Meeting Mobility Challenges in an Increasingly Mobile World: An American Perspective

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Abstract

Accompanying economic prosperity is increased demand for mobility. This paper critically examines initiatives that have sought to accommodate mobility demands in the United States, though in a more resource-efficient and sustainable manner. Among the strategies have been demand-management tools, including value-pricing, carpool lanes, station cars, and land-use initiatives that promote walking and bicycling. E-commerce and other forms of virtual-mobility have spawn demands for new forms of transportation and distribution networks. The paper concludes sustainable mobility is possible in affluent countries like the United States, however only if motorists pay prices that begin to match true social and environment costs.

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1. INTRODUCTION

Rising demands for mobility is a truly global phenomenon. The desire to travel more and farther has generally accompanied rising economic prosperity. As incomes rise, so does travel, whether in the form of workers commuting longer distances, residents venturing farther to shop for everyday items, or households traveling to far-flung exotic places for vacation. However, in an ever-increasing resource-constrained world, growing concerns over ecology, economic sustainability, and social justice have given rise to public policies that aim to constrain mobility. In the United States, a slow but steady paradigm shift is underway in the transportation planning field, marked by an attempt to balance the traditional focus on enhancing mobility with a more even-handed approach that gives equal attention to accessibility. This has led to policy initiatives like "smart growth" and "New Urbanism" that seek create built environments that reduce the need to drive a car. Master-planned communities that strive for "jobs-housing balance" and that are "self-sufficient" also are derivatives of the idea that travel involves resource expenditures – whether in the form of time losses or clean air – that ideally should be minimized.

This paper addresses a host of issues that swirl around the rising demand for mobility, with a focus on the United States of America. Understanding the metropolitan mobility pressures being exerted in the United States is important not only because of the country's wealth and international influence, but also because of the disproportionate amounts of scarce and finite resources consumed in America's metropolitan transportation sector. In the United States, urban transportation is a rapacious consumer of natural resources and emitter of pollutants; for example, with less than 6 percent of the global population, America consumes nearly one-quarter of fossil fuels and emits a comparable share of carbon dioxide worldwide, much within the transportation sector. For these reasons, there is a ever-loudening chorus that is demanding America's transport sector be judged on the basis of sustainability — maintaining or improving, as opposed to harming, the natural environment. Sustainability argues for resource-efficient forms of mobility, such as metrorail systems that link planned urban centers in the case of big cities and dedicated carpool and bus lanes that reward efficient motor-vehicle use in smaller ones. Congestion pricing, parking restraints, and the development of alternative-fuel vehicles are other strategies that embrace sustainability principles.

However, despite such concerns, the demand for mobility continues unabated throughout much of the United States, a product of not only rising affluence but also trends like on-going suburbanization and decoupling of economic production and residential location, leading to the emergence of new communities in far-flung locations. For example, telecommunication advances continue to diminish the need for spatial proximity, liberating companies and households from their time-honored bondage to urban centers. The information highway, cyberspace, and the emergence of 'smart' office parks laced

with fibre optic cables and satellite dishes have freed many companies to spin off their lower-tier, back-office functions to the outer suburbs and beyond. Today's workers can handle routine communications and obtain information electronically from remote, less costly locations. Such mega-trends have had and continue to have profound implications for mobility as we know it.

2. Travel Complexity and Mobility

Many powerful mega-trends are working against the broader objectives of transportation planning – namely, in favor of increased automobile dependence and usage at the expense of concerns like accessibility, sustainability and livability. The post-industrial world has given rise to "travel complexity" -- the trend toward irregular, less predictable work schedules, the geographic spreading of trips, and increased trip-chaining (e.g., linkage of trips, such as from work to the child-care center to the grocery store to home). All of these trends favor drive-alone, "auto-mobility". The share of trips by carpools and vanpools has fallen throughout U.S. cities over the past two decades despite the construction of dedicated high-occupancy vehicle (HOV) lanes and aggressive ride-share promotion (Pisarski 1996). Ridesharing's decline in metropolitan Washington, D.C., traditionally one of America's strongest vanpooling markets, is rooted in the shift from predominantly government to increasingly high-technology employment; many of the region's software engineers and Internet-industry workers keep irregular hours and rely on their cars during the midday, making it nearly impossible to share a ride to work. The entry of women into America's workforce, which soared from 26 million in 1980 to 63 million in 1997, has fueled trip-chaining – nearly two-thirds of working women stop on the way home from work, often to pick-up children at day-care centers (Sarmiento 1998). Telecommunication advances continue to diminish the need for spatial proximity, hastening the pace of new growth on the edges of metropolitan areas and in far-flung rural townships. As growth continues to spread out, there is a widening mismatch between the geography of commuting (tangential and suburb-to-suburb) and the geometry of traditional transportation networks, which tend to be of a radial, hub-and-spoke design. Circuitous trip patterns and mounting traffic congestion, especially in the suburbs and exurbs, have resulted.

Collectively, evolving economic, demographic, and urbanization trends have formed new space-time arrangements, conspiring against all forms of movement except the private car. Figure 1 portrays this evolution along a space-time continuum. The traditional monocentric city with concentrated activities (e.g., downtowns and 8-to-5 work schedules) supported point-to-point rail services reasonably well. As technology advances gave rise to polycentric settlements and less regular time schedules, more flexible forms of collective-passenger transport, like bus transit and carpools, prospered. As cities and the regions of the future become increasing "non-centric" and time schedules less certain and predictable, the frontier of space-time possibilities has expanded considerably. An immense challenge faced by the transportation planning profession is how to pursue the balanced agenda of mobility, accessibility, sustainability, and livability in light of these protracted, complicating trends.

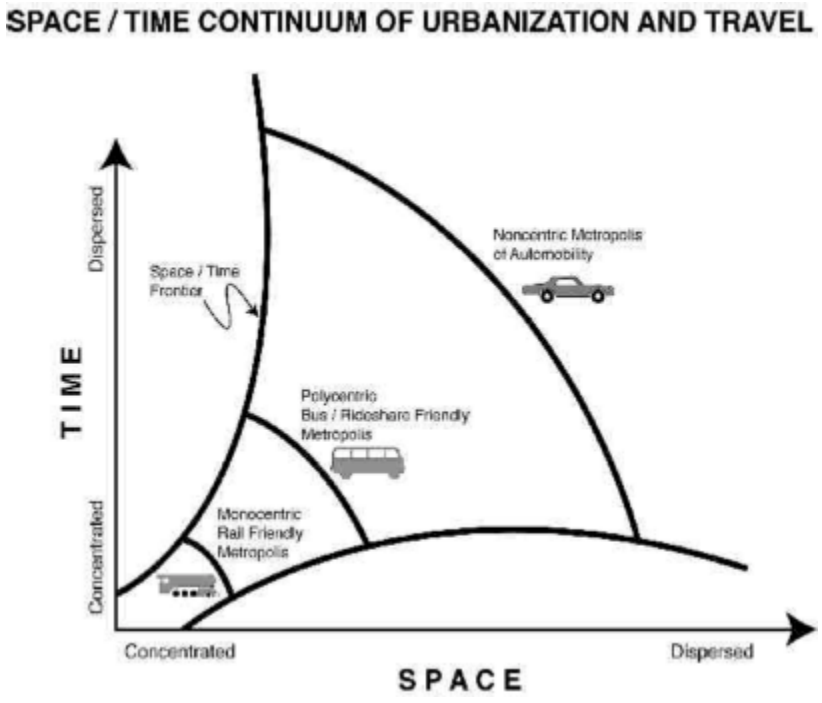

Figure 1. Space-Time Diagram of Urban Mobility Demands

3. Responding to Mobility Needs: The Example of Ridesharing and Priority Lanes

America is known internationally as having made reasonable progress in promoting its own unique form of "mass transportation" – individuals sharing vehicles to get to places, notably to work. Historically (and particularly during the energy crises of the 1970s), formal carpooling and ridesharing programs have been organized and managed through employers; Federal clean air legislation also placed considerable burdens on employers to prod their workers to share rides. In more recent times, carpooling has been organized across employees through regional ridesharing agencies. Increasingly, however, carpooling is a phenomenon of related individuals and family members sharing vehicles, such as in trip-chaining – a working parent drops off the kid, takes a spouse to a train station, and then drives to her workplace. Another form of ridersharing, found in metropolitan Washington, D.C. and the San Francisco Bay Area, is "casual" carpooling.

In the Bay Area, strangers pile into cars at rail stations and designated pick-up points to form 3-person carpools to save 20 minutes, plus $2, crossing the crowded Bay Bridge each morning, arguably the most laissez-faire form of transportation anywhere.

One of the most effective ways of spurring carpooling in America has been through the dedication of special lanes, called High-Occupancy Vehicle (HOV) lanes. Despite steadily increasing HOV-capacity, now close to 1,200 lane miles nationwide, carpooling and vanpooling continue to lose market share. During the 1980s, ridesharing fell by a fifth while the total number of commuters increased by a fifth; consequently, its share of work trips fell from 19.7 percent in 1980 to 13.4 percent in 1990. Larger carpools fared the worst -- 3-person pools declined by some 40 percent and 4-person pools by over 50 percent during the 1980s. Today, carpooling is predominantly a two-person phenomenon, made up mainly of family members heading to similar places at similar times. Carpooling, we should be reminded, is still the dominant form of "mass transportation" in the United States.

HOV Lanes: The Case of Houston, Texas

Houston, Texas provides a good snapshot of the mobility future of sprawling, minimally planned U.S. cities that seek to stem rising traffic congestion and promote alternative forms of mobility. There, the predominant form of "mass transit" is the private car with two or more occupants. To Houston's credit, the city has embarked on the build-up of a massive High-Occupancy Vehicle (HOV) program aimed at rewarding carpooling.

During peak hours, Houston's HOV lanes move between 96 percent (Gulf freeway) and 228 percent (Katy freeway) more persons per lane than general-purpose freeway lanes. Carpools make up 94 percent of the 38,000 daily vehicles that occupy Houston's HOV lanes. While buses comprise just 3 percent of the total, they account for 34 percent of the 80,000+ daily passenger throughput. High ridership is mainly attributable to time savings -- average bus speeds nearly doubled, from 26 mph to 49 mph, among express routes that switched to HOV facilities. In all, about 5 percent of the region's workforce uses HOV lanes each workday.

Houston's polycentric settlement pattern has helped sustain, and has been reinforced by, the HOV network. Greater Houston has as many widely dispersed activity centers – some 22 at last count – as anywhere. Mega-centers and mega-corridors where ridesharing captures over a quarter of all work trips include Uptown/Galleria, the Texas Medical Center (TMC), the Energy corridor along the Katy freeway, and Greenway Plaza. All feature mid- and high-rise offices, shops, hotels, and other commercial uses. Indeed, Houston has more of a mixed-use character than most U.S. cities since, in the absence of zoning, development has been more market-driven and less exclusionary. Subcentering has produced a "many-to-few" pattern of commuting, well-suited to ridesharing. As importantly, many subcenters control parking. At the TMC (the world's largest medical complex with over 60,000 workers), parking is expensive, comparable to what it costs downtown. Moreover, the TMC's parking garages lie on the periphery, whereas buses and vanpools provide near-door delivery. Most TMC employers underwrite commuting expenses of employees who share rides.

Equally important to Houston's HOV success has been good design -- long mainline segments and supporting armature. Most HOV lanes begin upstream of radial traffic congestion, beyond the inner beltloop (I-610), providing long stretches where significant time savings can accumulate. Fly-overs and ramps link 31 park-and-ride lots (Figure 2) and 19 transit centers to HOV lanes. Park-and-ride lots provide convenient staging points for forming pools, particularly important given Houston's low residential densities.

Figure 2: Houston's Network of HOV Park-and-Ride Lots

In Houston, ridesharing, and especially vanpooling, is actively promoted by both the public and private sectors. Some 2,500 vanpools, among the largest fleets anywhere, today operate throughout
greater Houston. Many are sponsored by employers. The regional transit agency, METRO, itself underwrites over 100 vanpools. In Houston, one only needs to telephone or register on-line to find a rideshare partner, and efforts are underway to one-day match carpoolers real-time using GPS (Global Positioning System) and automated vehicle dispatching and routing technologies.
Good HOV services and marketing have garnered public support. Surveys show 70 percent of general freeway travelers view HOV facilities positively. Press coverage of the HOV system has been, for the most part, positive.

In sum, Houston has much of what it takes for HOV facilities to succeed: subcenters, good hardware, supportive software, and active promotion. Environmentalists often

criticize Houston as being excessively auto-dependent and unsustainable, however Houston is implanting, step by step, a high-performance/high-capacity transportation system that is more in harmony with the regional landscape than most U.S. metropolises can lay claim to. HOV lanes have become Houston's unique form of fixed-guideway "mass transportation", providing small-to-medium-size vehicles (cars, vans, and buses) with significant speed advantages. Also important, the network has been guided by a cogent plan, called Access 2010, that articulates a clear vision of greater Houston's transportation and land-use future. Despite rising employment and traffic volumes, Houston's congestion levels have fallen in recent times, one of only three U.S. metropolitan areas where this has been the case. Houston's first-rate HOV network deserves some of the credit.

The HOT Lane Alternative

Despite their progress in cities like Houston, in truth HOV lanes have come under attack in recent times in parts of America. This is partly because travel complexity has made ride-matching difficult, eroding the market share of trips in carpools and vanpools. Critics charge that HOV lanes are often grossly underutilized, and have thus failed to relieve congestion or improve air quality, as promised. In late-1998, then-Governor Christine Whitman (now the head of the U.S. Environmental Protection Agency) decommissioned two unpopular carpool lanes in New Jersey, I-287 and I-80, which by most accounts was justified in light of their poor performance.

The one initiative on the horizon that offers the greatest salvation for struggling HOV facilities is High-Occupancy Toll, or HOT, lanes. Pioneered in Southern California, HOV lanes allow SOVs and two-person carpools to travel on underutilized HOV+3 lanes for a fee. Because they offer value for a price, the approach is also referred to as "value pricing". By providing motorists with a choice, they put a positive spin on road pricing.

In a way, HOT lanes represent a market-based compromise between HOV and general-purpose lanes in heavily trafficked corridors. They have political appeal. By rescuing underutilized HOV lanes, they defuse political opposition. They also generate extra revenues which, among other things, can go to rideshare promotion.

Experiences show that HOT lanes are cost-effective -- they increase average speeds and throughputs on both special and regular lanes. People like them not only because they are faster, but also because they are more predictable and less stressful than mixed-traffic lanes. Even truckers like them once they realize that HOT lanes can assure more reliable just-in-time delivery.

America's first HOT lane facility, State Route 91 in Orange County, opened in late 1995. Built by a private consortium, SR-91 features four fully protected center-lanes (two in each direction) that span Costa Mesa and the Riverside County boundary, a distance of 10 miles. Vehicles with three or more passengers travel for free, SOVs pay tolls exceeding $3 in the peak, and two-person carpools pay around half as much as SOVs. Toll schedules are set in advance, with rates changing according to time of day. Proponents maintain that an HOV+2 facility along SR-91 would be less successful because it would

not siphon off as many SOVs, which constitute the bulk of traffic diverted from general-purpose lanes. An even more sophisticated HOT-lane initiative has been introduced along San Diego County's Interstate-15, long a conduit to affordable housing to the north. There, dynamic pricing has been introduced wherein tolls vary in real time according to congestion levels, ranging from 50 cents to $4 in the peak.

The most common criticism against HOT lanes is that they are elitist. Dubbed "Lexus Lanes", critics contend that only the rich can take advantage of them. The fact is, they provide everyone with more travel choices, something that is in short supply. A working mom who is running late in picking up her child after work is apt to pay a $3 toll than face a $10 late penalty. Besides, if Americans can choose among multiple classes of services for air and train, why should they not be able to do likewise for metropolitan travel?

More Choice, More Flexibility

Overall, HOV and HOT facilities have introduced much-needed variety and choice in America's urban travel market, which is a good thing, especially in light of the increasingly complex and dispersed nature of travel. Efforts to decommission HOV lanes are worrisome for they threaten to reduce choice and variety. Dual roads -- a less-congested tollway and a more congested freeway -- have gained wide acceptance in France and elsewhere in Europe, and if given a chance, would likewise in the United States. A one-size-fits-all roadway system is anachronistic given changing lifestyles and patterns of travel.

Because ridesharing is inherently efficient and should thus be promoted, I believe there is an important place for HOV lanes in America's transportation system. However, HOV facilities must not be viewed as static investments. They need to be regularly monitored, and fine-tuned and adjusted as needed. The arrival of HOT lanes onto the scene has made HOV facilities fail-safe. If an HOV+2 lane is over-utilized, it can be easily converted to an HOV+3 facility. And if the HOV+3 facility is under-utilized, drawing the wrath of solo-commuters, it can then be converted to a more productive HOT lane. The key, then, is to be adaptable, almost in survivalist, Darwinian sense. Houston's Katy Freeway is a case in point. Originally an HOV+2, because too many two-person pools crowded the lane, it was converted to an HOV+3. However, as if often the case, not enough Houstonians were able to form three-person carpools, thus the higher occupancy facility went under-utilized. In response, two-person carpools can now buy into the HOV-3, filling available road space for a fee.

Rather than being abolished, more HOV+2 lanes should be built, as should HOV+3 and HOT-lane facilities. Treating roadways as dynamic investments that need adjusting in line with changing patterns of travel is important not only to the success of HOV facilities, but the broader mobility needs of America's traveling public.

4. Other Emerging Mobility Fronts in the United States

While HOV and HOT lanes have gained favor in some quarters as viable means for satisfying America's ever-increasing quench for mobility, other programs are also gaining recognition as promising mobility "fixes". Some of the more notable fronts being looked upon for safeguarding future mobility in the United States are reviewed in this section.

Intelligent Transportation Technology

Worldwide, billions of dollars are being spent on making roadways and cars smarter, under the guise of the Intelligent Transportation System (ITS). These initiatives seek to ratchet up the efficiency of automobile movements many orders of magnitude, relying on the kind of technology and intelligence gathering once reserved for tactical warfare.

Current estimates hold that ITS can improve traffic throughput by 15 percent or more in major urban corridors facing traffic congestion. Most favored ITS techniques for achieving such efficiencies include: traveler information systems (the "511" systems); incident management to clear accidents and assist stranded motorists; advanced traffic management centers (to suggest alternative routing using message boards and to dynamically adjust ramp meters and signalization); electronic toll systems; and electronic clearance systems for commercial trucking. While traditional radio broadcasts of traffic reports remains the prevalent form of information exchange, significant advances in the technology of data collection and transfer promise to make future traffic reporting more accurate, precise, and richer in content. Using GPS-enabled triangulation, vehicles equipped with mobile phones can now be located and tracked, and traffic speeds accurately estimated. Currently, only 10 percent of U.S. urban freeway miles are instrumented with vehicle detection devices, and this coverage is expected to increase to no more than 15-20 percent by 2020, according to the U.S. Department of Transportation.

Also strengthening its foothold in the ITS realm is "telematics" – loosely defined as wireless systems that use advanced location tracking and communication technologies to provide motorists with communication, information, and safety and security services. The increasing interest in telematics derives the America's auto industry's decisions to introduce factory-installed telematics equipment coupled by the launching of well-capitalized telematic services us as GM's OneStar, Ford's Wingcast, and the American Automobile Association's Response Service Center. The business model adopted involves traffic information providers working with paging companies, wireless carriers, and telematics service centers to provide economically priced real-time information.

One concern of making automobile's smarter is that travelers will flee buses and trains in droves. Mass transit must therefore also become smarter, such as through advanced technologies which optimize routing for door-to-door shuttles and which relay information on schedule-adherence to drivers and on expected times of arrival to waiting customers. Real-time passenger information systems that use GPS technologies to dispatch precise information to customers – either using message boards or hand-held

wireless devices – have an established track record in Europe and Canada but are only beginning to be introduced in the United States.

The one area where all sides agree that technology could yield important social, environmental, and economical benefits is by allowing for marginal-cost pricing, such as the collection of congestion tolls (Gómez-Ibáñez 1999). This is happening in Singapore, where an electronic road pricing (ERP) scheme was introduced in 1998 (Cervero 1998). The system applies a sophisticated combination of radio frequency, optical detection, imaging, and smart card technologies. With ERP, a fee is automatically deducted from a store-valued smart card (inserted into an in-vehicle reader unit) when a vehicle crosses a sensor installed on overhead gantries at the entrances of potentially congested zones. The amount debited varies by time and place according to congestion levels. Cameras mounted on gantries snap pictures of violating vehicles to enforce scheme. The system can identify a vehicle, deduct a charge, and capture a clear photo of its rear image at speeds up to 130 kilometers per hour. During its first year of implementation, traffic volumes declined by 15 percent on a major freeway along Singapore's eastern shoreline, matched by comparable patronage increases along a parallel mass rapid transit (MRT) route.

Another promising direction for new technologies which supports sustainability and livability objectives is the modification of vehicle propulsion systems. Hybrid electric propulsion can boost energy efficiency by an estimated 30 to 50 percent by electronically recovering braking energy, temporarily storing it, and then reusing it for hill climbing and acceleration. Visionaries see a future of ultralight hybrid vehicles that combine the advantages of regenerative electronic braking with on-board fuel cells (Von Weisäcker *et al.* 1997). A consensus seems to be forming that fuel cells offer a resource-efficient and environmentally benign form of "urban propulsion" over the long haul.

Car-Sharing

Car-sharing has gained popularity in European cities as ways of enhancing the quality of in-city living. Car-sharing relieves residents of the financial burden of owning one or more automobiles, allowing them instead to lease cars on an as-need basis through a cooperative arrangement. Car-share members can efficiently tailor car usage to specific purposes (e.g., small electric cars for in-neighborhood shopping and larger ones for weekend excursions). They also economize on travel by opting to get around by foot, bike, and mass transit more often. Presently, over 50,000 members share some 2,800 vehicles in 600-plus cities across Germany, Switzerland, Austria, Denmark, the Netherlands, Norway, Sweden, and Great Britain.

Despite car-sharing's meteoric rise in continental Europe, across America the idea is still in its infancy. There are signs, however, that in some U.S. cities – particularly fast-growing and denser ones with limited parking and a pro-environmental, politically green populous – that car-sharing has appeal. Notably, the cities of Portland, Seattle, San Francisco, and Boston has recently initiated car-sharing, and many other cities plan to do so soon. The jury is still out on the impacts of car-sharing to date, though there is some evidence that it is having some impact. A study of car-sharing in Portland, Oregon found 59 percent of households were carless, 26 percent sold their personal vehicles during

their first year of belonging to the service, and 53 percent stated they were able to avoid purchasing one (Katzev, 2000).

I am directing a current study on the impact of car-sharing on travel in the San Francisco Bay Area. A working hypothesis is that car-sharing will induce more efficient usage of motor vehicles, particularly in America where automobility is generally considered to be grossly underpriced. This is likely to occur through several mechanisms. One, by making the cost of each car trip more transparent and conspicuous, it is felt that participants will be more conscientious about the full cost of each marginal trip, inducing more efficient and resourceful travel behavior. This might take the form of a reduction in motorized travel for low-valued trips (and perhaps substituted by walking or bike trips instead). Second, consumers are apt to better tailor car consumption to particular trips, such as using a low-powered (potentially electric) vehicle for neighborhood shopping and a bigger one for week-end excursions. Additionally, more mindful of the cost of auto-motoring, participants might be expected to shift modes of travel, such as riding public transportation more for trips to major centers or getting around more by foot. The program might also have some unanticipated consequences – such as prompting some participants to give up transit riding and carpooling in favor of leasing cars.

While the study is still in progress, some preliminary evidence suggests that car-sharing in San Francisco is *inducing* new travel. A significant share of users come from car-less households, and many previously took public transit or rode their bikes for their current trips. Moreover, around one-third of car-sharers who pick up a vehicle at one of San Francisco's four car-share parking lots arrive there via public transit. As the program expands and pick-up areas are dispersed into most neighborhoods, it is expected that the incidence of car-sharing will rise dramatically. Proximity to a car-share parking lot was found to be the most decisive factor in influence in the rate of car-sharing in Portland (Katsev, 2000).

Station Cars

Station cars, small (often battery-operated) vehicles that connect suburban destinations to transit stations, have been touted as a promising means of creating "seamless" mobility (Cervero, 1997). Notably, they provide midday automobility, something that is sorely lacking among many American transit patrons that work in suburbia. Conventional electric battery-propulsion is thought to be adequate for station-car purposes because station cars serve a narrow market niche of short, neighborhood-scale travel. Since rail access and egress trips in the suburbs are typically under five miles in built-up areas and are made at modest speeds (40-45 kph), a low performance vehicle is suitable for many trips.

The "all-electric" station car/rail-transit commute could confer many benefits, including higher rail ridership (especially in the reverse-commute direction), less pressure for park-and-ride trips, and reductions in one of the most polluting and inefficient trips made by gasoline vehicles – slow, short urban trips (especially where cold-start emissions produce air-quality problems).

A station-car demonstration was attempted in the San Francisco Bay Area in the mid-1990s (Cervero, 1997). In fast-growing Emeryville, the Norwegian-made PIVCO electric-

vehicles were adopted by a large computer-industry firm to ferry workers back-and-force between the campus headquarters which were approximately three miles from the nearest rapid-rail transit station. Surveys revealed that the work-trip VMT associated with gasoline-engine cars fell by around 40 percent among those who switched to an "all-electric" rail-transit/station-car commute. By far, the biggest impact was on midday travel, inducing some off-site midday trips that previously were not made. Overall, station cars were driven more for non-commute than for commute purposes. Because of rising cost, however, the Emeryville station-car experiment was terminated within the first year of implementation. It has subsequently been replaced by other station-car experiments in the Bay Area that have relied more on conventional gasoline cars.

Efforts are underway to introduce bi-directional station-car programs that would hopefully inject some cost-efficiencies into the experiment. Under this initiative, someone living in the suburbs would drive a station car to a transit station in the morning, park it and catch a train to work. The same vehicle would then be picked up by someone else who would drive it to their nearby job site, have use of the vehicle during the midday, and return the car to the station in the early evening. The same person who dropped off the vehicle in the morning would then pick it up after work and drive it home, having the car available during the evening and on weekends. This "car-link" initiative, as being proposed for the Silicon Valley in the Bay Area, would be very efficient because the vehicle would be getting steady usage. Effectively, the traditional radial commuter and the non-traditional reverse commuter would be sharing the same vehicle.

5. Induced demand

While supply-side solutions have an important role to play in meeting America's increasing mobility needs, a number of important policy issues loom on the horizon that significantly challenge whether traditional supply-side responses are appropriate. Perhaps the most notable, and most contentiously debated policy issues in the America related to mobility-based planning, are claims of "induced travel demand". Few contemporary issues in the urban transportation field have elicited such strong reactions and polarized political factions as the view that new technologies and road improvements increase travel, exerting pressures for even more supply-side responses. Highway critics charge that road improvements provide only ephemeral relief – within a few year's time, most facilities are back to square one, just as congested as they were prior to the investment. Traffic is said to behave more like a gas than a fluid – it expands to fill available space. Time and again, experiences show that building new roads or widening existing ones, especially in fast growing areas, provides only ephemeral relief. In a short time, they are once again filled to capacity. A study using 18 years of data from 14 California metropolitan areas found every 10 percent increase in highway lane miles was associated with a 9 percent increase in vehicle miles traveled four years after road expansion, controlling other factors (Hansen & Huang 1997). Similar findings have been recorded in the United Kingdom (Goodwin 1996). In the United States, regional transportation plans, such as in the San Francisco Bay Area, have been legally contested by environmental interest groups on the very grounds that they failed to account for the induced travel demand effects of road investments and expansions.

The contention that “you can’t build your way out of traffic congestion” has become a rallying cry of the Surface Transportation Policy Project (STPP). In a recent study of 70 metropolitan areas across 15 years, the Surface Transportation Policy Project (STPP, 1999) concluded that metropolitan areas that invested heavily in road capacity expansion fared no better in easing traffic congestion than metropolitan areas that did not.

Methodological issues pervade the induced demand policy debate. Emblematic is the issue of causality – might traffic growth induce road investments every bit as much as vice-versa? Some observers point out that for a good century or more road investments have not occurred in a vacuum but rather as a consequence of a continuing and comprehensive effort to forecast and anticipate future travel demand. Accordingly, road improvements act as a lead factor in shaping and a lag factor in responding to travel demand. A recent study by the Urban Transportation Center (1999) at the University of Illinois at Chicago lends anecdotal credence to this position. Using 60 years of data, the study showed that road investments in metropolitan Chicago could be better explained by population growth rates a decade earlier than vice-versa. For both the Tri-state Tollway (I-294) and East-West Tollway (I-88), the study concluded “major population gains occurred in proximity to the expressways over a decade before the construction of the respective expressways”.

A normative framework for gauging induced demand impacts is shown in Figure 3. The causal chain works as follows: a road investment increases travel speeds and reduces travel times (and sometimes yields other benefits like less stressful driving conditions, on-time arrival, etc.); increased utility, or a lowering of “generalized cost”, in turn stimulates travel, made up of multiple components, including new motorized trips (e.g., latent demand previously suppressed),
redistributions (modal, route, and time-of-day shifts), and over the longer term,
more deeply rooted structural shifts like land-use adjustments and increased vehicle ownership rates (that in turn increase trip lengths and VMT). Some of the added trips are new, or induced, and some are diverted. While evidence on the induced-growth effects of new highways is limited (Dunphy, 1996; Boarnet, 1997), roads and prominent fixtures of America’s suburban landscape -- big-box retail, edge cities, and campus-style executive parks – that they serve are clearly co-dependent. While many contend that only newly generated traffic should be treated as induced

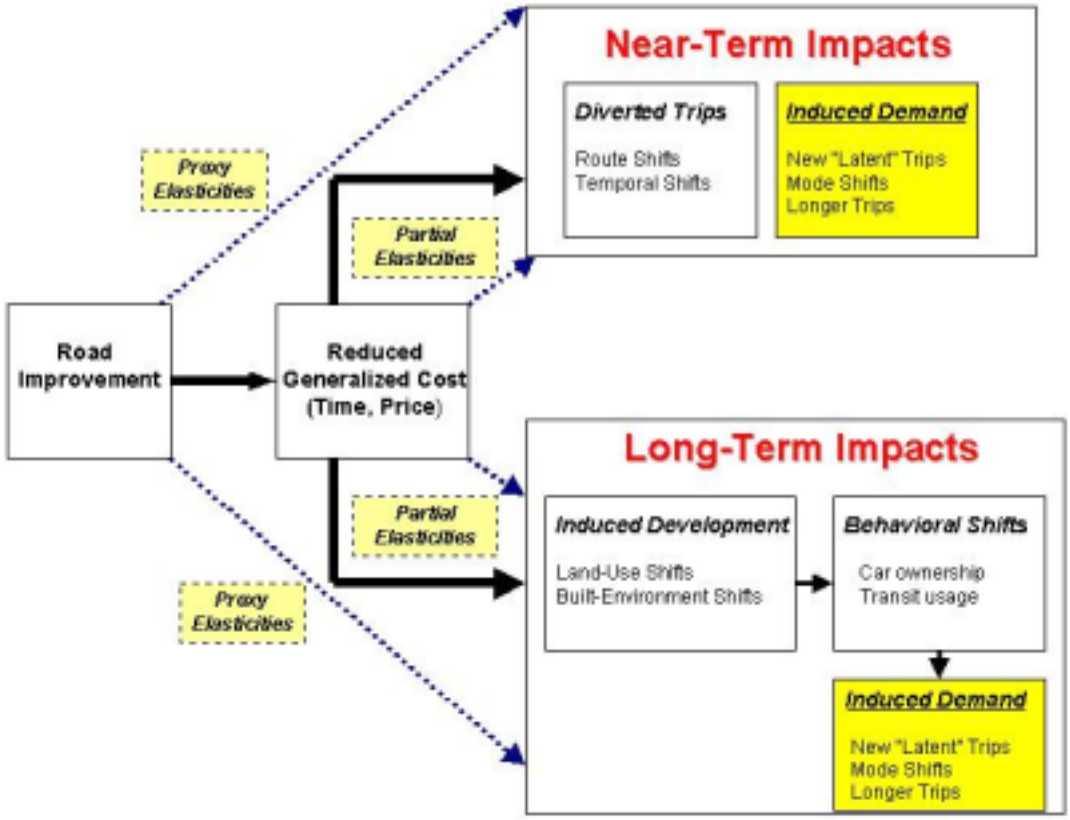

Figure 3. Normative Framework of Induced-Demand Impacts of Supply-Side, Mobility-Based Transportation Improvements

travel (as portrayed in Figure 3), others maintain all traffic, including redistributions, needs to be counted to demonstrate the futility of trying to relieve traffic congestion through road construction.

This normative framework was adopted in a recent study of induced-demand in California (Cervero and Hansen, 2001). Using data on 34 urban California counties from 1976 to 1997, VMT and lane-miles on state highways were jointly estimated employing various exogenous variables related to topographic, meteorological, air quality, and political variables as instruments. The simultaneously estimated models revealed an elasticity of VMT with respect to lane-miles of 0.56, controlling for fixed effects as well as the tendency for travel to increase with population and per capita income and decline with employment density and gasoline prices. (Using a distributed lag model structure, the research estimated a long-run elasticity of 0.78 to 0.84.) The research also showed evidence of "induced investments" – supply responding to demand. The analysis revealed an elasticity of freeway and highway capacity with respect to VMT of 0.33. Presumably, state highway investment in any year was based on levels of travel demand that were anticipated – suggesting, in California at least, road investments not only

stimulated travel demand but responded to it as well. The analysis revealed that, also controlling for fixed effects, road investments rose with population size, carbon-monoxide emissions (lagged several years), temperature differentials, and democratic governorship, and declined with employment density. Prior-year slippages in air quality were interpreted to have added momentum to road investment under the premise that congestion relief improves air quality. The influence of party affiliation reflected the time-lag structure in highway investments, with the impacts of a slowdown in highway construction engineered under Democratic leadership being felt by the time Republican governors were in office.

A further extension of this study provides evidence of how road investments spur real estate development over the longer term that in turn induces building activity. This analysis found a strong correlation between lane-mile expansion and the share of county building permits along impacted corridors five years later. An estimated 30 percent of induced-demand impacts over 5 to 10 year time horizon were attributed to the effects on land-use shifts on increased travel demand.

From our work, we concluded that while the induced demand phenomenon is important and not to be trivialized, far more energies need to go toward studying how America can best invest and manage scarce urban transportation resources – e.g., should we be building more bus rapid transit systems, expanding value-pricing on former carpool lanes, or more closely integrating transportation and land use, and if so, when, where, and under what conditions? The problems people associate with roads – congestion, air pollution, and the like -- are not the fault of road investments *per se*. These problems stem mainly from the unborne externalities from the *use* of roads, new and old alike. They also stem from the absence of thoughtful and integrated land-use planning around new interchanges and along new corridors. In opposing any and all highway investments, even those backed by careful benefit-cost analyses, critics are fighting the wrong battles. Energies should instead be directed at curbing mis-pricing in the highway sector and at better managing land-use changes spawn by road investments.

6. Other Policy Themes Related To Escalating Mobility Needs

Many transportation policy analysts, in both the United States and abroad, have argued for a more balanced approach to meeting urban mobility needs, one that equilibriates between traditional supply-side solutions while at the same time moderating the demand for mobility itself. Some of the more significant policy debates that addressed demand-side regulation of mobility are briefly reviewed below.

Road Pricing

As noted before, economists often argue that proper pricing — such as congestion fees, parking surcharges, and premature land-consumption taxes — would eliminate the need for smart growth campaigns and public interventionism. Design movements like the New Urbanism, transit-oriented development, and jobs-housing balance would quickly become passé. With substantially higher road prices, people would move closer to jobs and transit stops to economise on travel, and shops would be warmly welcomed into residential neighbourhoods. So far, road pricing is something that makes good sense in theory but

which finds absolutely no political constituency, at least not in the United States. Martin Wachs, as chair of a national committee that explored the possibility of implementing road pricing in the United States, concluded that 'except for professors of transportation economics and planning — who hardly constitute a potent political force — I can think of few interest groups that would willingly and vigorously fight for the concept...' (Wachs 1995).

Despite the political opposition, as noted technology has made electronic road pricing possible, although in the United States this takes the form of collecting flat, not time-of-day differentiated, toll-fares. On America's eastern seaboard, five tolling authorities in Delaware, New Jersey and New York have agreed to use compatible technology that allow motorist to travel seamlessly from one turnpike system to another. The consortium now has more than 4 million tags in circulation. The Port Authority of New York and New Jersey (PANYNJ) has approved a plan to use peak-period pricing on all bridges and tunnels under its jurisdiction within the New York metropolitan area.

New Institutional Arrangements

In the United States, traffic congestion has also been attributed to ineffective institutional structures that lead to a discordance between regional land-use and growth-management planning and regional transportation investments. While some states like Florida and Maryland have made progress in advancing concurrency laws that mandate land-use and transportation infrastructure be harmonized, for the most part ineffective institutional arrangements have resulted in mismatches between urbanization and infrastructure development. The state of Georgia is attempting to make a bold departure in this regard by forming an all-powerful regional transportation authority that is in a position to coordinate mobility planning and land-use development. Called the Georgia Regional Transportation Authority (GRTA), the organisation not only oversees the planning and expenditure of funds for all urban transportation improvements in the state, but also has broad control over regionally important land uses, like shopping malls, industrial parks, and sport stadia. Local land-use decisions must conform to broader regional transportation and development goals, otherwise GRTA can effectively veto the decision by threatening to cut off all state infrastructure funds. GRTA's formation was largely in reaction to decades of poorly planned growth in metropolitan Atlanta, matched by ever-worsening traffic congestion. The announced plans of a large high-technology employer to relocate out of Atlanta because of unsustainable traffic congestion and a declining quality of life was a political wake-up call. The region's new planning philosophy — one of balancing urbanisation and transportation investments — aims to enhance mobility while also placing the region on a smart-growth pathway. The ability of GRTA to leverage the mix-use transformation of an in-city brownfield site abandoned by the Atlantic Steel company into a mixed-use village has been an important victory for smart growth. For purposes of securing federal infrastructure funds currently frozen because of Atlanta's violation of air quality mandates, GRTA and others successfully argued that infill development would be less harmful to Atlanta's air basin than comparable growth on the car-dependent edges.

Privatisation

Privatisation of transportation facilities has gained momentum as a means of injecting efficiencies into the build-up of capital infrastructure and to off-load the burdens of road construction from the public to the private sectors. Privatisation makes sense in more than purely financial terms, however. The private sector largely dictates land development, and there is no reason it cannot successfully finance and integrate supportive infrastructure as well. Over the past century, there has often been a disconnect between privately-led land development and publicly provided infrastructure. The private sector is best positioned to ensure concordance between land and transport development. In America, this takes the form of concurrency laws, such as in the state of Florida, wherein private developers must furnish adequate infrastructure to accommodate their projects.

So far, most privatization of roads in the United States has occurred in California. State 79 was designed, financed, and built by a sole private-sector consortium. The Dulles Greenway corridor in Northern Virginia was similarly built and financed through a private-sector consortium. While the promise of profiteering from tolls is partly behind private interests in road development, so is the prospect of ancillary real-estate development from land holdings near interchanges. While on the surface there is nothing wrong with this, the longer-term implication is an acceleration of car-oriented development patterns. A public policy challenge is to elicit private participation in public transport development as well, at least as a counterbalance to privately built highways. Experiences in Tokyo and Osaka show privatisation of suburban railway development can spur compact, mixed-use patterns of suburbanisation (Cervero 1998). In Japan, suburban railway companies are mainly in the real estate business. Transportation is a loss-leader in that huge profits are derived from land sales near railway stations. Companies make handsome profits through value capture, but society at large generally benefits from the close nexus between rail and land use development.

7. Balancing Mobility and Accessibility Planning

In America, transportation planning is undergoing somewhat of a paradigm shift, marked by an effort to balance the traditional focus on planning for movement (mobility) with one that gives attention to planning for places (accessibility). Accessibility reflects the ability to efficiently and conveniently reach frequently visited places. It can be enhanced either by increasing travel speeds or by bringing urban activities closer together, or some combination thereof. Replacing automobility planning with accessibility planning means social and community considerations take precedence over individualistic ones. It also recognizes what cities are about, first and foremost — people and places, not movement.

Table 1 contrasts different transport planning approaches when objectives are framed in terms of enhancing accessibility rather than auto-mobility. Planning for personal mobility works on the *supply side*, aiming to increase the speed and ease (and in so doing, the amount of energy consumption, tailpipe emissions, etc.) of moving about the spread-out city. Accessibility planning, on the other hand, emphasizes *demand management*. It recognizes that new roads unleash new trips and thus provide only ephemeral congestion relief. Instead, it seeks to manage physical space and resources so as to avoid or minimize motorized travel, and for motorized trips that are made, to reward those travelling by efficient and more environmentally sustainable modes. Auto-mobility

planning focuses on the individual and his or her movement, while accessibility planning focuses on the good of the community, relegating physical movement as subservient to the city at-large and the places within it.
There is no arena in which accessibility planning has been more strongly expressed any more than land-use planning and development. Today, the goal of coordinating transportation and land-use planning is reflecting by such movements as “smart growth”, “New Urbanism”, “neo-traditional design”, and “transit villages”.

Table 1. Transportation Mitigation Approaches Under Contrasting Planning Paradigms

Automobility Planning	Accessibility Planning
! **Road Construction/Expansion** -- Motorways/Freeways -- Beltways -- Interchanges/Rotaries -- Hierarchical networks -- Arterial expansion	! **Land Use Management/Initiatives** -- Compact development -- Mixed uses -- Pedestrian-oriented design -- Transit villages -- Traditional neighborhoods/New Urbanism
! **Intelligent Transportation Systems/ Smart Highways/Smart Cars** -- On-Board navigational systems -- Vehicle positioning systems -- Real-Time informational systems	! **Telecommunication Advances** -- Telecommuting/Teleworking -- Telecommunities -- Teleshopping
! **Transportation System Management (TSM)** -- Rechannelizing intersections -- Removing curbside parking -- Ramp metering	! **Transportation Demand Management** -- Ridesharing -- Preferential parking for HOVs -- Car parking management and pricing -- Guaranteed ride home programs
! **Large-Scale Public and Private Transport** -- Heavy rail transit/Commuter Rail -- Regional busways -- Private tollways	! **Community-Scale Public and Non-Motorized Transport** -- Light rail transit/Trams -- Community-based paratransit/Jitneys -- Bicycle and pedestrian paths

8. An Example of Balanced Mobility and Accessibility Based Planning: Adaptive Re-Use of Urban Landscapes

One of the most noteworthy trends, as it relates to the mobility-accessibility "balancing act", in the United States is adaptive re-use of dysfunctional spaces. An example has been the re-use of superfluous surface parking lots near rail-transit stations. Car parks are proving to be a blessing in disguise for they provide large swaths of pre-assembled land. Most attractive are surface parking lots at train stations since they enjoy great accessibility. Many were originally overbuilt, thanks to generous federal funding for rail development. As areas have matured and surrounding land values have increased, market pressures are prompting U.S. transit agencies to sell off at least portions of them as a means to both create a ridership base and to reap windfalls in the form of value capture. Often, the profits earned are more than enough to cover the cost of replacement structured parking, freeing up land for infill development. Surface parking conversion, then, is a back-door form of land-banking, which in many European cities, including Stockholm, has been a principle means of leveraging transit-oriented development.

The city of San Jose, California and the Santa Clara Valley Transportation Authority (SCVTA) recently joined forces in designing a mid-rise, mixed-use project on the park-and-ride lot at the Ohlone-Chynoweth light rail station. Historically, the region's light rail system has struggled to build a ridership base in large part because much of its service territory is the Silicon Valley, a landscape of sprawling office campuses and car-oriented shopping plazas. However, as the demand for affordable housing with good access to the Silicon Valley has intensified, local policy-makers have come to the realization that parking-lot infilling was too good an opportunity to pass up. At the time of project development, only 30 percent of the 1,140 original parking spaces at the Ohlone–Chynoweth station were used. Already, 500 parking spaces have been converted to 195 units of two- and three-storey town homes, a retail plaza, a child-care facility, and a community recreation centre.

Another promising area is to smartly reuse antiquated and dysfunctional shopping centers. The trend in retailing toward warehouse shopping, e-commerce, and mega-entertainment malls has led to the closure of many outdated 1960s and 1970s shopping centres across the United States. Like rail parking lots, one of the biggest assets of dying shopping centres is their huge amount of pre-assembled real estate. One of the more successful adaptive re-uses of a shopping centre and integration with rail transit is The Crossings project in Mountain View, California. The Crossings is an 18-acre compact, mixed use and walkable neighbourhood near a commuter rail line some 30 miles south of San Francisco. It replaced a dying shopping centre and movie theatre that were surrounded, in big box fashion, by a huge, underutilised surface parking lot. The project's 540 housing units have commanded a rent premium, partly because of proximity to rail and partly because of the high quality of urban design. Many well-paid young professionals with jobs in downtown San Francisco and the nearby Silicon Valley have opted to buy into The Crossings, drawn by its ambience and exceptional accessibility to transit. Generous landscaping and public spaces punctuated by an internal pathway network have created a highly attractive urban milieu, notwithstanding residential densities of 30 units per acre, fairly high by suburban California standards. Zero-lot lines and rear-lot parking have allowed such densities to be achieved. As a gateway to the

Mount View CalTrain station, The Crossings stands as one of the few transit villages oriented toward commuter rail.

9. Toward the Future: Mobility in Tomorrow's Cyber-cities

In the United States and elsewhere in the industrialized world, a powerful land-use trend with huge mobility implications is the emergence of the distributed workplace. The growth in communications industries, back offices, self-employed entrepreneurs, and cottage industries promises to spread more and more workplaces into the suburbs, exurbs, and rural hinterlands. New types of communities are already beginning to take form. Some, like Montgomery far north of Toronto, have been developed and marketed as mixed use communities suited to telecommuters who only need to make the 100-km long trek to their main office in central Toronto once or twice a week.

A common view is that teleworking, teleshopping, and other forms of virtual presence will replace the need for physical presence, and by extension will replace the need for physical mobility. The home, some postulated, will increasing become the locus of daily activity, transforming into an "electronic cottage" (Graham, 1997). Such futurecasts, however, ignore the importance places on face-to-face contact and social interaction. In the United States, attendance at conventions grew by 11 percent from 1992 to 1995 (with many conventions devoted to technology themes) (Moss, 1998). To some degree, this suggests that one form of travel substitution is inter-city air travel replacing intra-city automobile travel. Salomon (1986) contends that many people place a value on the experience of mobility itself, casting some doubt over the often-contended view that travel is almost always a 'derived demand'.

Some have speculated that working from home and tele-commuting will fail to bring about transportation and environmental benefits because people will adjust by making more and longer non-work trips; borrowing from time-budget theory, the suggestion is that people have an innate and insatiable desire to travel, and when denied this unalienable right, they compensate by driving more often to shopping malls or taking longer weekend excursions. A study of a pilot tele-commuting program of 200 government employees in Sacramento, California found just the opposite(Mokhtarian 1991). VMT went down among tele-commuters (to just 20 percent of the distance they normally travelled on commuting days), and on the one or two days a week when they went to their offices, they tended to make more efficient trips (e.g. chaining work, shopping, and personal business travel). Even greater reductions in travel were found several months into a tele-commuting demonstration program in Rijswijk, The Netherlands (Travers Morgan 1995). A recent study of tele-work centers, which are neighborhood-based shared workplaces equipped with advanced communications facilities, in the greater Seattle-Tacoma area found VMT was cut by more than half (Koenig, Henderson & Mokhtarian 1996, Henderson & Mokhtarian 1996). Yet telecommunications has not proven to be the panacea that some had hoped for, in large part because most occupational roles are not suited for working from home, at least not on a regular basis. Management fears of losing oversight controls over tele-workers have also thwarted past initiatives. Another concern is that workers at home will feel cut off from office social life and promotional opportunities. It is for these reasons that part-time

tele-commuting, say working at home one or two days a week and in the office the remaining workweek, has gained popularity.

Whether telematics and the Internet will substitute for or stimulate physical travel is anyone's guess. What is abundantly clear, however, is that future travel will take on new shapes and forms: international trips (air travel) will increasingly substitute for intra-metropolitan trips (car travel); with e-commerce, truck delivery trips will replace personal shopping trips; and real-time information on how to avoid congestion will enhance automobility. Such structural shifts, of course, will exert strong land use influences every bit as much as did past transport innovations. E-commerce suggests the emergence of goods distribution centres in many pockets of the city. Cyber-work will exert pressures for in-neighbourhood shops, services, and 'watering holes' for those wanting a break from staring at the screen for four straight hours. Global-sourcing promises that airports and all the ancillary activities around them will become dominant activity centres and trip generators. It is sometimes said transportation and land use planning is today inconsequential because transportation is of weakening importance in location decisions. Such banter is totally blind to the reality that we are today in the midst of revolutionary changes in forms of transport — albeit more in the way of ideas and information than physical movement. While the canvas on which we are working is vastly enlarged, the need for integrating land development and transportation is as great today and in the foreseeable future as anytime in our history.

The one dimension of information technology that many feel will have profound implications for future mobility is "teleshopping". On-line, Internet-based shopping made an impressionable debut throughout America during the 1990s, though the degree this will alter mobility patterns remains unclear. Estimates from the U.S. Department of Commerce reveal that in 2000 electronic retail purchases provided 0.8 percent of total retail activity nationwide. While this is a pittance of entire retail sales, the growth rate is steady – total online purchases increased by 67 percent from the fourth quarter of 1999 to the fourth quarter of 2000 (U.S. Census Bureau, 2001).

Whether teleshopping will significantly substitute for traditional shopping trips is unclear. Some note that shopping fulfills psychological, social, and recreational needs in addition to satisfying consumption demands (Salomon and Koppelman, 1988). Graham (1996) sees teleshopping as a complement rather than a substitute to traditional retailing. For example, shoppers might increasingly use online services to search for information, to make product comparisons, and to find the best deals, while still going to the store to "kick the tires", enjoy the shopping experience, and make a purchase. This is partly borne out by empirical evidence. A study of those who work at home in the Portland, Oregon area found these individuals tended to make more shop trips than the typical worker (Gould, 1998). The author speculated this might be due to the need for teleworkers to break their social isolation at home through shopping activities.

Home delivery of items, like groceries, is thought to produce trip economies – notably, a reduction in Vehicle Kilometers Traveled (VKT). When shopping trips are made by delivery, travel reduction occurs partly by replacing two trips (one to the store, on home again) with one delivery trip. To the degree most shop trips are links of trip chains, then VKT reduction is apt to be minimal. Gould (1998) found Americans who worked at

home had longer shopping trips than out-of-home workers. This was attributable to the ability of out-of-home workers to efficiently chain shopping trips after work.

Another issue related to e-tailing's impact on travel is whether, in light of time-budget theories, people will simply use time freed up from not making shopping trips for other trip purposes, like for social-recreation. Another issue involves the paradox of home delivery. Since the people most likely to be attracted to online purchasing are the most "time-starved" – i.e., looking for ways to cut time spent shopping – it follows that these individuals will be the least likely to be home to actually receive the goods being delivered. In the case of grocery deliveries, some speculate that delivery receptacles will have to be constructed on the exteriors of house – ones that are secure from theft and possibly are refrigerated to keep perishables from spoiling.

Another obstacle to the home delivery scenario resides within the delivery industry itself. According to Kilpala, et al. (1999, p. 8)), currently, "...only about 20 percent of United Parcel Service's (UPS) deliveries are to residential customers, and they are just covering costs." Presumably, teleshopping deliveries need to reach a critical mass, where enough deliveries are made in each area of delivery coverage to increase the marginal profit of each drop-off. However, until this threshold is reached, and without substantial profits for the carriers, we can assume that the costs to the user for deliveries will remain high, dampening the growth of teleshopping.

Other home delivery factors potentially limit the success of teleshopping. Time-starved people looking for ways to reduce the demands of shopping and travel on their schedules are one of the most likely groups that would be attracted to teleshopping (Kilpala, *et al*., 1999). Specifically, people with high incomes may be more attracted to teleshopping as a way of saving on purchase time and shopping related travel. However these people are also the most likely to require deliveries on weekends or evenings when they would be home to receive them. This presents a problem to the delivery service provider, who must find means to work around these potential delivery bottlenecks.

Teleshopping also has clear implications for urban form. One, to the extent that teleshopping creates fewer reasons for people to live near shopping areas, it could be a further impetus for urban dispersal. Second, if we assume that teleshopping will replace traditional retail shopping, traditional retail establishments may be forced out of business. This could radically change urban land uses, and further degrade the importance of cities as centers of consumption. Finally, if the neighborhood delivery center concept takes off, we might see a reversal of trends in retail consolidation. While retail stores have been tending to consolidate into malls, and the success of "big box" retail has further eroded the tradition of neighborhood retail districts, a neighborhood delivery center could potentially refocus consumption patterns to the neighborhood scale. Not only would people pick up their goods at a neighborhood distribution center, but also they would very likely engage in additional purchasing at these distribution sites or adjacent to them. Either impulse buying or pre-planed, chained retail trips could be brought back to the neighborhood scale.

10. Close

The demand for mobility in affluent and geographically expansive societies like the United States will not diminish in the foreseeable future. Technologies, institutions, and policies will change, however slowly, and different forms and patterns of mobility will be one of the by-products. What is abundantly clear, however, is that new forms of checks and balances are and are beginning to be put into place that form firewalls – assurances that escalating mobility demands will not be at the expense of permanently damaging the social, economic, and ecological fabric of cities. Findings ways where auto- and mass- mobility can co-exist in harmony with a highly livable, socially just, and environmental sustainable urban landscape will remain one of America's most pressing urban policy concerns in the twenty-first century.

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