's time to leave you press a button and order an SAV. The car has been strategically positioned to wait in high-demand areas, so you don't have to wait long. You might share the ride with a couple travelers just as you share an elevator, or perhaps pay a premium to ride alone."

A unified national mobile payment system will make payment hassle-free.  (Jaffe, August 12)

- "The long term goal is to make each person"s car into what Eden calls a ""mobile payment system."" That could take the form of something as simple as a windshield sticker, or be embedded into the vehicle"s frame. In such a scenario, it"s conceivable that transponders could act even more like credit cards — with fast food restaurants charging the car directly as it pulls into a drive--     thru, for instance."

GM is building a massive in-house app development capability. (Trop)

- "Over the next three to five years, G.M. plans to hire 4,400 workers for its information technology centers in the Detroit suburb of Warren as well as in Austin;; Roswell, Ga.;; and Chandler, Ariz. It will be the fastest-growing employee group within the nation's largest automaker, and about 1,200 of those employees will be recent college graduates, said a spokeswoman, Juli Huston-Rough. The hiring is part of Mr. Akerson's strategy to reduce sharply G.M.'s reliance on outside technology. The strategy carries risk, though, because G.M. must prove it can manage its own information more effectively than an outside firm can."

Solar energy will power transport needs in suburbia. (Byrd, et al)

- "The results indicate that low dense suburbia is not only the most efficient collector of solar energy but that enough excess electricity can be generated to power daily transport needs of suburbia and also contribute to peak daytime electrical loads in the city centre. This challenges conventional thinking that suburbia is energy inefficient. While a compact city may be more efficient for the internal combustion engine vehicles, a dispersed city is more efficient when distributed generation of electricity by PVs is the main energy source and EVs are the means of transport."

Automated parking ease of use. (Alan)

- "We wanted to illustrate what automated parking could do in the smallest possible footprint. But we also wanted to prove that you don't have to have trained industrial knowledge to use this system—everyday people, tenants, could use this system, like an ATM."

Automated parking seen as safer for women, and causing fewer accidents. (Alan)

- "The interesting thing, though, is that six of the eight units have single women, and the reason that they like it is because of the safety associated with the system. They never have to go down into a parking structure and worry about who's in there. When the garage door opens there are sensors in the load bay, and the door will not open if someone is in there. When the door opens, security is already cleared, and you can pull in. 42 percent of sexual assaults that are committed by someone you don't know—meaning not by family or acquaintances—occur in parking structures. 18 percent of insurance claims happen in parking structures, but not in Auto Parkit systems because there is no one in the system."

Automated parking can double the number of cars in same volume. (Alan)

- "So if you have a piece of property where you can park 100 cars, I can park 200. I do that by the diminishment of the drive aisles, turning radiuses, etc., but also volumetrically. Instead of having 10 to 11-foot floor-to-floors like you would in a traditional structure because of the concrete structure and the HVAC (heating, ventilation, and air-conditioning), I can pull them down as low as 6 foot 6 inches. Most cars are less than 5 feet tall, so I don't need the additional space, all I need to do is park the car. When you pull into the loading bay, I measure the car so when it goes into the system, I can put a compact car on a compact level and an oversized on an oversized level. Almost all parking is subterranean now in LA development. If you have to go 60 feet to get your envelope to do traditional parking, I can do it in 35 feet. I can do three levels of automated in two levels of traditional parking."

Automated parking will stimulate development and densification. (Alan)

- "If you have a site that's not profitable because you can't get the density you need because you can't park it, you need a solution."

Car users hire different models of "robotaxis," based on their individual needs. (Templeton)

- "If one can hire a cheap specialized "robotaxi" (or whistlecar) on demand when one has a special automotive need, car users can elect to purchase a vehicle only for their most common needs, rather than trying to meet almost all of them -- or to not purchase at all."

Self-driving cars can refuel in non-central locations, and do so more slowly. (Templeton)

- "A robocar or whistlecar will refuel/recharge itself after dropping of its passengers. Fueling/charging stations need not be conveniently located on major travel routes. Vehicles can travel a modest distance (vacant) to reach them. (As they do this, energy is wasted, but human time is not.) This allows slower and more expensive refueling systems, including pressurized gas refueling (hydrogen, LNG or even compressed air.)"

Self-driving cars allow for more rapid introduction of alternative fuels. (Templeton)

- "It also allows -- at an energy cost -- early adoption of new refueling technologies without having to put stations everywhere. As long as trips to stations do not require a significant or expensive

fraction of the vehicle's range, stations can be rare and still work. (The lack of suitable refueling infrastructure is often cited as the main barrier to several alternative fuel technologies, such as hydrogen.)"

Increase in popularity of small vehicles.(Templeton)

- "Single passenger vehicles will be much more common"

Robocars make full use of all paved surface for parking. (Templeton)

- "Robocars/Whistlecars can store themselves in many places HDVs cannot, such as at the entrances to driveways on city streets, since they can always accept a request to temporarily unblock the entrance. They can also make dynamic use of street-sides, if necessary taking up every lane but one during low traffic periods, but clearing out when traffic increases. It is not a problem to have robocars "double park" and even "triple park" as they will clear out on request."

Large venues may move outside of dense, urban areas for cheaper rent. (Templeton)

- "A "destination" retailer or service, such as a major department store or a big cinema may decide it does not gain much advantage from being in a central downtown. With little walk-in traffic, it may move to the outskirts for cheaper rent while still offering short travel times for customers or people going somewhere else in a CBD. This could result in "downtown sprawl." This is already a feature of many late 20th century towns (often suburbs who developed commercial bases) which have no pedestrian downtowns."

The creation of a grid of reversible one-way streets will improve travel conditions. (Templeton)

- "Robocars at high penetration also enable one-way streets and narrow streets. The "street" in a residential cul-du-sac may be a small narrow thing, safely shared with pedestrians and cyclists and children. Grids of one-way streets improve traffic flow and safety, and are much more acceptable to people in robocars. While getting to a particular point may require a small backtrack, it's all handled by the vehicle and the slight extra time is productive, and more than made up for by other improvements in the trip. Streets may also be reversed at rush hour to increase capacity."

New sharing economy services can self-regulate. (Sundararajan)

- "First, the government should recognize that the new peer-to-peer marketplaces have sophisticated controls naturally built in…. Likewise, government-mandated taxi fares and meters seem unnecessary when Uber, Lyft and Sidecar set uniform rates and track routes exactly using navigation technology."

Self-regulation of sharing economy will allow for rapid regulatory innovation. (Sundararajan)

- "Self-policing isn't a universal panacea. We'll still need government mandates to prevent effects like congestion, or for, say, providing accessible vehicles and ensuring disaster preparedness — things that markets don't easily self-provide. As we better understand the scope and sustainability of effective self-policing, and what new forms of oversight are needed, we should encourage the creation of a new class of self-regulatory organizations that set and enforce regulations for peer-to-peer sharing marketplaces, perhaps initially with some federal or state oversight. As hundreds of new peer-to-peer marketplaces emerge over the coming years, such organizations would ease

what would otherwise be a tremendous strain on the government's resources: having to constantly monitor and correct regulatory misalignment across an evolving set of industries. They could also inform the new oversight questions that emerge as these platforms reach mass-market scale, like the liability of ride-sharing platforms for accidents involving drivers between fare-paying rides, and whether residential zoning and noise laws should change when individual apartments become mixed-use real estate."

Insurance companies will require drivers to be tracked by sensors, software. (McCrum)

- "For now, the option is simply to have a little robot track your driving in return for a discount on your car insurance. The insurer learns how you drive, you quiet your boy racer instincts, and when it comes to working out what happened after a crash the electronic witness caught every squeal of rubber. Over time, as more and more drivers sign up, the premium for refusing a robot could become significant. Oh, you're the type of guy who doesn't want us to see how you hare around, are you? Young drivers facing very expensive insurance will lead the way."

Phases of robot car adoption (Morgan Stanley in McCrum)

- "now to 2016: passive autonomous driving To begin with, cars warn you if you drift out of lane, or if the driver shows signs of drowsiness. They turn the lights on when it's dark, the wipers when it rains, and help you park. 2015 to 2019: limited driver substitution sensors then start to help out in other, pro-safety ways. The car applies the brakes itself if the bus in front stops sharply. When you're in traffic, the robot takes over the job of moving slowly along in line. Perhaps they could do the motorway stint on long journeys, an advanced form of cruise control. 2018 to 2022: complete autonomous capability Phase 4: two decades, 100% autonomous penetration, utopian society"

Communication between self-driving vehicles will increase safety. (Neil)

- ""We're bullish on both technologies," Mr. Strickland said. "With V2I, cars we'll be able to see around the corner and nine blocks away. Vehicles will be able to predict scenarios and avoid them. They'll be able to deal with the chaos of traffic much faster than humans.""

Telecommuting continues to allow people to reduce/alter commuting patterns through 2025. (Levinson)

- "Getting every-other Friday off (the 5/4 schedule) became standard by 2015, establishing the 3-day weekend every other week as the norm. By 2020, this was every weekend, as people moved to a 9 hour day, 4 days per week at the office, and the other 4 hours were "at home" work – checking email on the long weekend, erasing once strict separation of home and work. By 2025 taking every-other Monday off (the 4/3 schedule) was established in most large employers. Today we are seeing half-days on Wednesdays for many office workers, with only Tuesdays, Wednesday, and Thursdays as interactive collaboration days. The "flipped" office, where people were expected to do "work" at home on their own computers, and only show up for meetings is now standard."

Office buildings converted to housing, driving down prices in suburb.

- "The empty office buildings across the landscape led to the famous Skyscraper Crash, the Real Estate Office – fueled recession of 2021. Many of those empty buildings were converted to apartments, as we had about twice as much office space as we needed with the new work

arrangements. Some cities were virtually abandoned by business in this process. This helped undercut new residential construction in the suburbs, and suburban land prices fell, attracting lower income immigrants, who subdivided large tract mansions into housing for large extended families, and leading to a measurable "white-flight" back to the center city. So while the suburbs were now less expensive, some actually gained population. Lower income residents still own cars, but not as many, and many a 2 and 3-car garage is being transformed into a workshop or small store." (Levinson)

Pilot project for suburban car sharing - demonstrate that a fleet of shared cars (about 700 serving 200 rail stations could be economically viable.

- "A private company puts up the cars to expand the market, a transit agency puts up some initial costs to increase ridership over time, and local businesses (or offices) pay to access the fleet during the day." (Jaffe on Steininger and Bachnera)

Private sector innovation / proliferation of mobility options undermines funding and support for transit, as well as union negotiating powers. (Roose)

- "The BART strike has shown how decades of erosion of the tax base, coupled with the rise of a tech-savvy elite that can afford to pay for private services, has reduced public transportation to a second-class alternative and taken away much of the subway unions' negotiating leverage."

Google begins manufacturing autonomous vehicles in 2018. (Lawler)

Uber provides data to Google to optimize autonomous car routing algorithms. (Lawler)

- "Uber announced its biggest bet on autonomous vehicles yet, saying it would purchase 2,500 driverless cars from Google. In addition, the two companies have agreed to a deal in which Uber will share data from its local transportation services with Google, which will use it to further improve its own autonomous car-routing algorithms."

Google cars serve as mesh wireless nodes. (Lawler)

- "Like previous Google models, each car acts as its own wireless base station, so that passengers can connect to the Internet through Google's WirelessGig service."

Fully driverless taxi fleets will be available for hire in 2023. (Lawler)

- "the GX3200 has been licensed for commercial use in several states — such as California, New York, Illinois, and Washington — Uber will be able to deploy the cars without drivers in several of its largest markets."

1st commercially available driverless Google cars hit road in 2017.

- "2017 — Google makes driverless cars commercially available, as Sergy Brin has predicted. This will just be in a few of the states that have shown openness to fostering the technology, like California, Nevada, Florida, and Michigan." (Mui)

In 2019-2020 car manufacturers enter marketplace for driverless cars.

- "2019 — The experience of early adopters demonstrates to regulators and mainstream buyers that the technology is safe and effective. More markets open; adoption speeds. Other automakers enter the market with their own offerings, increasing options and driving down prices for consumers.

Volvo jumps in early because safety is so central to its brand proposition—its stated corporate mission is to eliminate deaths in its new cars by 2020. Nissan beats its promise to offer affordable autonomous vehicles by 2020 by a year. Given its head start, however, Google remains the clear market leader." (Mui)

2021 sees major gains seen from modest penetration of semi-autonomous technology.

- "2021 — Adoption of semi-autonomous (such as GM and Mercedes' adaptive cruise control) and fully-autonomous vehicle technology reaches 16% market penetration, resulting in dramatic reduction in traffic congestion, congestion-related accidents and accident-related injuries" (Mui)

2022 - Google taxi service launches in San Francisco and Ann Arbor.

- "2022 — Initial success and early adoption of privately-owned driverless cars emboldens Google to launch its long-planned driverless car taxi service. The initial service offering is priced at half the cost-per-mile of private ownership—without the up-front cost. This leaves Google a healthy 30% of additional savings from which to reap its profits—plus the added revenue from its other products and services, like search and local advertising. Following the Google Fiber model, Google first launched in San Francisco, CA and Ann Arbor, MI with initial fleets of 2,000 cars. Tens of thousands of users sign up before launch." (Mui)

In 2023, a full scale deployment of 50,000 driverless cars hit the road in San Francisco.

- "2023 — Based on its pilots' initial success, Google announces that it will ramp up its San Francisco and Ann Arbor pilots to full-scale operation. An estimated 50,000 driverless cars are needed to serve those markets." (Mui)

In 2023 Google acquires Tesla. (Mui)

Cars move themselves to avoid parking tickets.  (Bilton)

- "parking tickets could become a rarity since cars would be smart enough to know where they are not supposed to be."

Urban real estate costs will fall as the elimination of parking garages opens up more space. (Bilton)

- "Some city planners expect that the cost of homes will fall as more space will become available in cities. If parking on city streets is reduced and other vehicles on roadways become smaller, homes and offices will take up that space. "

# conflicts

Car companies retooling as mobility providers (Lev-Ram)

- ""Our historic model has been 'Design, build, and sell vehicles,' " says Peter Kosak, executive director of GM's urban-mobility division. "Fleet maintenance, data and analytics, and ride sharing–these are not things that we've historically done.""

Shared AVs undermine parking subsidy constituencies (Geeting)

- "In theory, shared autonomous vehicles present an opportunity to undermine the political foundations of these secret parking taxes and other anti-density land use controls, and facilitate more plentiful construction of cheap, multi-family housing. But as Durning warns, even large shifts in transportation preferences won't make the parking subsidies vanish automatically."

Are car advances taking us forward to more progressive mobility and accesibilty frameworks, or back to traffic engineering. (Benfield)

- "Could this be a step not forward but back, to an era when the emphasis was all about moving as many cars as possible as quickly as possible, rather than on creating better environments for humans that don't rely so much on cars?"

Will AV's be a transit option for the public, or a privilege for the rich?

- "Unless automated vehicles are conceived as additions to public transit systems, they could become a privilege of the rich." (source)

AV's will change how we think about commuting, and have an impact on property values.

- "Moreover, driverless cars could shake the foundations of our economic and public policy structures, which depend on current property values, said Dena Belzer, president of Berkeley-based Strategic Economics, which specializes in real estate and urban and regional economics. Transportation is inextricably linked to land use and real estate value, she said, a lesson learned over decades as cars carried people to the suburbs while downtowns and center cities lost worth. "A big leap in technology will inevitably change how we think about certain locations." (source)

# COLLAPSE

## technology and services

MatNavi (Nairobi informal transport trip planning tool) uses cell phone data to improve the commute of drivers.

- "MatNavi takes cell phone data (volunteered through SMS or smartphone apps) and uses traffic flow modeling and simulation to inform matatu passengers of nearby routes and their destinations. It also informs drivers of traffic congestion, warning them to take alternate routes. Using a smartphone app, MatNavi users can view an entire route's information in a menu and can choose a particular route to view the approximate time and cost of each peak and off-peak hour of the day. The application locates a vehicle, checks its speed and traffic flow, and informs the commuter of the wait time." (source)

MobileEye creates $300 version of google's self-driving car (Markoff, May 27)

- "While the widely publicized Google car and other autonomous vehicles are festooned with cameras, radar and the laser range finders called lidars, this one is distinctive because of the simplicity and the relatively low cost of its system — just a few hundred dollars' worth of materials.... The Mobileye car does not offer the autonomy achieved by Google's engineers. By contrast, the Mobileye vehicle is capable only of driving in a single lane at freeway speeds, as well as identifying traffic lights and automatically slowing, stopping and then returning to highway speeds.

Oxford U. project hopes to cut cost of self-driving technology to £100. (Lee, Feb 14)

- "The Oxford RobotCar UK project self-driving vehicle system uses lasers and stereo cameras to dramatically lower the hardware costs. the system is designed to be trained by a human driver and after becoming familiar with the route and environment can take over the driving in "auto-drive mode" "At the moment, the complete system costs around £5,000 - but Prof Newman hopes that future models will bring the price of the technology down to as low as £100."

Drivers find in-vehicle heads-up displays that can show safety alerts delivered from V2I networks very confusing in Ann Arbor demonstration site. (Zax)

- "I brace myself as we approach, and something unusual happens: an alarm sounds from the dashboard, and an alert flashes in a corner of the rearview mirror. I realize the mirror doubles as a heads-up display — it shows a right-turn arrow against a blue background that suddenly turns red to warn of danger. Byrd, at the wheel, slows down."

Biometrics in the car that measure workload and manage distractions (various) (source)

Lit Motors C-1 - programmable electric motorcycle that is gyroscopically stabilized and allows owners to buy software upgrades that unlock new behaviors (like drifting) (source)

# forecasts

5 characteristics make for resilient informal transit systems.(de la Peña)

- "the highly distributed nature of informal transit can easily fulfill the five core characteristics of resilient systems: - Flexibility – The ability to adopt alternative strategies, especially when changing circumstances preclude returning to previous modes of operation. - Redundancy – Spare capacity to accommodate increasing demand or extreme pressure. Redundancy also concerns diversity and the ability to adopt alternative pathways and a variety of options. - Resourcefulness – The capacity to identify and act on problems, to establish priorities, and to mobilize resources and assets to achieve goals. - Safe Failure – The capacity of resilient network infrastructures to absorb shocks and cumulative effects of slow-onset challenges so as to avoid catastrophic failure if thresholds are exceeded. Resilient systems have built-in mechanisms that prevent failures from rippling across the whole network. - Responsiveness – The ability to re-organize and re-establish function and a sense of order following a failure. - Learning – The ability to use direct experience to self-organize, even if that experience includes elements of failure."

A Cambrian explosion of vehicle types is enabled by makers (Forum for the Future)

- "The whole city has become more informal, with crop- growing, temporary and creative use of space, self-planned settlements and open- source enabled mobility systems, and multiple road users in multiple vehicle types, all to be found right across the urban area."

Forum for the Future predicts four possible future mobility scenarios. (Forum for the Future)

- Planned-opolis: high energy costs dictate a strict planning regime and heavy investment in public transit -
- Sprawl-ville: unplanned expansion and high energy costs isolate the poor and impose high mobility costs -
- Renew-abad: transition to alternative energy allows for more distributed neighborhood-level hubs for energy and mobility networks -
- Communi-city: sustainable, chaotic, lots of private modes of transport compete for road space

AV taxi fleet for Manhattan 9000 vehicles, avg wait time 30-45 seconds cost reduced from $5/trip-mile to 50 cents/trip-mile (Burns et al) (Burns)

AVs will need to be contained and allocated to private/transit use (Geeting)

- "Well-defined rights of way will be crucial for the viability of autonomous transit because, like a gas expanding to fill whatever sized container it's given, AV traffic could otherwise inundate every space it's not specifically forbidden. As ever, the amount of public space allocated to different modes will depend on the relative status of their users. Will transit options continue to

win exclusive rights of way, or will an exodus of wealthy transit riders to drone taxis restore transit's stigma as the modal redoubt of low-income others, weakening its claim on precious street space?"

<ore shared cars does not mean less traffic (Geeting)

- "Even if the total number of vehicles dropped, more car sharing could mean more cars in motion at any given time."

The benefits of semi-automated vehicles will be limited. (Geeting)

- "In a world where shared-authority vehicles dominate the streets, all we really get are marginally safer highways and faster traffic speeds. Humans ultimately still pilot taxis and delivery trucks, and nothing jolts car ownership trends off their current path."

First large scale test of AVs will occur in Gotherberg, 2017 (Geeting)

- "Volvo awake at night. The Swedish carmaker plans to do the world's first large-scale test of driverless cars in 2017, putting 100 on the road. For a venue, the company chose its native Gothenburg. "

Autonomous vehicles add to overall VMT and congestion. (Zmut et al)

- "Affluent families hire multiple aut-Vs to ferry their children to school while they head to work, and the elderly have not curtailed their driving."

New designs for fully autonomous vehicles market niches. (Zmut et al)

- "The newest mobile-office vehicles now come equipped with in-vehicle web access, telepresence connections, and high-resolution display screens. Vehicles serving the elderly and disabled have low-floor entry, a medical emergency call button, and some basic bio-scan features so tele-nurses can continue getting the medical feeds they might routinely monitor."

Super-commuters will be early adopters of fully autonomous vehicles. (Zmut et al)

- "Finally, a third group, albeit the smallest, were the "super-commuters," people who did not mind driving 90 minutes or more each way when they could turn their vehicles into a true mobile office. Mobile devices allow them to carry work everywhere and seamlessly, from home to car to office with almost no disruption in e-services. Early predictions that aut-Vs would allow people to live and work anywhere proved to be exaggerated, not unlike the dream that computers would eliminate paper."

The elderly will be early adopters of fully autonomous vehicles. (Zmut et al)

- "The elderly made up another key group, seeing a chance to keep living the suburban dream even as their doctors revoked their driver's licenses. Aging baby boomers, now in their 70s and 80s, have been able to remain independent because loss of a driver's license no longer means relying on grown children or expensive taxis for rides."

Affluent teens will be early adopters of fully autonomous vehicles. (Zmut et al)

- "A few key and fairly affluent groups were early adopters. First, parents bought them for their teenagers. Teen- agers still needed to get to school and work, and stricter licensing standards and stiffer penalties for texting while driving meant that fewer teenagers were driving themselves. By

2028, the percentage of 19-year-olds without a license passed 50 percent, continuing a trend that started in the early 2010s. A skill that used to be nearly universal—the ability to drive—is fading among this generation."

Regulations will allow autonomous vehicles pushed by interest groups: elderly (AARP?), transit planners and operators, car mfgs (Zmut et al)

- "It was still nearly a decade before autonomous vehicles were allowed in most states because of insurance and licensing regulations. Many states with heavily urbanized populations were reluctant to change their regulations, especially after several early and heavily publicized crashes caused by malfunctioning sensors. In the late 2010s, autonomous vehicles—or aut-Vs, as they are now commonly known—were legal only in the sparsely populated western states. By 2022, however, more than half the states allowed aut-Vs on the roads, and the last holdout legalized them in 2026. Several groups were instrumental in pressuring states to legalize them. Advocacy groups representing the disabled and the elderly were the most vocal, pointing to the increased quality of life for people who would be able to travel independently, not to mention the cost savings of allowing people to live more easily at home. The auto manufacturers themselves pushed for them. Even transit agencies, which had concluded that some types of service could be provided more cheaply through aut-Vs than conventional transit, wanted to see them on the roads."

wildcard: self-driving cars hit the market much faster than anticipated (Zmut et al)

- "In 2016, an academic research team invented a solid-state phased-array sensor that worked just as well as earlier mechanically scanned lidar sensors but that could be manufactured at scale at a lower cost." "Autonomous vehicles have entered the mainstream by 2030, much more quickly than predicted, with about 15 percent of the fleet being autonomous. The key reason is a technological breakthrough that greatly reduced the cost of sensors. They have been judged safe, are legal for on-road use in all states, and have provoked several key changes in transportation."

better integration between vehicles and devices reduces the opportunity cost of congestion (Zmut et al)

- "Years ago, drivers might have been up in arms about increased congestion, but technologies have made it easier to be productive while stuck in traffic. Smart-phone capabilities have evolved, and most smart phones now communicate seamlessly and easily with almost any post-2020 vehicle. Like many offices, vehicles operate with a bring-your-own-device (BYOD) ethos, under which almost any smart phone works in almost any vehicle, so drivers are not buying expensive and quickly outdated in-vehicle systems. But they can talk on the phone and send texts while driving, thanks to vastly improved voice-recognition software. In-vehicle cameras and windshield displays even allow telepresence, so drivers can conduct in-vehicle meetings."

Growing senior 75+ driving population will become a growing safety risk (Shaheen et al)

- "In contrast, since the 1980s, older adults have increased the length of time they retain their driver's licenses. In 1983, 55% of people over 70 maintained a driver's license, but by 2008 that percentage increased to 78% (16). This increase in older drivers introduces a safety issue, as people over 75 have the highest collision fatality rate of 11.5 deaths per 100 million miles (16). Fewer than 10% of seniors walk, bike, or use public transit as their primary transportation mode."

People will anthropomorphize self-driving cars (Laursen)

- "That may give away another clue as to how people will respond to self-driving cars: They will anthropomorphize them. As Ruiz talked me through the other driver assistance systems, from advanced cruise control to parking assistance, he referred to them as "the guy." As in "the guy" does this and then "the guy" does that. The pieces of "the guy" are starting to fall into place. Now it is up to drivers to decide how to welcome him."

Semi-automated cars will keep drivers attention for some time (Laursen)

- "That sort of decision, to require constant attention on the part of the driver, will remain a feature of ADAS for some time, say people in the industry. There was no technical reason for the car not to return us to our lane over and over as we headed out of town, but Ford and others are very cautious about taking away so much control that a driver's attention might wander too far to return to the car when it is needed."

Automakers will differentiate cars by design of semi-auto features (Laursen)

- "Manufacturers will use those cars to gather real-world data on the trade-offs between different kinds of sensors and algorithms for driving the car. Any car you drive may "know" you are about to drift out of your lane, for example, but manufacturers will perhaps differentiate themselves by the way they warn you or how soon they take over."

More short-distance travel (Feige)

- "Relating all this to transport, we see that these developments mean an increase in particular in short-distance travel (rendered for example by a service provider to the customer or vice versa) and an increase in mileage covered in business and commercial transport."

Jevons-type rebound effect for driving - as it costs less (in terms of opportunity cost), will we use it to do more things? (Torbert and Herrschaft)

- "What if our driverless cars of the future have a valet mode that allows them to park themselves, becoming not just driverless but also passengerless? What if they run errands for us, such as picking up lunch or dry cleaning or the kids at soccer practice? What if driverless cars—and the efficiencies and flexibility they offer—actually incentivize us to drive more? This "rebound effect" could increase VMT and fuel consumption, eating into the potential energy savings we'd otherwise expect from highly efficient autonomous vehicles. We must be prepared to address these undesirable yet entirely possible outcomes."

AV's decrease risk of driving, and change public perceptions of road safety. (Burns)

- "With services like Maghicle enabling people to get around safely, affordably, conveniently, and sustainably, Sam does not have to worry about his wife or daughters getting into automobile accidents, as his parents worried about him."

Google cars may not be able to operate in snow by 2030, limiting their appeal to purchasers in snow-free zones of the US = Florida, urban California, Gulf Coast. (source)
- "Finally, there is a still photograph of a snow-covered avenue in which lane markings are entirely obliterated. This is a challenge Google has said it has not yet solved."

revenue from parking tickets will vanish in a world of automated parking payments (Bilton, July 9 2013)

- "the parking ticket could vanish from the future city as cars park themselves and refill parking meters electronically. (If there even are meters in the future.)"

As automated vehicles avoid traffic accidents, the auto insurance industry will see a major overhaul. (Romem June 11)

- "93 percent of all traffic accidents result from human error. If cars are smart enough to avoid accidents — and many researchers working on these cars believe they will be — the multibillion-dollar car

NIMBYists will resist densification through parking freed up by self-driving cars (Romem June 11)

- "The true barrier to densification within the built-up footprint stems from the opposition of local stakeholders, who influence land use planning through various means of civic engagement and effectively suppress densification."

value of connected cars will be generated through network effects (Yoshida)

- "the automotive industry is about to step into a brave new world where the network effect rules. The value of a car you just purchased might soon be determined, not by your car alone, but by how many others also have cars like yours....As Egil Juliussen, principal analyst, responsible for Infotainment and ADAS at IHS Automotive, put it in a recent interview with EE Times, cars of the future (V2V, V2I, and self-driving) will be "the first automotive product that depends on Metcalfe's law." "

Self-driving cars open up driving time and transform the in-car social and productivity experience. (Alter)

- "The implications of the self-driving car become apparent when you watch this video. You see a kid alone in the car, you see a mom playing with her son. This changes everything about what the car does and how it is used.... Grandma isn't stuck in the house all day; the kids get driven to school and to soccer practice; mom can work while the car drives to the office. Parking lots and garages disappear as the cars are shared and always on the move. It's less Andrés Duany and more Woody Allen."

connected vehicles being developed in Ann Arbor are more important in mid-term than autonomous vehicles (Zax)

- "Many have heard by now of high-profile research into autonomous cars that can drive themselves by using fancy sensors to detect their surroundings. The automotive revolution we're likely to see sooner, say experts here in Michigan, may not come from cars that sense but from cars that talk."

Planning processes and institutions are not as adaptable as new technology (Rose)

- "Resilient, responsive, and adaptable transportation technologies are rapidly evolving. Technology is not a constraint, but our rigid ways of planning, designing, building, operating, and funding transit systems can be. Too often, transport agencies are bound by rigid federal, state, and local regulations that limit their integration with other city services and objectives — preventing them from responding more effectively to rapidly changing climate, economic, housing, and work patterns."

Automated cars dramatically increase the mobility of children. (Templeton)

- "Robocars could take children to school without burdening the parents, allowing easy attendance of remote schools -- even including play visits to friends from that school who live far away. Similarly robocars could take children to soccer matches and other activities, or take children and parents together to parks, play dates and play spaces. In theory, a child might live on a farm and still participate in school, play and events like an urban child. Will parents push in this direction, or will they prefer pleasant urban spaces with more walking?"

obstacle to densification - self-driving cars will improve freeway traffic, but not necessarily surface streets (Arieff)

private sector innovation / proliferation of mobility options undermines funding and support for transit, as well as union negotiating powers (Roose)

- "The BART strike has shown how decades of erosion of the tax base, coupled with the rise of a tech-savvy elite that can afford to pay for private services, has reduced public transportation to a second-class alternative and taken away much of the subway unions' negotiating leverage."

Future cities will not be congestion-free.  (Bilton)

- "The future city is not going to be a congestion-free environment. That same prediction was made that cars would free cities from the congestion of horses on the street," said Bryant Walker Smith, a fellow at the Center for Internet and Society at Stanford Law School and a member of the Center for Automotive Research at Stanford. "You have to build the sewer system to accommodate the breaks during the Super Bowl; it won't be as pretty as we're envisioning."

rise of e-commerce increases traffic (Jaffe, August 2, 2013)

- "Consider it this way: people around the world seem to have a travel time budget of a little over an hour each day [PDF]. Before the rise of e-commerce, part of that time would have been spent in the service of purchasing goods. But if that budget remains fixed, then people today may sim ply buy something online, then hop in a car and go visit a friend across town. In that scenario, personal travel stays constant while commercial travel increases — a net gain of people and goods on the road." (Jaffe, August 2, 2013) expansion of e-commerce will make last-mile freight a growing problem. ""It's definitely — from what I explored — it's an issue and it's going to be a growing issue as we move into the future," he says. "To get the word out that this is something people haven't thought about before, I think is key.""

private sector transport innovations put private, not public capital at risk, and pay off more quickly (Salmon)

- "One reason is simply fiscal. Projects like the self-driving car, and the Sartre platooning project in Europe, move the costs of new technology onto companies (Google) and individuals (people buying smart cars). As such, while the total amount of money spent might well be enormous, the money doesn't need to be spent up-front by any state or national government. That stands in stark contrast, of course, to rail projects, which cost billions of dollars up front; if they ever do pay for themselves, they do so only very slowly."

# conflicts

who will own the data generated by self-driving vehicles (Sottek)

- "Some observers have called self-driving cars "a privacy nightmare." Since driverless cars will likely talk to each other on the road and periodically report back to the mothership, that means they'll collect a lot of data, and nobody really knows yet how that scheme will work. Will Google target ads to drivers based on where they roam? Will companies share your driving data with dubious marketers or sketchy data brokers?"

transit agencies hamstrung to innovate AV services "Lutin sounds skeptical that transit agencies will be able to move into this space. (Badger, Jan 17) Transit agencies limited in integrating AV services.

- "They don't adapt well to change," he says. They're also governed by rigid mandates that limit what they can do. A mass transit agency can't overnight start operating something that looks like a taxi service. Public agencies also must contend with labor unions, and labor unions likely won't like the idea of replacing bus routes with autonomous cars."

new conflicts arise over design and use of streets in AV world (Geeting)

- "The option to speed cars through the city will still have to be balanced against service levels for transit, cyclists and pedestrians. Autonomous vehicles may increase street capacity by obviating the need for many curbside parking lanes, but should that space automatically go to cars?"

Google wants to power logistics and collect data, not sell cars. Automakers won't want a smaller market for shared cars. (Geeting)

- "In the long run, automakers are likely in no rush to move beyond shared-authority vehicles, and arguably have every reason to oppose drone cars now classed as Level 4. Since level 2 and 3 cars would always require a human in the driver's seat, they would do little to nothing to change the norm of one car per person. Only level 4 would enable the type of widespread carpooling that could gut auto sales and reshape the built environment in ways that diminish the usefulness of cars in general. If these vehicles are perceived to contain the seeds of the auto industry's long-run stagnation, it may fall to Google to finish the job."

The deployment of self-driving cars will cause economic and labor conflicts (Geeting).

- "Politicians on state and federal levels could face intense pressure from drivers unions and other auto-stakeholder industries to permanently delay legal deployment of Level 4 vehicles."

security considerations for a national connected vehicle environment are unprecedented (RITA)

- "Research to date has revealed that security system requirements for a Connected Vehicle Environment are unique and complex. Existing security systems tend not to be based on such rigorous requirements for safety or privacy protection, nor do they address such a large set of users on a national scale. While the program has been able to draw lessons from existing industry examples, the connected vehicle security models will need to incorporate new and innovative processes."

Will tort liability issues arise over V2I/ITS? (RITA)

- "It is not clear whether V2I technologies will create new issues with regard to tort liability for State and local agencies or whether operating agencies are protected through similar immunities offered with the operation of traffic signals."

so much legal uncertainty because so many different kinds of assisted and autonomous drive technologies (Laursen)

- courts "tied up trying to sort through it all where do we draw the line on semi-autonomous vs fully autonomous "For one thing, the international Vienna Convention on Road Traffic requires the driver to be in control of the vehicle. Whether a driver can farm out "control" to a semiautonomous system such as lane-keeping is up to lawyers, legislators, and regulators. Carmakers are already restricting some advanced driver assistance systems to Europe due to liability concerns in the United States. Insurance companies are studying the risks, and several U.S. states have already passed preliminary legislation for handling experimental autonomous cars. In March, California's Department of Motor Vehicles held a hearing to discuss rules for privately operated self-driving cars. The rules will be drafted around June and must go into force at the end of this year, but even those closest to the problem of how to allocate autonomous cars' risks are unsure how to proceed.

Distractions inside vehicles may increase faster than assistive driving technologies to mitigate their safety risks. (Richtel and Vlasic)

- "What we really have on our hands is a looming public safety crisis with the proliferation of these vehicles," said Yolanda Cade, a spokeswoman for AAA, whose Foundation for Traffic Safety released the study on Wednesday. She characterized the rush to equip cars with Internet-enabled systems as "an arms race.""

long time frame to deploy city-scale systems - Los Angeles's traffic signal controls (Stewart)

- "But the city began installing the ATSAC system long before – in fact, shortly after the original 1969 film was made. ATSAC is decades in the making."

If the vehicles aren't shared, they could exacerbate traffic and heighten parking demand, adding to congestion rather than alleviating it (source)

While self-driving cars may get rid of the issue of driver fatigue; however, they may cause under arousal. (Stenquist)

- "Lost in the debate around autonomous technology," Mr. Reimer of M.I.T. said, "is that these features pull workload away from the driver and can result in under arousal. The traditional cause of that is driver fatigue, but semiautonomous features may be driving us in that direction."

Will the rise of autonomous vehicles create issues of social equity?(Arieff)

- "What About Social Equity? Public transit is a public good. Autonomous vehicles — not so much. If you could afford a BMW before, you'll be able to afford a subscription to BMW's suite of offerings in this scenario. You can select a car to fit your task and even your mood. But if you couldn't afford a car before, you probably won't be able to afford a self- driving one either. The issue of equity — particularly for those who are most often passengers today — is glaringly absent from discussions of driverless cars."

How will the auto insurance industry respond to fewer car accidents. (McCrum)

- "To start with, fewer crashes means lower costs and more profits. But don't get sucked into extrapolating those forward. Competition is fierce, and premiums come down, and down, and down. ars will still be vulnerable to falling trees, floods and (maybe) thieves. But it is the driver who is insured, and when that driver is a robot it seems much more likely that the supplier of the robot or the control software is going to bear a lot of the liability. Indeed, that is another aspect likely to drive adoption, insurance will be wrapped up in the overall service that you buy from Google, Teslapple, Roombadrive or whoever."

Are the obstacles of making the switch to autonomous vehicles insuperable? (Arieff)

- "There are some very good things autonomous vehicles might possibly provide — yet the obstacles to their integration seem insurmountable. If we've struggled so much to get a few hybrid cars on the road, how could we ever begin to get even near replacing our existing auto-dependent system?"

# CONSTRAINT

## technologies and services

smart traffic signals (RITA)

- "Traffic signal control has experienced very few fundamental improvements in the past 50 years. - Intelligent Traffic Signal System (ISIG): Using high-fidelity data collected from vehicles through V2V and V2I wireless communications, this proposed application seeks to control signals and maximize flows in real time. The ISIG application also plays the role of an overarching system optimization application, accommodating transit or freight signal priority, preemption, and pedestrian movements to maximize overall network performance. - Transit Signal Priority (TSP): This proposed application allows transit agencies to manage bus service by adding the capability to grant buses priority based on a number of factors. The proposed application provides the ability for transit vehicles to communicate passenger count data, service type, scheduled and actual arrival time, and heading information to roadside equipment via an on-board device. - Mobile Accessible Pedestrian Signal System (PED-SIG): This application integrates information from roadside or intersection sensors and new forms of data from pedestrian-carried mobile devices. Such systems will be used to inform visually impaired pedestrians when to cross and how to remain aligned with the crosswalk. This application may also support the accommodation of safe and efficient pedestrian movement of a more general nature. - Emergency Vehicle Preemption (PREEMPT): This proposed application, while similar to existing technologies, will integrate with V2V and V2I communication systems. The application would account for non-linear effects of multiple emergency responses through the same traffic network. - Freight Signal Priority (FSP): This application provides signal priority near freight facilities based on current and projected freight movements. The goal is to reduce delays and increase travel time reliability for freight traffic, while enhancing safety at key intersections."

unified payment systems make navigating transit systems easier. (source)

- "Hangzhou Omnipay Card's primary innovation is the creation of an integrated payment system where the passenger needs only one card to access multiple transit options in the city. Omnipay card holders can use the rechargeable value card to pay for the city's metro, bus, bike share, and car share services. The card makes navigating the city's public transport system (including the fractional use services) seamless to the commuter." *see also Hong Kong, Singapore, Seoul T-Money, etc.

Microsoft analytics solution for bus fleet tracking saves " as much as 5 percent savings in fuel costs due to more careful driving and improved maintenance" and lets managers understand big picture issues like emergency braking hotspots (source)

Urban Engines - analytics company that uses fare card data to create incentive programs for transit operators to offer weekly prizes to people willing to commute outside peak hours (Jaffe, May 15, 2014)

- "Urban Engines, which has been developing its twin approach for two years, is already working with three cities. In São Paulo, the company is working to relieve the crowded bus system; in Singapore, it's using incentives to promote off-peak travel on the MRT railway; in Washington, D.C., it's in the early stages of data analysis for Metro. At the moment, Urban Engines is working only with transit agencies, though eventually they plan to develop ways to help commuters directly."

Break Shuttle popup bus company coordinates rides for college students heading home for breaks. (Seelye)

- "Mr. George, while a student at Middlebury College in Vermont, was part of a team that built what he says is the nation's largest network of pop-up bus services for college students going home on break. Called BreakShuttle, it has generated about $1 million a year in revenue by serving 15 colleges; it is scheduled to serve about 40 this fall."

Boston-based bus company Bridj uses big data on commuting patterns to develop bus schedules. (Seelye)

- "This new-old method of transport has comfortable seats and Wi-Fi. But its real innovation is in its routing. It is a "pop up" bus service, with routes dictated by millions of bits of data that show where people are and where they need to go. The private service uses chartered buses and is run by a start-up technology company called Bridj."

Transportation Network Company creates carpooling system in California. (Scola)

- "Transportation Network Company, a [California public utilities commission]-made neologism. You'll know TNCs by the fact that they connect people online for rides in personal, non-commercial vehicles."

On-Demand Bus System Pilot at Tokyo University follows no fixed route. (Tokyo University)

- "On Demand Buses are buses where people rideshare using a reservation system. Unlike buses that travel a fixed route on a fixed schedule, on-line buses have no fixed route or schedule. Just like with a taxi, the bus goes just where the passenger wants. What's different from a taxi is that passengers ride together. Passengers traveling similar routes ride together, with the bus making only short detours along the way. In the case of Tokyo University On Demand Buses, even in cases where there were slight detours for people sharing the ride, it was possible to stay on time, arriving at the time promised to the passengers booking the ride."

San Francisco Bay area private bus network RidePal operates via an app to mimic the Google corporate bus experience (Garthwaite)

- "RidePal, a company that recently began a pilot test of its service, would help smaller firms provide workers with business-class commuter shuttles as an alternative to public transit or personal vehicles. Shuttle times and pickup locations are established based on preferences and votes entered by users on the RidePal Web site. Companies enroll to reserve any number of seats on a shuttle and can choose to subsidize any portion of the fare for their employees. Riders sit next to neighbors who work for offices near their own, rather than sitting exclusively with their co-workers."

Project 100 plans to create a transportation system which will make car ownership a thing of the past. ([source](#))

- "Project 100 is the code name for a complete transportation system designed to let you get rid of your car and be more connected to your neighborhood. It includes on-demand cars with drivers, shared cars you can drive yourself, bike sharing, shuttle buses and more. The experience is simple: open an app so we know where you are and tell us what zone you want to travel to. With that information we'll give you a set of options, for example, 1 – Be picked up by a driver in a Tesla in 3 minutes, 2 – Drive yourself in a low range electric vehicle that's 0.2 miles away, 3 – Grab a bike that's 0.1 miles away or 4 – Hop on the party bus that will be near you in 4 minutes."

Ma

- AccessWay - AccessWay is a mobile way-finding app that would help visually-impaired or wheelchair-assisted individuals navigate the subway. The app incorporates text-to-speech technology and pulls real-time service status updates from MTA timetables. (MTA App Quest 2013) ([source](#))

# forecasts

smart para-transit carpooling system reduces road congestion. ([Gorton](#))

- "A new form of mass transit can be created that offers trip times highly competitive with the private automobile to nearly all points in the region. This new form of mass transit takes advantage of the existing road network and requires very little in the way of capital investment. This new form of transit is Smart Para-Transit. Smart Para-Transit uses information technology to group and optimize the existing trips that take place on the road network. Take for example the group of people who want to travel from Tribeca to Montclair, NJ around 5:30 PM on a Tuesday. There might be a dozen people who plan to make this trip by car in a 15 minute period. These dozen people might require 8 separate cars for their trips. Instead of 8 separate cars, one large van could fit 12 people and consolidate these 8 vehicles into just one vehicle. The van could make 3 quick stops in

Tribeca, pick up all 12 people and head directly to Montclair. Once in Montclair, the van could stop at a couple of central transit points, and then continue directly to some passengers houses."

Boomers retiring will undermine the car market (Lev-Ram)

- "After taking a major hit in the last recession, U.S. car sales have steadily grown for the past few years. But the number of automobiles sold in the U.S. last year, 15.6 million, is still significantly lower than the 16.7 million sold in 2003. What's more, analysts expect the recent growth to start slowing over the next five to 10 years as aging baby boomers exit the market and millennials–many of whom would rather own the latest smartphone than a new car–enter it."

death of car culture / emotional attachment to cars (Lev-Ram)

- "While autonomous vehicles won't erase the need for cars, they could certainly put a dent in demand and further our emotional detachment from automobiles, utilizing algorithms, not drivers, to shuttle multiple passengers to their destinations."

entire transportation network is self-aware (Forum for the Future)

- "Expect mobile networks to extend beyond human communication; everything that could benefit from a wireless network is likely to have one; and connectivity will combine with energy, water management, transport and health as more services are delivered online."

Biobuses, a public transportation system powered by plants. (Forum for the Future)

- "'Biobuses' are one of the most popular cheap ways to get around the city."

four scenarios - Forum for the Future predicts four possible future mobility scenarios. (Forum for the Future)

- Planned-opolis: high energy costs dictate a strict planning regime and heavy investment in public transit
- Sprawl-ville: unplanned expansion and high energy costs isolate the poor and impose high   mobility costs
- Renew-abad: transition to alternative energy allows for more distributed neighborhood-level hubs for energy and mobility networks
- Communi-city: sustainable, chaotic, lots of private modes of transport compete for road space

automated buses achieve same throughout as trains (Badger, Jan 17)

- "When buses have the same autonomous, communicating power that cars will have, they'll be able to drive safely within inches of each other, too. Picture a dedicated Bus Rapid Transit lane with moving buses queued up end-to-end. In this world, cars may start to function like transit, but buses could come to work like trains. And they're a lot cheaper to deploy."

low-wage workers take autonomous jitney dollar vans to work at nursing homes (Zmut et al)

- "Second, transit agencies started using aut-Vs to provide service on low-use bus routes at lower labor and fuel costs. Transit agencies provide eight- and ten-seat aut-V jitney-type service to serve primarily immigrant neighborhoods where workers need access to low-wage jobs clustered in malls and assisted-living centers."

Metro areas will see a boom in transit use. (Zmud et al)

- "In most metro areas, transit agencies have responded by adding about 35 percent more miles of service than they provided in 2012."

By 2030, there will be a significant rise in the percentage of employees working in locations other than their typical workplaces  - 15 to 45 percent (Zmud et al)

- "in 2030, 40 percent of workers telecommute, meaning that, on any given day, 40 percent of employees are working either at home or from another location close to home that is not their usual work- place.4 Similarly, online shopping has grown to 30 percent of all retail sales, in dollars, from about 4 percent in 2009. Trips that cannot be substituted with telework or other virtual communications are often taken in shared vehicles. "
- "In the workshop, the experts' projections ranged from 15 to 45 percent. In the course of the workshop discussion, the experts settled on a high projection of 40 percent and a low of 15 percent. We have kept these projections because they reflected the expert opinion. We recognize that the assumption that 40 percent of the workforce will greatly reduce or eliminate their commute by telecommuting on any given workday may be unrealistically high. The expert participants were clear that their definition was not a person's "usual" place of work. Since the workshop, we have not been able to identify data support for the projection that 40 percent of workers will be telecommuting on any given day by 2030 that includes a specification of the survey population or definition of telecommuting. We reran the RAHS analysis with projections of 20 percent and 30 percent. Neither of these lower projections leads to a different scoring on the consistency matrix. And rerunning the analysis did not change the RAHS results, in terms of either the raw scenarios or the clustering. The use of this projection and others in the analysis and sub- sequent scenario development is described in Appendix A."

As demand rises, oil prices set new records.  (Zmud et al)

- "Oil prices have soared to $190 per barrel based on Chinese and Indian demand, as well as political instability in the Middle East... Oil prices have soared to $190 per barrel based on Chinese and Indian demand, as well as political instability in the Middle East."

price of energy is out of government's control, the two driving factors that matter in US transport futures that policymakers can influence are: (Zmud et al)

- "the development of environmental regulation, and the amount of highway revenues and expenditures"

observable and severe climate change impacts drive popular push for GHG reduction (Zmud, et al)

- "One path recognizes that climate-change effects, if severe and observable by enough Americans, will shift public sentiment to heavily favor regulation to mitigate greenhouse-gas (GHG) emissions. This policy direction, in addition to other global influences, causes a very high price of oil. Americans are driving less and using alternatives to conventional vehicles. "

concerns about cybersecurity push large organizations to centralize workforce on campuses (Orange)

- "As a consequence of greater emphasis on organisational control and data protection, we witness an increase in investment in office spaces for workers as employers seek to create a campus-like feel to work areas and to keep employees happy. Organisations incorporate services catering to worker health and wellbeing demands..... The organisations in this scenario are preoccupied by maintaining control of information about the products they create and consume. "

tight research budgets will drive the adoption of cell phone data in transportation planning (Airsage)

- "Two factors are driving interest in new technologies: research/study budgets are constrained, and new technology can deliver larger, more accurate data samples much faster, making the data more current than most other methods. Increasingly, public agencies and commercial clients are studying and using new strategies, especially cellular data, to supplement or replace traditional traffic study methods."

survey of transportation planners - what will the future hold? (Airsage)

- 44% Dense neighborhoods connected by transit and multi-use roads for walking/biking
- 37% Expand transit options and optimize roads for more flexibility
- 16% Expand roads but provide more for buses and bicycles
- 3% Expand current roads; people prefer traditional suburbia

millennials want more digital amenities in public transit (APTA)

- "Millennials would like to see in the next ten years:
  1. 61% more reliable systems,

  2. 55% real-time updates,

  3. 55% Wi-Fi or 3G/4G wherever they go,

  4. 44% a more user-friendly and intuitive travel experience.

Fully leveraging technology, through real-time transit applications that connect users with community amenities, through smartphone fare payment, and the provision of WiFi and 3G/4G,  will allow transit users to be more spontaneous, thus addressing the key competitive advantage of the car."

in 2025, German budget travelers will drive innovation (Feige)

- "the use of mobility will be more pragmatic. The choice of means of transport will be less of a routine than in the past.... but this fundamental flexibility will be set off by financial restrictions in many cases due to limited household budgets. The result will be a large market of low-cost offers, with today's no-frill flights marking only the beginning of a development in which we will see extremely inexpensive long- distance bus services and a growing number of low-priced cars in the market."

in the year 2025 in Germany, complicated daily schedules still favor the automobile and flexible modes of travel (Feige)

- "With an increasing number of women entering gainful employment, the daily routine of many families has become significantly more complex. Most people are therefore required to carefully plan their routine and ensure a high standard of efficient time management. People tend to handle several errands at the same time, using in particular their car for such complex travel requirements. So despite very customer-oriented options are now available, public short haul passenger transport still suffers from inherent drawbacks in this respect."

in 2005-2025 in Germany, significant increase in mobility spending (Feige)

- "Expenditure on mobility has increased in both relative and absolute terms over the 2005 figure. This is attributable, first, to the increase in prices for using transport services and participating in traffic, and, second, to the fact that mobility still has high priority in the everyday life of the population."

transport in 80 different scenarios in US metros indicates that density strategies could cut VMT substantially (Bartholomew and Ewing)

- "a typical compact land use–transportation scenario could, by 2050, produce 17% fewer vehicle miles traveled (VMT) than trend conditions at the same population and employment levels. This probably is a conservative estimate due to substantial shortcomings of current transportation models, which constrain scenario planning as a tool for assessing potential futures and developing effective policy responses."

passive tracking of drivers helps build and validate crowdsourced maps, like the one used by Telenav, the first ever based on OpenStreetMap (Quain)

- "Increasingly, however, mapmaking is becoming a more passive pursuit. Simply by driving, users are automatically submitting information over their phones about their

routes and the roads they travel. It's the collection of such data that acts as a check on possible crowdsourcing errors."

Intelligent self-driving cars will communicate with traffic lights to maximise fuel efficiency. (Torbert and Herrschaft)

- "Driverless cars connected to the traffic light system could communicate with an upcoming light and have it stay green or change to green, so that you could maintain cruising speed and optimal fuel efficiency (not to mention avoiding an unnecessary delay at the light)"

connected cars as road maintenance sensors (Torbert and Herrschaft)

- "By feeding information into (and obtaining info from) a shared database akin to the smartphone app Pothole Alert, they could avoid road hazards or even notify the local highway department or department of public works to road repair and maintenance needs. "

transport innovations continue to fill gaps in the transportation network (Geron)

- "In addition, looking at the larger transportation system, many of these apps emerge as a result of some hole, problem or weakness in an existing system, whether taxis or public transit, Amin says. Lyft, Sidecar and Uber are a result of problems with taxis. And some people may take them instead of public transit. That doesn't mean public transit shouldn't be fixed or funded. "The answer is, for transit, to innovate and not stop people from getting around," Amin says."

ride-sharing should increase transit use by providing a last-mile solution (Geron)

- "Ride sharing through apps like Lyft and Sidecar similarly should also decrease car ownership, Shaheen believes, though she hasn't done the research yet. That should also increase, not decrease, public transit usage. Why? If ridesharing can provide the "last mile" from public transit to a destination–and it's cheaper than a taxi–people should be less likely to buy a car. They can then piece together a range of transportation options."

the poor can benefit enormously from ride-sharing services (Geron)

- "Also carpooling, which is a predecessor to what these apps do, has long been common among lower income people, she adds. "(Ride sharing apps) can be worth it, including to people with very low income," adds Tumlin. "Many low income people rely on public transit could not afford a car. But they also place a high value on time.""

the new transportation bill may allow states to toll Interstates for maintenance, not just expansion, and it could be used to transit as well as roads (Jaffe, May 7, 2014)

- "That's an idea to let states place tolls on their free interstate highways. Right now, states can only toll an interstate highway to pay for the construction of new lanes. The new plan

would let states create tolls to pay for maintenance of a crumbling highway they have no plans to expand at all. "

RFID will continue to play a major role in multi-modal transportation payments (Shaheen and Christensen)

- "Apart from the smartphone, RFID technology may also play an increasing role in multi-modal and intermodal transportation in the future. Most public transit services, as well as many carsharing and bikesharing providers, currently enable user access through a RFID card. Some partnerships have already been formed; for instance, in 2009, the Chicago Transit Authority and I-Go Carsharing began offering a joint carsharing and public transit pass. In New York, San Francisco, and Chicago, bikesharing systems are equipped with RFID card readers in anticipation of a multi-use RFID card. And in London, the Oyster card has set the precedent for RFID admission, as cardholders are able to access local and regional forms of the transportation network with a single card, including the subway, light rail, regional rail, trolleys, and buses."

mandating the sharing of private mobility data with planners (Shaheen and Christensen)

- "Central to the development of an intelligent transportation system is open data. To understand and monitor the complete network of available transportation modes, each modal provider must be willing to make their data available to an aggregator. The closer that data is to real time, the better for the system. While it is widely expected that the public sector will support open data policies, the private sector is generally more hesitant to share data. Many private-sector mobility providers see a competitive advantage in keeping data proprietary. This may be the case in certain situations, but there are many benefits associated with a private company opening its data: these include increasing system efficiency, expanding the market of users, fostering innovation ancillary to the service, and other benefits associated with transparency (e.g., emission and fuel-use reductions)When those benefits don't provide enough incentive for private mobility providers to share their data, mandates could offer a solution. In the case of urban mobility, many services require access to public rights-of-way to operate and are subject to the policies imposed by the local governing bodies. Local policies could request that mobility providers share their data in exchange for access to the rights-of-way as one way to foster an open data environment."

revenue from parking tickets will vanish in a world of automated parking payments (Bilton, July 9 2013)

- " the parking ticket could vanish from the future city as cars park themselves and refill parking meters electronically. (If there even are meters in the future.)"

SAV networks will emerge around 2030 (Jaffe, February 13)

- "The big market question is when this world will begin to emerge. Levinson subscribes to a timeline in which autonomous cars enter the luxury market in 2020, the technology trickles down into the affordable mid-level range over the next several years, and by 2030 every car on the road is driverless. (Other cars would be banned a decade later.) Since car- and ride-sharing operations tend to rely on smaller cars, that would peg SAV networks closer to 2030 — about 16 years from now."

SAVs could become a cheaper option for low-demand transit corridors (Jaffe, February 13)

- "At the same time, SAVs might even represent an upgrade to existing transit service in many low-demand corridors. A few SAVs perched outside such neighborhoods might provide the area more cost-efficient and reliable service than a few buses running every half hour or hour."

SAVs could serve as feeders to boost transit ridership (Jaffe, February 13)

- "Could an SAV network perpetuate car travel so much that it eliminates public transportation? For sure, it means a greater reliance on roads and automobiles. But Kornhauser points out that an SAV network also has the potential to enhance transit ridership on existing commuter routes. After all, a convenient ride to and from the station could increase demand enough for transit agencies to run even more trains or buses."

shared autonomous vehicles, metered by time/distance will encourage people to move closer together (Jaffe, February 13)

- "Skeptics have also charged that autonomous cars will disrupt any city-based travel models, since people freed from the need to drive will move even farther away from the core. That might be true for people who own their autonomous cars, says University of Minnesota transport scholar David Levinson, but a strong sharing system could promote the opposite movement. "If you're paying for the car by the minute, then you're not going to want to move farther out," says Levinson. "You're going to want to move closer in.""

self-driving shared cars will be pre-positioned in areas of high demand (Jaffe, Feb 13)

- "You wake up and get ready for work, and a few minutes before it's time to leave you press a button and order an SAV. The car has been strategically positioned to wait in high-demand areas, so you don't have to wait long. You might share the ride with a couple travelers just as you share an elevator, or perhaps pay a premium to ride alone."

apps will monitor vehicles and drivers to produce reports (Trop)

- "For example, new apps will allow drivers to interact with their vehicles both from inside and remotely. Drivers can also use apps to monitor fuel efficiency or track mileage for business expenses. Younger drivers can benefit from driving instructor apps that allow them to log their hours for daytime and nighttime driving to produce a summary report."

self-driving taxis supplant off-hours transit use (will we see this in Uber?) (Templeton)

- "Elsewhere I detail how robocars might spell the decline of transit because they could potentially be faster, personal, higher capacity and more energy efficient than existing transit systems. Even if transit remains dominant at rush-hour due to capacity constraints, self-driving taxis are likely to supplant it to a large degree in the off hours, radically changing its economics."

elimination of residential garages (Templeton) The decline of car ownership will cause the elimination of residential garages.

- "People also will have less need for garages in their homes. This allows an increase in urban density for walkability."

private autos banned in Manhattan (yeah right, tell this to the 1%ers) (Arup)

- "autonomous electric taxis provide clean, efficient transportation throughout the city, private passenger vehicles are banned"

self-driving cars will be slower, lighter and fewer (Alter)

- "The autonomous car will likely be shared, smaller, lighter, slower, and there will likely be about a tenth as many of them. Urban planners and theorists have to start thinking about this or we will screw it up again."

falling demand for cars drives auto manufacturers into mobility services (Lawler)

- "Drastically reduced demand for cars in urban and even some suburban areas where Uber operates has sent shares in companies like Ford and General Motors to five-year lows. With auto sales lagging, those companies have introduced their own on-demand rental and transportation services, but consumer interest has been lackluster so far."

urban land prices fall from glut of parking lots re-used (Bilton)

- "Some city planners expect that the cost of homes will fall as more space will become available in cities. If parking on city streets is reduced and other vehicles on roadways become smaller, homes and offices will take up that space."

reduced parking allows big-box stores to urbanize (Bilton)

- "Today's big-box stores and shopping malls require immense areas for parking, but without those needs, they could move further into cities."

the rise of e-commerce increases traffic (Jaffe, August 2, 2013)

- "Consider it this way: people around the world seem to have a travel time budget of a little over an hour each day [PDF]. Before the rise of e-commerce, part of that time would have been spent in the service of purchasing goods. But if that budget remains fixed, then people today may simply buy something online, then hop in a car and go visit a friend across town. In that scenario, personal travel stays constant while commercial travel increases — a net gain of people and goods on the road." (Jaffe, August 2, 2013)

expansion of e-commerice will make last-mile freight a growing problem. ""It's definitely — from what I explored — it's an issue and it's going to be a growing issue as we move into the future," he says. "To get the word out that this is something people haven't thought about before, I think is key.""

# conflicts

car companies retooling as mobility providers (Lev-Ram)

- ""'Our historic model has been 'Design, build, and sell vehicles,' " says Peter Kosak, executive director of GM's urban-mobility division. "Fleet maintenance, data and analytics, and ride sharing–these are not things that we've historically done.""

transit agencies operating AVs will be competing with private sector (Badger, Jan 17)

- ""There's an opportunity for autonomous taxi services to make money," Lutin says. "And nobody wants the government to compete with private industry and make money. We barely tolerate toll road authorities. If it looks like we can trade in our buses for a fleet of autonomous vehicles, and we can drop fares and at the same time we can make money, somebody in the private sector is going to want that."

seamless multi-model trip planning and payment requires a lot of difficult integration (Shaheen and Christensen)

- "transitioning from a world chock-full of tickets, memberships, and key fobs to a world where travelers compare modes, plan routes, and pay for publicly accessible services on a single digital platform involves overcoming many barriers. Even the most advanced smartphone apps and other digital platforms that aggregate trip data and services still have major limitations. This vision of urban mobility hinges upon transportation providers — both public and private — sharing data, collaborating, and supporting innovation."

transit agencies to make mobile ticketing available at stations. (Shaheen and Christensen)

- "While there are a growing numbers of mobile ticketing success stories for public transportation, retrofitting stations with the ability to accept payments from smartphones is a significant investment for transit agencies."

# TRANSFORMATION

## technologies and services

cashless informal carpools that serve corporations (RITA) Virtual currency offers safe carpooling for corporate employees.

- "The primary innovation of Caronetas Caronas Inteli- gentes deals with informal carpool services in Brazil. Caronetas created a virtual currency that allows passengers to participate in carpool services without the need for exchanging (or carrying) cash. Caron- etas also increases the trust level in the system by allowing only individuals with valid corporate email addresses to join the system. The virtual currency can also be used in stores and shops. Caronetas sells the service to Brazilian companies. Companies that opt in must authenticate their employees' email addresses to use the service, reducing concerns about safety of carpooling with other unknown passengers. The email certification allows people to rideshare within one company or across multiple companies that have been vetted and authorized employees to participate. More than 900 businesses in Brazil registered for the virtual currency carpooling service during Caronetas' first year of operation. Based on the model's initial success, Caronetas now plans to expand operations to Mexico and the United States."

Social Bicycles - station-less bike share system that is unlocked with a smart phone. (source)

Boost by Benz which shuttles kids to soccer games and piano lessons in a candy-colored Mercedes-Benz van, complete with concierge service (as if getting picked up by your mom or dad weren't embarrassing enough). (Lev-Ram)

Mercedes-Benz Driving Academy adds four additional locations and is running abroad. Duchene, head of the L.A. school, says the company is evaluating other locations in the U.S. (Lev-Ram)

- "It's about how to extend our brand beyond our normal business," she says.

MobileEye Israeli company $300 version of Google car tech (Markoff, May 27) creates $300 version of google's self-driving car

- "While the widely publicized Google car and other autonomous vehicles are festooned with cameras, radar and the laser range finders called lidars, this one is distinctive because of the simplicity and the relatively low cost of its system — just a few hundred dollars' worth of materials.... The Mobileye car does not offer the autonomy achieved by

Google's engineers. By contrast, the Mobileye vehicle is capable only of driving in a single lane at freeway speeds, as well as identifying traffic lights and automatically slowing, stopping and then returning to highway speeds.

Place Pulse - platform for crowdsourced ratings of Google Street View images based on perceived safety is a good predictor of actual crime rates (Salesses) Google's Street View predicts actual crime rates.

- "the recorded gap between ''good'' and ''bad'' neighborhoods is larger in NYC and Boston and that both positively evaluated and negatively evaluated images cluster more in these American cities than in their Austrian counterparts. Finally, we showed that the inequality of perceptions helps explain the location of violent crime in a NYC zip code, even after controlling for income, population, area and age."

Shyp app that lets you take a picture and enter pickup and destination addresses to send something anywhere - Shyp picks up your items, packs them and sends them via lowest cost, most reliable. $5 + shipping (source)

Postmates Will pickup and deliver any retail / food takeout item, delivery starts at $5. (source)

BlaBlaCar - UK app for intercity carpooling. (source)

RidePal - San Francisco Bay area private bus network, operates via an app to mimic the Google corporate bus experience (Garthwaite) RidePal, a San Francisco Bay area private bus network, operates via an app to mimic the Google corporate bus experience.

- "RidePal, a company that recently began a pilot test of its service, would help smaller firms provide workers with business-class commuter shuttles as an alternative to public transit or personal vehicles. Shuttle times and pickup locations are established based on preferences and votes entered by users on the RidePal Web site. Companies enroll to reserve any number of seats on a shuttle and can choose to subsidize any portion of the fare for their employees. Riders sit next to neighbors who work for offices near their own, rather than sitting exclusively with their co-workers."

SmartWalk - projected displays of transit location and arrivals developed by Transit Screen (Ferro) TransitScreen's project SmartWalk, allows commuters to see displays of transit locations and arrivals.

- "TransitScreen's latest endeavor, SmartWalk, involves bringing the same real-time dashboard of information into the physical world by projecting the information onto public spaces. In addition to the real-time transit data provided by the screens, the projections would also embed way-finding information for transit options on sidewalks, walls, plazas, or even billboards: think arrows pointing you in the direction of the bus, subway, or bike share."

TurtleTaxi - passengers press a button to slow their ride down in Yokohama (De Boer)
TurtleTaxi allows passengers to press a slow down button.

- "Turtle Taxi lets commuters choose whether or not they want the driver to speed up through a Yukkuri button on the back of the driver's seat. If passengers aren't in a rush they can press the button to let the driver know he can slow down, which is obviously safer and friendlier for the environment. They don't have to keep the engine running at red lights, they can accelerate more gradually, and they don't have to drive max speed on the fast lane. It also offers commuters a less stressful ride, which gives them time to look outside the window and experience the city in a pleasant way."

ARIA, the open source alternative to MatterNet (The Economist, Dec 1 2012)

- "autonomous roadless intelligent array" <<< this is ARIA's full name. A quote about them (from the same article could be "It believes the matternet should be free, open and based on standardised protocols, just like the internet. It is developing these protocols and building prototypes that adhere to them, and inviting others to follow suit."

Indoor Atlas - using magnetic fingerprints to position indoor phone users, say to route them to their weekly shopping list (Hardy) IndoorAtlas company allows customers to use phones to determine the exact location of desired products as they walk through stores.

- "A Finnish company called IndoorAtlas has figured out that all buildings have a unique magnetic "fingerprint" — and has solved how to use that to determine locations inside a structure to within six feet. That is enough to take a consumer to a product in a crowded supermarket, or figure out the location of, say, a half-dozen workers in a building full of them. It's also much better than cell phone towers can do... shoppers can load their week's shopping into their phones, and get interior directions about where every product is located, and how to efficiently walk through the store to get eve  rything."

Matternet (Lee) Matternet company to build a drone delivery system.

- "a startup called Matternet is plotting to build a drone-based package delivery service in low-income countries."

Project 100 plans to create a transportation system which will make car ownership a thing of the past. (source)

- "Project 100 is the code name for a complete transportation system designed to let you get rid of your car and be more connected to your neighborhood. It includes on-demand cars with drivers, shared cars you can drive yourself, bikesharing, shuttle buses and more. The experience is simple: open an app so we know where you are and tell us what zone you want to travel to. With that information we'll give you a set of options, for example, 1 – Be picked up by a driver in a Tesla in 3 minutes, 2 – Drive yourself in a low range

electric vehicle that's 0.2 miles away, 3 – Grab a bike that's 0.1 miles away or 4 – Hop on the party bus that will be near you in 4 minutes."

MakeSpace - Dropbox for physical stuff, random access storage and delivery. (Crook)
MakeSpace offers Dropbox-like service for physical stuff; random access storage and delivery.

- "Users pay $25/month to get four bins worth of storage. But the key here is that users have on-demand delivery and drop-off of all those items, not unlike a download or upload to a cloud storage service. You can keep track of your stuff on a bin-by-bin basis, through pictures and lists within the app, and request a single bin delivered or your entire stash."

Car2Go one-way stationless car sharing service (Daimler subsidiary)

DriveNow one-way station-based car sharing service(BMW joint venture)

LiveHoods - research tool developed by Justin Cranshaw at CMU identifies neighborhoods based on place-based social network clusters identified from Foursquare checkins. in this paper, demonstrates how these clusters reflect the impact of transportation networks - such as the clustering of groups on either side of the BQE, which severed Williamsburg in the 1950s? (source)

AccessWay - AccessWay is a mobile way-finding app that would help visually-impaired or wheelchair-assisted individuals navigate the subway. The app incorporates text-to-speech technology and pulls real-time service status updates from MTA timetables. (MTA App Quest 2013) (source)

T-Drive - navigation service powered by machine learning from analysis of historical

SF Express - Shenzhen-based delivery drone - (souce)

Public e-bike Sharing in Berkeley and Oakland - 90 bikes (including 22 cargo bikes) at 25 locations will allow people to get up and down hilly terrain (source)

Google Glass bicycling apps help commuters navigate the streets of NYC.

- "Built by the R/GA Prototype Studio, the NYCycle Google Glass app was designed for New York City's Citi Bike program to help bikers navigate through the streets of New York without the need to pull out their phones. Incorporating Citi Bike's real-time data, the app marks a seamless integration between wearable technology and bike-sharing." (souce)

Open source data being used to program very small drones.

- "very small drones — called micro air vehicles, or MAVs — are a great way to teach aerospace engineering because they're relatively cheap, safe and easy to program." (source)

Website / app that predicts station platform temp for the L train using surface temp and calibration from direct observations (souce)

BentoBox Secure neighborhood pick-up solution for ecommerce deliveries (reducing last mile frieght) http://www.city-log.eu/lyon/bentobox

real-time dynamic logistics CITYLOG's delivery system uses telematics to create the most traffic-friendly route.

- "CITYLOG researchers conceived of a three-tiered telematics solution to optimize delivery routes. First, a pre-trip planning application maps the most traffic-friendly sequence for drivers to deliver their packages. On the road, a dynamic navigation application keeps the route up-to-date, altering it as necessary to reflect real-time changes in traffic conditions. A last-mile parcel tracking system then automatically sends customers a text message to inform them of imminent delivery. The idea is to have customers meet couriers at the door, minimizing the time that a truck has to be double-parked at the curb." http://www.city-log.eu/overview-wp2-3s

# forecasts

solar scooter (Forum for the Future) solar powered scooters

- "solar-scooter (an electric moped with a wrap-around roof that both generates electricity and shades the rider)"

mind-controlled vehicles (Forum for the Future)

- "Neuro-sensing control via brain activity is being widely used in information technology and more recently in transport."

e-bike cities (Forum for the Future) Cities designed around bikes rather than cars as a primary mode of transport.

- "New suburbs have often been designed around the electric bike, not the car, with narrow streets that blend walking space with bike space."

four scenarios - Forum for the Future predicts four possible future mobility scenarios. (Forum for the Future)

- Planned-opolis: high energy costs dictate a strict planning regime and heavy investment in public transit

- Sprawl-ville: unplanned expansion and high energy costs isolate the poor and impose high mobility costs
- Renew-abad: transition to alternative energy allows for more distributed neighborhood-level hubs for energy and mobility networks
- Communi-city: sustainable, chaotic, lots of private modes of transport compete for road space

benefits of AV trucks - travel at night (exclusively?) - in urban areas, larger fleets of smaller vehicles "(think electric vans, rickshaws and even flying drones)" to cut delivery times (Geeting)

The rise of home work revitalizes local communities (Orange)

- "The rise in home working has seen a revival of the local economy as people spend more and more time and money in the area where they live. A strong sense of community has emerged, with friends and neighbours cooperating around such needs as child care and crime prevention. Spaces such as coffee shops and gyms have become social centres where people can congregate to counter the time they spend working in isolation."

many kinds of services will be delivered entirely virtually (Orange)

- "Due to the prevalence of the internet as the preferred medium for transactions and interactions for both customers and business and customers alike, fewer functions are performed face-to-face. Though the 'real life' experience is still important for some 'experiential' sectors, the improved quality of the online interactive experience has allowed many formally 'real world' sectors to make the switch to virtual interaction."

the monitoring of mobile workers ensures that they arrive on-time at the correct location (Orange)

- "Employees are monitored in their places of work, and even those who are extremely mobile (couriers, repairmen, high-level consultants) follow schedules designating where they have to be, and when."

the electronic cottage will be driven by fuel price spike (Orange)

- "It is 2016 and the preceding years have seen the cost of personal transportation rise dramatically through a combination of green taxation and high oil prices. Combined with the increasing availability and decreasing cost of communications technology this has helped to make decentralised working both attractive and practical."

mobile phone data allows planners to study variations in travel behavior for specific individuals over time, which was never possible using intercept and survey methods (Airsage) (this lack of longitudinal studies in travel behavior research is reaffirmed in Lanzendorf, p3)

- "A joint project by researchers at IBM and MIT, Predicting Personal Mobility with Individual and Group Travel Histories, concluded that fine-grained, extensive data from mobile phone networks "is providing us with a more comprehensive view of activity and

mobility at the urban scale than travel diaries can possibly do on their own. It also enables us to shed light on hitherto invisible intra-personal variation in travel activity."

survey of transportation planners - what will the future hold? (Airsage)

- 44% Dense neighborhoods connected by transit and multi-use roads for walking/biking
- 37% Expand transit options and optimize roads for more flexibility
- 16% Expand roads but provide more for buses and bicycles
- 3% Expand current roads; people prefer traditional suburbia

a new generation of planners will embrace big data for transportation planning (Airsage)

- "The next generation of planner will no doubt embrace digital studies because they accept the credibility and cost of the new technology."
- "There's no question that cell phone data will replace all other surveys."

millennials want more digital amenities in public transit (APTA)

- "Millennials would like to see in the next ten years:
  1. 61% more reliable systems,

  2. 55% real-time updates,

  3. 55% Wi-Fi or 3G/4G wherever they go,

  4. 44% a more user-friendly and intuitive travel experience.

  Fully leveraging technology, through real-time transit applications that connect users with community amenities, through smartphone fare payment, and the provision of WiFi and 3G/4G, will allow transit users to be more spontaneous, thus addressing the key competitive advantage of the car."

V2V and V2I road network as backup telecommunications system during disasters (Shaeen et al)

- "As cell towers may be damaged or destroyed in the event of a severe storm, the road network could act as a redundant communications network. Provided that the roadway sensors were advanced enough to transmit data through fiber, dedicated short range communications, or Bluetooth®, the emergency app signals could align with transmissions made by road sensors to ensure connectivity in a disaster. This auxiliary network would need to be designed and built to survive severe storms and flooding. As with the evacuation app, it is important that the public be educated that such a network exists so they know to find a road to ensure that their distress signals reach emergency responders."

ITS will play a role in evacuation from natural/man made disasters (Shaheen et al) Intelligent transportation systems will play a role in evacuating from natural and man made disasters.

- "ITS Role in Evacuation In order to preserve lives, ITS could be adapted to efficiently and effectively evacuate people. This new role for ITS could mitigate the effects caused by the disproportionate access to vehicles that adds to the casualties and suffering caused by natural disasters, such as Hurricane Katrina and Sandy (27). Apps could be developed to assist in evacuation in lieu of individual auto access. In-vehicle and handheld device apps could help organize ridesharing and inform evacuees about available modes near their location. Incentives could be tied to these apps to encourage people with extra space in their vehicles to offer rides to other evacuees. In addition, if apps included location awareness technologies, governments would have information on the location and number of people needing evacuation and could use it to more effectively dispatch evacuation shuttles. It is essential that the public be aware of these technologies prior to a disaster to ensure that they are used properly. The government or other organizations could inform people about the apps and encourage their use as part of warnings prior to storms."

passive tracking of drivers will help build and validate crowdsourced maps, like the one used by Telenav, the first ever based on OpenStreetMap (Quain)

- "Increasingly, however, mapmaking is becoming a more passive pursuit. Simply by driving, users are automatically submitting information over their phones about their routes and the roads they travel. It's the collection of such data that acts as a check on possible crowdsourcing errors."

preferred signalling as a fuel efficiency measure (Torbert and Herrschaft) Intelligent self-driving cars will communicate with traffic lights to maximise fuel efficiency.

- "Driverless cars connected to the traffic light system could communicate with an upcoming light and have it stay green or change to green, so that you could maintain cruising speed and optimal fuel efficiency (not to mention avoiding an unnecessary delay at the light)"

connected cars as road maintenance sensors (Torbert and Herrschaft) Connected intelligent vehicles will communicate possible danger to one another,

- "By feeding information into (and obtaining info from) a shared database akin to the smartphone app Pothole Alert, they could avoid road hazards or even notify the local highway department or department of public works to road repair and maintenance needs. "

self-driving vehicles will platoon to increase speed and efficiency (Torbert and Herrschaft)

- "But what if driverless cars—by being able to safely maintain much closer following distances in platoons than human drivers—could actually increase the speed of peak efficiency? We'd get places faster while still using less fuel."

in TRANSFORMATION - lots of biofuels vs EVs, easier and more organic (sic) to deploy biofuel infrastructure than EVs)EV charging networks won't be necessary because most vehicles will be hybrids (Berg)

- "'In the future, everything will be a form of what we now call a hybrid,' says Timothy Lipman, co-director of the Transportation Sustainability Research Center at UC Berkeley. He foresees a greater variety of hybridizations combining oil, natural gas, electric batteries, hydrogen fuel cells and maybe some as yet undeveloped alternative fuel options. He agrees that battery technology will continue to improve and therefore increase the range cars will be able to travel using just electricity. But, when combined with other fueling technologies, there'll be something to supply more power when the battery runs out, potentially making public charging infrastructure largely irrelevant. GM's Britta Gross agrees. 'These sort of bi-fuel mixtures mean we don't have to wait for infrastructure. We don't have to wait for everyone to figure out how infrastructure happens,' she says, noting its expense. 'It should not be an issue. Public charging is not a necessity.' She calls public charging infrastructure like Superchargers 'nice for awareness.'"

in 2030, automated delivery vehicles to smart homes (Burns) By 2030, automated delivery vehicles will deliver to "smart" homes.

- "At 11:30, as a victorious Sophia trades her karate uniform for something better suited for her sister's graduation, Sam receives a text message confirming that a small temperature-controlled pod has delivered the appetizers for Sally's party in the secure, refrigerated drop-box at the house."

smart on-demand carpooling (Roberts, Feb 1) Smart cars will locate passengers willing to share rides nearby, and automatically create a carpooling network.

- " If cars are smart, they will be able to create carpools, on the fly, for those willing to save a little money by sharing rides. All cars will know where all other cars and all car requests are at any given time; they will be able to communicate and coordinate to consolidate as many riders as possible as efficiently as possible. Carpooling will become the default: a dynamic, just-in-time form of public transportation."

conversion of suburban garages (AT - to housing, small fabs and workshop) (Roberts, Feb 1) Much land will open up as declining car ownership will eliminate the need for garages.

- "think about the last time you drove around in an American suburb. Imagine if all those houses didn't need garages. What could all the extra space be used for?"

safer automated cars can be much lighter, saving energy and road maintenance (Roberts, Feb 1) Self-driving cars can be significantly lighter than normal vehicles, which will save energy and decrease road maintenance.

- "With human error out of the picture, cars won't need to be so heavy. Right now we drive around in huge steel tanks, up-armored to protect against high-speed collision from any angle. With collisions minimized or eliminated, cars can be made from far lighter materials, reducing stress on roads and resource consumption."

ride sharing and private services will provide a fallback to public transit disruptions (Hull)

- "In a blog post, Sidecar said that "in times of crisis, this is when alternative transportation services like Sidecar are at their best." The San Francisco-based startup has asked all of its East Bay drivers to turn on their driver app when they commute, so they can fill empty seats and help additional commuters get in and out of the city. And the company, which makes money by taking a cut of the fees that riders pay to drivers, is letting all drivers keep those passenger donations between 6 a.m. and 7 p.m. on weekdays. Uber has also seen an increase in demand, particularly from the East Bay. "This strike is an important illustration of why more transportation options – particularly low-cost options like uberX – are important for consumers, businesses and cities," said Uber San Francisco General Manager Ilya Abyzov. "It means that in the event of a strike, residents and visitors can rely on Uber to commute to work and get around the Bay Area without breaking the bank.""

cities organized around shared EV fleets will become self-sufficient energy systems (Roberts)

- "The authors envision USVs converging with other technologies -- rooftop solar panels, small wind turbines, geothermal heat pumps, cogeneration systems, large-scale batteries, smart grids -- to create a new kind of power system in which cities are generating, managing, and distributing all or most of their own electricity. This kind of local, distributed power system will eliminate the high cost of transmission lines bringing power from a distance, reduce smog and other particulate pollution, eliminate dependence on foreign energy, and, at the limit, make possible carbon- neutral cities."

vehicles will become smaller and slower to integrate with cities (Roberts)

- "Second, today's automobiles are wildly overbuilt for the purpose of getting around cities. Most are capable of speeds over 100 miles per hour and distances of more than 300 miles without refueling. Yet average speeds in cities range from 10 miles to 25 miles per hour, and 80 percent of Americans drive fewer than 50 miles a day. We need go-karts, but we're driving tanks."

revenue from parking tickets will vanish ($80m a year in DC alone) in a world of automated parking payments (Bilton, July 9 2013) revenue from parking tickets will vanish in a world of automated parking payments

- " the parking ticket could vanish from the future city as cars park themselves and refill parking meters electronically. (If there even are meters in the future.)"

drone networks will be more likely to find success in congested rich cities, even if rural poor is where the technology is proven (The Economist, Dec 1, 2012)

- "For the delivery of drugs in developing countries, a rider on a motorbike may be a much simpler and more rugged solution. Maintaining a network of drones—a complex, immature technology—is unlikely to be easy, particularly in the remote areas that Matternet intends to target. It may be that congested city centres in rich countries will prove a more promising market."

UAV delivery systems will operate around a network of base stations, and not direct delivery to recipient (The Economist, Dec 1, 2012)

- "Rather than having a drone carry each package directly from sender to recipient, which could involve a long journey beyond the drone's flying range, the idea is to build a network of base stations, each no more than 10km (6 miles) from the next, with drones carrying packages between them. After arrival at a station, a drone would swap its depleted battery pack for a fully charged one before proceeding to the next station. The routing of drones and the allocation of specific packages to specific drones would all be handled automatically, and deliveries would thus be possible over a wide area using a series of hops. It is, in short, a physical implementation of the "packet switching" model that directs data across the internet, which is why its creators call their scheme the "matternet"."

indoor tracking will power advances in asset management (Hardy)

- ""The world is going to be incredibly optimized," said Simon Thompson, the director of commercial relations at Esri, a company specializing in geospatial analysis. It already uses maps for predictive policing, forestry management and disaster preparedness. In the future, he said, "indoor knowledge will become a resource. Hospitals will manage equipment better. Sports stadiums will know where to put the beer taps.""

drone delivery will build a physical Internet (Raptopoulos in Lee)

- "the big potential of this technology is to create a physical Internet: a network that would allow us to transport packages between locations in an autonomous way. It would be a new type of transportation infrastructure."

drone delivery will be like mobile phones - a solution to the last mile logistics problem (Raptopoulos in Lee) Drone delivery networks will become as extensive as those of cell phone companies.

- "Imagine if this type of network could be as big as mobile telephony. Imagine if you had transportation networks able to solve the last-mile delivery problem. It could be frictionless, cost-efficient, energy-efficient, and very scalable, with very little infrastructure investment."

drone delivery will become more reliable (Raptopoulos in Lee)

- "You have a level of reliability that countries with bad roads have never seen before. Eventually we'll have urban delivery with cost savings. It can be automated to a very large degree."

the web allows people to explore options before relocating, reducing residential mobility over time (Kaplan and Schulhofer-Wohl)

- "We analyze the secular decline in interstate migration in the United States between 1991 and 2011. Gross flows of people across states are about 10 times larger than net flows, yet have declined by around 50 percent over the past 20 years. We show that micro data rule out many popular explanations for this decline, including aging of the population, the rise of two-earner households, other compositional changes, regional changes, and the rise in real incomes. We argue instead that the fall in migration is due to a decline in the geographic specificity of occupations and an increase in workers' ability to learn about other locations before moving there, through both information technology and inexpensive travel."

evolution of local car sharing from rent-and-return to one-way (McGrane) Car sharing evolves from traditional rent-and-return policy, to one-way use, which has become highly popular.

- "Since the first commercial one-way car-sharing systems started in Germany two years ago, 183,000 people have signed up, according to Bundesverband CarSharing — a large number, considering that long- established car-sharing systems in Germany have 262,000 members. Car2Go has started service in 11 North American cities including Austin, Tex., Seattle and Washington. DriveNow is in San Francisco, but it uses the older station-based model. "It's going to alter what car sharing is," said Susan Shaheen, co-director of the Transportation Sustainability Research Center at the University of California, Berkeley. "We didn't have the technology to do this in the '90s.""

autonomous mobility-on-demand systems: EVs that can be delivered from docks to users on request. can also re-balance system themselves automatically (Chin) Intelligent self driving cars will be able redistribute themselves based on demand.

- "Unlike bicycle share programmes that suffer from redistribution problems (such as too many bikes in some locations and none in others), the A-MoD system could simply deliver a vehicle to a user. Once the user is dropped off, the shared LEV will drive on its own to pick-up another user, or to park itself for recharging."

Diverse vehicle sizes will allow carshare users to select the car they need. (Mui) the distribution of vehicle sizes will change significantly in a world of massive car sharing

- "Today many buyers buy cars based upon occasional usage scenarios: Buying minivans to accommodate the occasional family outing or car-pooled soccer game. Buying SUVs for the weekend excursions or large load. Buying the second car for the one or two days a week when having it is critical. In fact, most of the time, cars carry just one or two

passengers on a known commuting route. Car sharing would allow riders to call for the car that they need for each particular. This means that, with massive car sharing, the cars needed most of the time could be small electric cars— a huge contrast to the large expensive cars from which auto companies make most of their profits today."

Walmart has a long-haul fleet of 6000 trucks - autonomous trucks could cut fleet size by 1/3, with vehicles half their current size.  (Conway)

- "But the total cost of outfitting a truck with equipment and software could be as much as US$200,000. Although the savings created by autonomous vehicle technology will vary, they could exceed $100,000 per truck annually. The gains would far outstrip the initial investment. The Center for Automotive Research estimates that driverless trucks would increase fuel efficiency by 15 to 20 percent. Accident-related expenses and insurance premiums also could decline, because automated trucks would be programmed for maximum safety, eliminating the driver errors that cause most crashes. Higher asset utilization rates would reduce the need for capital spending on additional trucks." "If truck driving shifted to off-peak periods, which is a viable option in a driverless vehicle, highways would be less congested. "On the technical front, driverless trucks could reach commercial viability within a decade" "if existing trucks can be retrofitted as autonomous vehicles, the current national fleet could find itself 30 percent over capacity" "For example, some companies may opt for "remote- control trucking," in which a driver pilots a truck hundreds of miles away through a complex environment of local roads until the truck gets onto the highway. At that point, a more basic, less expensive autonomous system designed for the relatively simple environment of highway driving would take over. This could be a palatable option for legislators and the public." "We won't see highways dotted with driverless trucks in the near term. But the economics suggest that over the long term, the industry will migrate to autonomous vehicles."

Traffic can be improved through diverting cars by blocking off certain streets.  (Youn, et al)

- "Our simulation shows that uncoordinated drivers possibly waste a considerable amount of their travel time. Counterintuitively, simply blocking certain streets can partially improve the traffic conditions."

automated cars and coordinated signals will reduce need for speed and acceleration (Templeton) The perfect timing of self-driving cars will reduce the need for speed and acceleration in cars.

- "While electric vehicles all have good acceleration, an ideal robocar trip is perfectly timed with traffic lights and other traffic so it does not stop and start regularly. We like this because it's more efficient, but it also means that acceleration is rare, and need not be that zippy. Indeed, for comfort, you may prefer it slow. Vehicles meant just for urban trips need not even be capable of highway speeds. Vehicles only for long trips need not be fully efficient at slower speeds. If passengers find a pleasant working/talking/reading/viewing environment in the vehicle, trip time may become less

important than comfort. If the passenger can work efficiently while in the vehicle, they might accept a longer trip to be cheaper or have fewer stops. Such vehicles do not need to be fast."

hybrid system of very remote and local depot parking for self-driving cars (Templeton) A hybrid system of very remote and local depot parking will be used for the storage of self-driving cars.

- " If there is a good estimate for when they will be needed (commute times, fixed length events) they can park, if need be, remotely for a while, and then park more closely around the estimated time of need."

Reliable, short travel times (Templeton) Self-driving cars will offer reliable, short travel times.

- "The robocar is not a teleporter, of course, and people will not completely disregard travel time. Robocars may offer reliable and quick travel times over short distances. Today a two mile trip can involve traffic congestion, finding and getting in and out of parking and more. The robocar should create a larger zone of destinations that can be reached in very short times, like 5 minutes. This may confer other advantages on density, allowing a dense 2-3 mile zone with a million people who can all get anywhere in under 10 minutes."

More ability for walking and mode-shifts (Templeton) Advances in transportation will give people many options for commuting.

- "Robotaxis offer a novel ability for car-users to take one-way trips. This means that having a car take you one place, walking a mile and having a car take you back home is entirely practical. Other mode shift trips, like car-subway-car, or "train downtown, car-back-home" or "carpool to work, robotaxi back home" become practical."

Delivery Robots (Templeton) Convenient "deliverbots" will be used frequently for delivery.

- "The "Deliverbot" might deliver just about anything in under 30 minutes, not just a pizza. Quick delivery warehouses could send you almost any product in less time and for less money than it would take you to pop out to a nearby store and get it, as long as you don't need to see it in hand to select it. (Don't like it? Send it back and get something different in a very short time.)"

elimination of residential garages (Templeton) The decline of car ownership will cause the elimination of residential garages.

- "People also will have less need for garages in their homes. This allows an increase in urban density for walkability."

expanded area for just-more-than-walking trips (Templeton) Self-driving cars allow pedestrians to easily reach their desired, walkable area.

- "Robocars may expand the zone considered proximate to these attractions by offering a quick, on-demand trip in 1-2 minutes total time to the walkable zone. They are likely to

encourage polycentric urban spaces by offering public (taxi) transportation that is not tied to corridors."

bikes on demand, self-driving cars portage bikes for one-way journeys (Templeton) Self-driving cars offer portage for bikers to get to specific locations.

- "The robocar also offers easy transportation for you, and your bikes, to the places where it's fun to bike. Get driven to the coast, then bike it, then get driven back from your endpoint. Or bike the "interesting parts" and drive the boring (or difficult) ones."

people only walk, goods travel by robot (The Economist, 2010) While most people will travel by foot, the movement of goods will be carried out by robot delivery systems.

- "Another, more radical step would be to question the notion of personal mobility itself. At the moment, people need such mobility because there are things they want to bring home as well as places they need to get to. Electronic networks may change that. It is not completely far-fetched to imagine charming, vast and dense cities in which most human movement takes place on foot while most movement of goods is by robot delivery systems."

drones as "guardian angels" - protecting cyclists, rescuing people in burning buildings, searching for avalanche survivors (Frog Design)

bioswales replace parking (Arup) As parking needs are reduced, parking spaces are replaced by bioswales.

- "plant parking - storm water green streets replace much of the space formerly devoted to street parking"

New York City restaurants delivering to non-office or residential locations, using phone technology to deliver to non-traditional location (parks, people waiting in cars for alternate-side parking (Yee)

rise of e-commerce increases traffic (Jaffe) The rise of e-commerce will result in increased traffic.

- "Consider it this way: people around the world seem to have a travel time budget of a little over an hour each day [PDF]. Before the rise of e-commerce, part of that time would have been spent in the service of purchasing goods. But if that budget remains fixed, then people today may simply buy something online, then hop in a car and go visit a friend across town. In that scenario, personal travel stays constant while commercial travel increases — a net gain of people and goods on the road." (Jaffe, August 2, 2013) expansion of e-commerce will make last-mile freight a growing problem. ""It's definitely — from what I explored — it's an issue and it's going to be a growing issue as we move into the future," he says. "To get the word out that this is something people haven't thought about before, I think is key.""

private sector transport innovations put private, not public capital at risk, and pay off more quickly (Salmon)

- "One reason is simply fiscal. Projects like the self-driving car, and the Sartre platooning project in Europe, move the costs of new technology onto companies (Google) and individuals (people buying smart cars). As such, while the total amount of money spent might well be enormous, the money doesn't need to be spent up-front by any state or national government. That stands in stark contrast, of course, to rail projects, which cost billions of dollars up front; if they ever do pay for themselves, they do so only very slowly."

recovered land from reduced parking needs (Chase) As car sharing becomes more popular, reduced parking needs will result in significant recovery of land.

- "While the hell vision results in gridlock everywhere, this heaven vision takes all those personal cars — now parked 95 percent of the time — off the streets and out of garages. We can repurpose those lanes to trees, bike lanes, sidewalks, play spaces, bike parking, café expansion, community gardens, or even swimming pools. It's not too early to consider this alternative universe."

## conflicts

conflicts between more intense AV traffic and peds/cyclists (Geeting) The use of self-driving cars could cause conflict between AV traffic and pedestrians/cyclists.

- ""Congestion's not going away," Lockwood predicts. "This is something you're going to hear a lot of people say — that Google cars can get five times more cars through intersections than now, since they'll drive closer together. How's that going to feel for pedestrians and cyclists? It's going to be like a machine gun spray of cars down the street.""

US land use and transport planning processes are inherently not agile/VUCA-proof. only concern themselves with factors under their control (Bartholomew and Ewing)

- "Business-style scenario planning focuses on influences that extend beyond the control of the agency doing the analysis (Smith, 2007) to articulate a range of risks and to develop a commensurate range of responses. When the technique was grafted onto 3C and NEPA-style processes, however, this dimension was suppressed in favor of trans- portation agencies' more traditional approach, which varies only the transportation investments and land use policies arguably under local and regional governmental control. There are, of course, many other factors that influence travel choices and patterns, including the potential effects of large-scale economic and environmental issues like peak oil and climate change."

established vs new entrants to transportation (Sadowski) The widespread use of drones will require sets of new laws to maintain safety and the privacy of individuals.

- "Industries that are heavily regulated, with widespread use of drones will create conflicts over flyover rights and privacy "While the proper authorizing paperwork may become easier to obtain, drone operators will also have to consider other laws. In particular, Calo pointed to the fact that "although trespass law no longer grants ownership rights 'to the heavens,' landowners still own the air rights above their land that they can reasonably use. Thus, drone-based delivery systems will have to take care not to fly too close—whatever that means—to private property." Last month, National Geographic photographer George Steinmetz was arrested for flying a paraglider over a feedlot. An Explainer column points out that the airspace rights on private property probably extend to an altitude of 80 to 500 feet. It should be no surprise that a flying robot would ignite worry and confusion about traditional concepts of property and privacy. Therein lies another reason why something like the drone network has much more potential in other countries where legal restrictions aren't as stringent."

liability and safety issues of drones (Sadowski) The use of drones will cause liability and safety issues.

- "Dangerous malfunctions are a realistic hazard, for instance, and the risks have to be seriously considered before we jump on board with this new innovation. "Given the rate of gravity, it doesn't take much height for a dropped item—or a plummeting robot itself—to be harmful or lethal, whether intentional or not.""

Planning cycles are out of whack with the need to adapt quickly to changing threats. NYCT Transit's $530 million overhaul of Whitehall Street subway station improved throughput and disabled access, but wasn't modified to deal with sea level rise and flooding, and the experience of Sandy was catastrophic. (Rose) As shown by superstorm Sandy, in is necessary that urban infrastructure be prepared for extreme circumstances.

- "The $530 million project was completed in 2009, and as projected, significantly increased the throughput capacity and comfort of the station. However, because of the very long planning, engineering, funding and procurement cycles, the project was set in motion before the risks of a more volatile climate and rising seas were being taken seriously by the transit community. As a result, only three years later, the rising seas of Superstorm Sandy swept across Lower Manhattan and flooded the South Ferry station with salt water, destroying much of what had just been built. The repairs are projected to cost $600 million and won't be completed until 2016."

Unions will oppose the use of driverless trucks, as it would likely result in the loss of jobs. (Conway)

- "the use of driverless trucks is likely to face opposition from unions and their political allies as they are faced with the elimination of hundreds of thousands of truck driving jobs."

# STATISTICS &

# QUANTITATIVE FORECASTS

worldwide safety stats and impacts (de la Peña)

- "Nearly 1.3 million people die and 20 to 50 million people sustain injuries in urban road accidents each year; 70% of these deaths occur in developing countries and generate a direct economic cost of 1% to 2% of worldwide GDP. A majority of such victims are poor pedestrians and bicyclists, mostly between 15 and 29 years old."

Increased ride-sharing is reducing car sales (Lev-Ram)

- "Research indicates that 32 new-vehicle sales are lost for every car added to a ride-sharing fleet."

Los Angeles - world car capital (Lev-Ram)

- "With more than 6.1 million registered automobiles and a population of about 10 million, the L.A. metropolitan region has more cars per capita than any other urban area in the world... Angelenos clock a combined 300 million miles every day (each of them spends an estimated 90 hours a year just sitting in traffic jams, which is more time than they devote to procreating or brushing their teeth)."

decline in youth driving licenses (Lev-Ram)

- "Today only 77% of Americans ages 20 to 24 have a driver's license, down from about 90% in the early 1980s."

reduction of unwanted interactions with police from self-driving cars 26.4 million contacts with police from traffic stops; 68.1% could be eliminated with self-driving cars (Sottek)

limits on throughput of roads, even with AVs (Badger)

- "Theoretically, a highway [lane] can carry 2,200 vehicles per hour," Lutin says. "Even if you go to 4,400 or 6,600 vehicles per hour, there's still that limit."

nearly 1 billion cars and trucks on earth, costing trillions of dollars a year on personally-owned vehicles (Burns et al)

3.8 m jobs at risk from automated driving (Geeting)

- "3.8 million people whose jobs Level 4 automation could send the way of the telephone operator, including truck and taxi drivers, subway and streetcar operators, train engineers,"

truck drivers create large labor costs (Geeting)

- "Labor costs eat up 61 percent of the budget at unionized UPS and 43 percent at non-union FedEx."

cost of parking infrastructure (Geeting)

- "motorists pay just 1 to 4 percent of the cost of the parking supply in user fees. The rest of those costs are hidden in the prices for everything else. The Sightline Institute recently found that off-street parking requirements cost Seattle renters $246 a month on average."

excess land used for parking (Geeting)

- "current parking codes have made it so there are between three and eight parking spaces for each of the 250 million cars in America. If the number of personal cars dropped and parking provisions were loosened, as many as 675 million parking spaces, particularly those in urban cores, could be turned into something else — housing, parks or a million other uses more desirable than street-deadening parking lots."

transportation is 27% of US GHG emissions (2010), 2nd largest after electric power (RITA)

costs of road accidents (RITA)

- "Highway safety is one of our nation's major public health challenges, responsible for 32,885 fatalities in 201012 and the leading cause of death for people between the ages of 4 and 34.13 NHTSA estimates the economic impact of motor vehicle crashes on U.S. roadways is $230.6 billion a year, nearly 2.3 percent of the nation's gross domestic product, or an average of $820 for every person living in the country. NHTSA has reported that the average roadway fatality has economic costs of $977,000, while the costs associated with a critically injured crash survivor surpass $2 million.14 Although these statistics reflect a recent decrease in the number of fatalities, they represent an unacceptably high loss of lives."

cost of traffic congestion (RITA)

- "Traffic congestion is an $87.2 billion annual drain on the U.S. economy — more than $750 for every U.S. traveler. Americans waste 4.2 billion hours in traffic every year or nearly one full work (or vacation) week for every traveler."

congestion has tripled on US roads in last 40 years (Zmud et al)

- "However, growing congestion is a critical issue in the United States. The Transportation Research Board (TRB) has called the early 21st century the era of congestion (Executive Committee, 2009). For example, yearly hours of delay per auto commuter in large urban areas, on average, have almost tripled from 19 hours in 1982 to 52 hours in 2010. Even in medium-sized urban areas, average yearly hours of delay tripled during the same period from seven to 21 hours (Shrank and Lomax, 2012)"

Population jumps to 360M Americans in 2030, up about 16-17% from 2010 (Zmud et al)

- "For example, the U.S. Census Bureau projects that the U.S. population will grow from 308 million in 2010 to about 360 million in 2030"

travel demand models are only updated every 5-10 years in many places, due to cost (Airsage)

- "The traditional "gold standards" in compiling origin-destination data—household travel surveys, vehicle intercept surveys and license plate surveys—are being supplanted by

new technologies. The pros and cons of household travel and vehicle intercept surveys are well documented. Both generate detailed traffic and demographic data. However, they are costly, limited in the geographic area that can be surveyed, and can require months—or even a year or more—and significant personnel and other resources to complete. Because of the time and costs, many jurisdictions only have the resources to update their travel demand models using traditional methods every five to 10 years, or even less frequently."

younger planners more technology-friendly (Airsage)

- "Age and enthusiasm for new technologies goes hand in hand" in the transportation planning workforce. of respondents age 29 and younger 65.4% "strongly prefer" technology-based solutions vs 81.4% over age 57 who are "very skeptical"'"

millennials are much less white than previous generations  (APTA)

- "40% of Millennials are African American, Latino, Asian or racially-mixed compared to only 25% of the next two older generations."

by 2050, US population 400m, 20% immigrants (Shaheen et al)

- "The U.S. Census Bureau forecasts that the U.S. population will exceed four hundred million people by 2050 (10). In 2010, 13% of the American population was foreign born. Pew Research predicts immigrants will comprise 19% of the U.S. population by 2050"

Uber is over-valued (Mims)

- "Even the most aggressive estimates of Uber's value — let's assume the company captures 50% of the world taxi market in 5 years — mean the company would still be worth less than $18.2 billion."

low transportation costs allow density to fall without compromising social interaction Ortman et al - (Ortman et al)

- "In the BOM we find values of a*0:2{0:3 ha (Table 1) that are relatively consistent across cultural periods. This suggests that the ratio of social interaction benefits to transportation costs did not change appreciably over time. However, in the census of 1960, a is almost twice as large as it had been in the pre-Hispanic periods, suggesting that modes of social interaction and certainly transportation technologies had changed in the direction of creating greater social incentive for interaction and/or less costly movement."

worldwide in 2011, 1.3m killed in auto accidents (Laursen)

- "Worldwide that year, 1.3 million people died from road injuries, making it the ninth-leading cause of death, according to a 2011 World Health Organization report."

each shared car takes 9-13 cars off the road (TRB)

- "n aggregate analysis suggests that carsharing has taken between 90,000 and 130,000 vehicles off the road. This equates to 9 to 13 vehicles (including shed autos and postponed auto purchases) taken off the road for each car sharing vehicle."

taxis complement rather than compete with transit (Jaffe)

- "A quick rehash of some of that evidence for those who missed it last time around. In one study from years back, Bruce Schaller, a former policy director for the Taxi and

Limousine Commission of New York City, modeled cab use in 118 U.S. cities and found that two of the most significant predictors of taxi demand were subway commuting and being car-‑less. In other words, taxis made it easier, not harder, to live in a city without driving a car."

enormous latent demand unlocked by self-driving cars (Plumer)

- "More and more people will drive. Think about all the people who are not allowed to drive right now. Everyone under 16. The elderly. The disabled. People who are intoxicated or on medication. People who are sleeping. That's a huge portion of the population. And all of those people will be able to ride in driverless cars. And that means we could see many more car trips."

self-driving cars undo peak driving: they are ideal cars for Millennials

driverless cars could be up to 80% lighter (Plumer)

- "Driverless vehicles could also, in theory be much, much lighter — since collisions will no longer be a big concern. Cars that currently weigh 4,000 pounds could one day weigh just 750 pounds. That development alone there would nearly double energy efficiency."

During Jully 2013 BART strike, (Geron)

- "Ride sharing apps such as Lyft, Sidecar and Uber have reported a spike in ridership–for Sidecar 50% more drivers were on the road and there was a 40% increase in rides."

cost of a Tesla supercharger station (Berg)

- "Each Supercharger station is estimated to cost between $100,000 and $175,000, and Tesla is picking up the entire tab — from installation to maintenance to the cost of providing the large amount of energy needed to charge their cars so quickly."

wages in transportation industry were stagnant/declining long before the recent period of innovation, esp. ride-sharing (Rajarman)

- "The average national wage (whose natural growth has lagged behind inflation since the late 2000's economic crisis) increase far outpaces the wage growth for both the housekeeping and the transport industries. The size of the wage growth gap started accelerating in the early 2000's, and has been increasing steadily ever since. This difference appears unaffected by the market crash and was present long before smartphones -- the preferred medium for many new tech companies -- received massive adoption, and therefore long before Uber, Homejoy and other services like these existed. The workers in transportation and housekeeping have been faced with decreasing work prospects for longer than the past decade."

Uber's massive impact on taxi business in Boston - 30% (Seelye)

- "Ride-sharing services like Uber, which allow customers to hail cars — and now, even water taxis — on their smartphones, have disrupted Boston's traditional taxi industry, which says that Uber has taken away 30 percent of its business."

lightweight 2-seat vehicles would meet most US car needs at much lower cost and energy (Burns)

- "For example, lightweight, two-passenger vehicles can be up to ten times more energy efficient than a typical car. In the United States, where 90% of automobiles carry one or two people, reliance on such vehicles would result in a dramatic decline in carbon emissions, which would fall even further as a result of less road congestion and smoother traffic flows. Moreover, the land and infrastructure needed for parking would be significantly reduced. Under such a system, personal mobility could cost up to 80% less than owning and operating a car, with time efficiencies augmenting those savings further. For Americans earning minimum wage ($7.25 per hour), time spent driving at a rate of 30 miles (48 kilometers) per hour costs $0.24 per mile. At the US median hourly wage of $25, each mile costs $0.83. Given that Americans drive roughly three trillion miles annually, saving just one cent per mile implies $30 billion in annual savings."

50 percent of new cars in 2019 have voice-activated systems (Richtel and Vlasic)

- "More than half of all new cars will integrate some type of voice recognition by 2019, according to the electronics consulting firm IMS Research. The auto companies argue that these systems are safer because they are hands-free."

Millennials searching for transportation diversity (Transportation for America)

- "Four in five millennials say they want to live in places where they have a variety of options to get to jobs, school or daily needs, according to a new survey of Americans age 18-34 in 10 major U.S. cities, released today by The Rockefeller Foundation and Transportation for America."

driving's cost Drivers kill 34,000 per year in the USA – #3 in years of life lost (Templeton)

- 1.2 million die worldwide

- 12 million accidents, 1.8 million with injuries

- $230 billion cost of accidents: 2.5% of GDP (8 cents/mile)

- 50 billion hours spent driving, 240 billion spent working

federal government telework deficiency (Global Workplace Analytics)

- "the latest Status of Telework in the Federal Government report showed that while 32% of federal employees are deemed eligible for telework, only 6% do so on a regular basis. And while private sector telework grew 42% between 2006 and 2012 and state government telework grew 60%, federal telework actually declined 2.4%."

Matternet deployment costs (The Economist)

- "A case study of the Maseru district of Lesotho put the cost of a network of 50 base-stations and 150 drones at $900,000, compared with $1m for a 2km, one-lane road."

rideshare users also are transit users (Peterson)

- "Surveys by ridesharing companies promote the idea that their service complements mass transit; Sidecar found that, after ridesharing, 53% of people who use its service also use public transportation — almost double the response for cars."

Trucker's logbooks are dated, as well as inaccurate (Janson)

- "Three million truckers today still use paper logbooks, although it's widely acknowledged that information in driver log books is often less than truthful."

LA drivers faced with continuous road congestion (Stewart)

- "A recent study indicated that commuters in LA spend around 60 hours per year in congestion."

V2V communications could reduce non-impaired crashes by 80 percent (Zax)

- "The National Highway Traffic Safety Administration has already estimated that vehicle-to-vehicle communications technology like what's in these Ann Arbor cars and on these Ann Arbor roads could reduce "non-impaired crash scenarios" (read: crashes caused by sober drivers) by 80 percent. "That's bigger than seatbelts, bigger than airbags," says Belcher. "Basically, you're creating cars that don't crash."

Many US drivers on the road for shopping (Leber)

- "30 percent of all miles driven in the U.S. are related to shopping."

Usage of personal vehicles is down (Jaffe)

- "Right now less than 17 percent of U.S. household vehicles are in use at a time. "

Parking in the US makes up massive real estate (Mui)

- "One estimate is that the parking spots in the US add up to the equivalent of the size of Connecticut—with much of this real estate in dense, high priced urban centers."

Cars prove to be among the most dangerous forms of transportation (Mui)

- "Every year, more than 1.3 million people die in car accidents worldwide, and more than 50 million are seriously injured. In the US alone, more than 34 thousand die and 2.2 million are injured in over 5 million accidents. 90% of these accidents are caused by human error."

Vehicle accidents valued at $450B (Mui)

- "The economic benefits and business disruptions of this accident reduction is enormous. In the US alone, the direct and opportunity cost associated with vehicle accidents amounts to about $450B."

Growing elderly population (USAToday)

- "The nation's population of those 65 and older will double between 2000 and 2030, according to the federal Administration on Aging. That adds up to one out of every five Americans — 72.1 million people."

Private vehicles spend majority of time not in use; are they worth the cost? (Neil)

- "Mr. Burns noted that private vehicles spend 90% of their time parked and unoccupied."

In 2011, Americans were involved in more than five million auto accidents, with more than 32,367 killed. The cost to the U.S. economy in mayhem, lost productivity and lives totals $300 billion per year, according to the AAA. (Neil)

Driving ability down as a result of aging and disability (ArupConnect)

- "People now unable to drive because of age or disability — 25% of the US population — could become enfranchised."

The rise of car sharing causes drop in parking (ArupConnect)

- "Indeed, if the system is designed properly using a shared fleet and is widely embraced, required parking should drop to 20% of what it is now, said Paul Godsmark, chief technology officer of the Canadian Automated Vehicles Centre of Excellence in Ottawa."

Autonomous vehicles increase the efficiency of freeways by anywhere from 100 to 300 percent, mostly by having them behave more like a networked rail system. (Arieff)

Without intervention, traffic crashes would become the fifth leading cause of death by 2030, according to the World Health Organization. (Flegenheimer)