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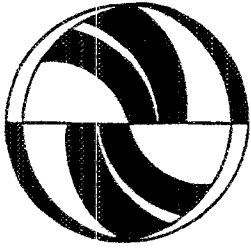
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**New Mobility: Using Technology and
Partnerships to Create More
Sustainable Transportation**

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The University of California
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The University of California
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**New Mobility: Using Technology and Partnerships to Create
More Sustainable Transportation**

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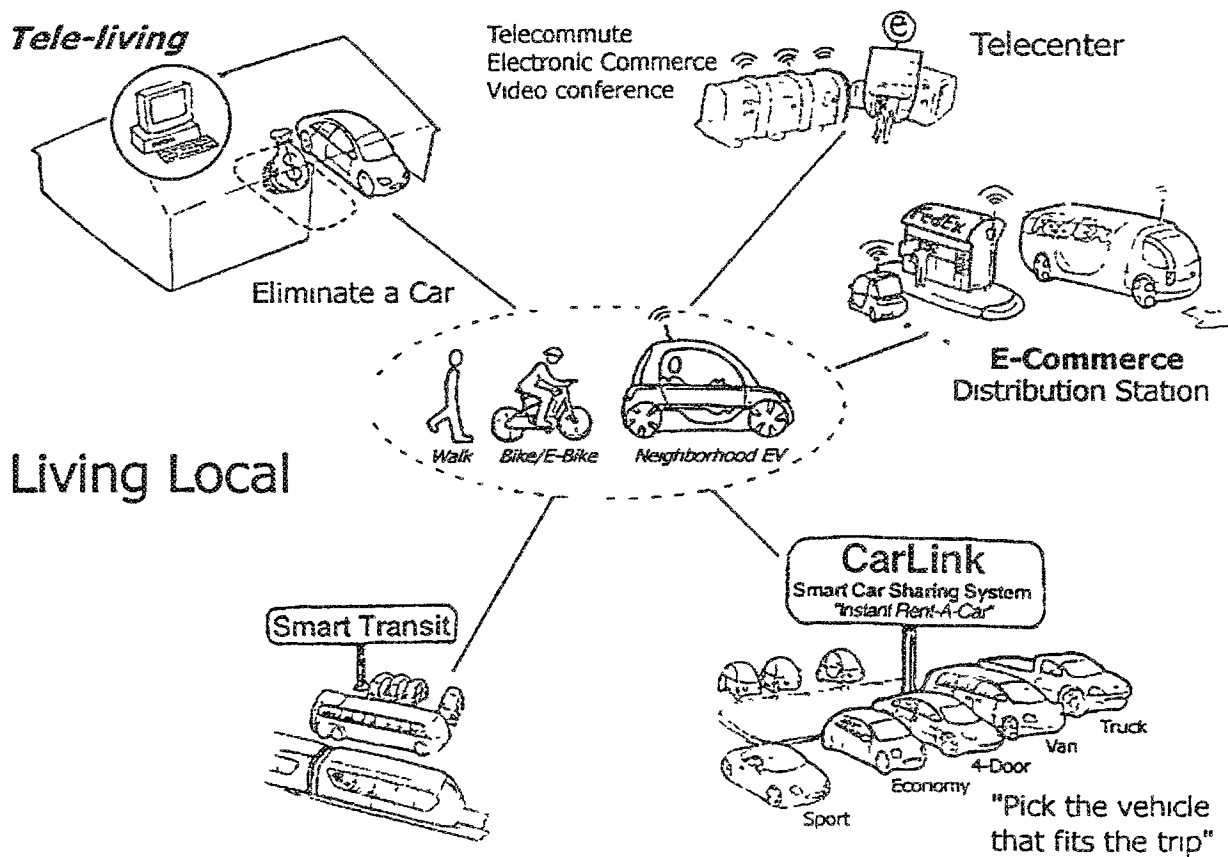
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Abstract

Land development and vehicle travel continue to outpace population growth. Efforts to manage this growth and the adverse impacts associated with it have been mostly ineffective. Promising technology solutions include telecommunications (telecommuting, electronic commerce, teleconferencing, etc.), small personal vehicles (electric bikes and neighborhood vehicles); and new "smart" transport modes (car sharing, "smart" paratransit, etc.).

These options have the potential to be environmentally and economically superior to today's car-dominated system. Yet none have flourished. Why? One hypothesis is that many automobile substitutes and complements have been rejected because they have been introduced individually and incrementally – not as part of a coordinated transportation system.

New mobility is a fundamentally new approach to this problem, focusing on intermodal clustering of innovative technologies with existing transportation options to create a coordinated transportation system that could substitute for the traditional auto. The concept of new mobility was explored at a workshop hosted by the Institute of Transportation Studies at the University of California, Davis on November 2, 1998. This report describes the technologies of new mobility and suggests ways that they might be coupled together through public-private partnerships and experimentation at the local level.



The Hegemony of Cars

The automobile, used for over 95% of all person miles of surface travel in the US,¹ has been remarkably successful in providing reliable transportation that is relatively safe and widely affordable. It has created a level of personal service that is unequalled and highly valued.

This success does have a downside. air, water, and noise pollution; increasing oil imports, increasing greenhouse gas emissions, ecosystem fragmentation and damage, and less access to goods, services, and jobs for those without cars. And there are other downsides for which the car is less directly implicated – urban social ills, perceived loss of community, and degraded aesthetics. The challenge is to reduce the adverse effects of personal transportation and sprawling land development, while retaining (or expanding) the mobility and accessibility benefits provided by cars.

One adverse effect well on its way to being solved is air pollution. Today's vehicles emit about one tenth the pollution of pre-control cars of the 1960s. And firm requirements are in place in California (and soon to be imitated elsewhere) that reduce vehicle emissions another 75% or more. The introduction of even cleaner hybrid and fuel cell electric vehicles in the next decade provides a solid promise of still further reductions. But clean cars do not solve the other adverse effects of vehicle proliferation.

Many attempts have been made over the years to temper reliance on the privately-owned vehicle by investing in and subsidizing new transport modes and systems. These efforts at balance generally focussed on mass transit. Although several transit alternatives have thrived at certain times and places, the single-occupant private vehicle is becoming ever more dominant. The percentage of workers commuting to work by transit in the U.S. decreased from 8.4% in 1969 to 5.3% in 1990; those carpooling to work (defined as two or more occupants) also decreased, from 19.7% in 1980 to 13.4% in 1990; and those driving alone increased from 64.4% to 73.2%.² This shift away from transit occurred at a time when public subsidies for transit increased dramatically.³ These trends are the same in virtually all other countries as well. The problem is that conventional fixed-route, fixed-schedule transit is not suited to the evolving land use and lifestyle patterns of the US and other industrialized countries. Even ridesharing, handicapped by costly and cumbersome information flow between prospective users, falls short.

Single-occupant cars fit these evolving patterns much better. They provide unparalleled versatility, privacy, comfort, and convenience. And they are getting even better, raising the hurdle for alternatives still higher. New enhancements are resulting in greater car comfort and convenience, and are mitigating many disadvantages. New cars are safer as a result of redesign and added features, more productive as a result of cellular phones and internet connections (even as traffic congestion worsens), provide more and better entertainment thanks to enhanced sound and information storage systems, and are more convenient as a result of real-time access to traffic and

¹ Stacy Davis. Transportation Energy Data Book, Ed 18. Oak Ridge National Laboratory, 1998.

² "1990 Census of Population and Housing. Journey to Work in the US." Washington DC. US Department of Commerce, Bureau of the Census, 1995.

³ Martin Wachs, "US Transit Policy. In Need of Reform," *Science* 244, 1545-49, 1989.

destination information. In short, the benefits of vehicle ownership and use continue to expand. Competitors to cars face a difficult challenge

But the creation of a transportation monoculture can be detrimental. As a general principle, any system is most efficient and robust when there is some diversity. One size does not fit all. One vehicle type can not serve all the transportation demands of a household during its tenure with the household. A healthy system is one that allows trip desires to be matched with travel modes (in terms of cost, convenience, etc.), provides all segments of the population with high levels of access to goods and services, and provides alternatives in times of emergency. It is neither environmentally *nor* economically efficient to obligate an individual to drive a two ton vehicle to a neighborhood park or convenience store because sidewalks and bicycle lanes do not exist. The dominance of today's multi-purpose light duty vehicles has created lifestyle and professional patterns of behavior focused almost completely on one means of travel. They have led to infrastructure designs and personal choices that are becoming ever more fixated on the exclusive use of these vehicles. The result has been to push many low-cost and environmentally desirable options (as well as expensive public modes) into near extinction, and to suppress new options.

To what extent this pattern has proceeded beyond what is societally desirable is unclear. But our intent is not to indict the auto for causing societal ills. We take a positive approach. Indeed, we marvel at the high levels of mobility and accessibility it provides and wonder how the benefits of personal transportation can be retained while simultaneously diminishing social and environmental ills.

At the new mobility workshop, we discussed tactics and strategies to create transportation alternatives that are superior to today's private vehicle. The underlying premise was that substitutes and complements to the automobile have faltered because they have been introduced individually and incrementally – not as part of coordinated systems. By integrating some of these technology-based options, and providing a supportive policy context, synergies might result that would lead to a healthier and more efficient transportation system.

Cost and Convenience of New Mobility

For alternatives to traditional single-occupant vehicles to succeed, they must provide one or more superior attributes; cost and convenience are primary.

The cost of owning and operating a motor vehicle are substantial – about \$6000 annually in the US. The “out-of-pocket” variable costs – fuel and motor oil – account for about 10% of this amount.⁴ The inclusion of other variable costs, such as parking fees and roadway tolls, is close to zero except for central city driving and a few intercity roads. Other costs, such as insurance, depreciation, and even tire wear, are generally not perceived by drivers as trip costs. Thus, even though the true cost of a vehicle is large, the perceived costs of operating the vehicle are very low. As a result, most car alternatives are unattractive.

⁴ US Bureau of Transportation Statistics, Pocket Guide to Transportation, BTS98-S-02, 1998

For new mobility services and options to flourish, households must choose to reduce the size of their owned fleet of conventional vehicles by one or more. If they don't, the alternatives will generally be economically unattractive. If they do eliminate a vehicle, the economics of car alternatives can be highly favorable. The challenge is to create a mix of alternatives that provide a high level of service, at less cost. The latter condition, low cost, appears to be readily attainable – if only because the cost of conventional car ownership is so high. The larger challenge may be to weave together two or more credible and compelling alternatives for travelers.

But cost is not travelers' sole nor, in many cases, even their principal decision variable. Vehicles provide a variety of benefits, such as home-like security and entertainment. They are a social symbol and office. They are more than just a convenient conveyance of cargo and ourselves. To forego conventional single-occupant vehicles, travelers must value the attributes of other transportation options more than those of traditional personal vehicles. This is not an impossible task: in addition to their many attractions, today's privately-owned vehicles also can be inconvenient. These inconveniences include the time and irritation of registering and insuring vehicles, driving vehicles in congested travel conditions, and fueling, maintaining, and repairing vehicles.

Alternatives to today's privately-owned vehicle can thrive in two situations: 1) when cost is less and key car attributes, especially convenience, are not overly compromised; and 2) when the alternatives provide greater convenience.

Alternatives, New and Old

A two ton car or light truck is not needed to carry a one pound loaf of bread. But most Americans (and, increasingly, travelers elsewhere in the world) use vehicles in this way. One reason is the lack of acceptable alternatives. At the new mobility workshop, we explored alternatives to traditional privately-owned vehicles. We sort these alternatives into those that already exist and have been widely experienced, and those that are relatively new with little or no user experience. In the first category are walking, bicycling, and conventional mass transit; they account for a small and shrinking share of trips.

The observed decline in these widely known non-car modes suggests that a fresh approach is warranted, and that new alternatives with a new set of attributes may be needed. New alternatives include small personal vehicles,⁵ shared-use vehicles,⁶ various telecommunication complements and substitutes,⁷ and smart paratransit⁸. These options are not entirely new. They have all been experimented with and gained some acceptance in some regions and some population segments. But their net impact has been miniscule. We hypothesize that by coupling

⁵ See Daniel Sperling, "Prospects for Neighborhood Vehicles," *Transportation Research Record* 1444:16-22, 1994; and Kenneth Kurani, D. Sperling, T. Lipman, D. Stanger, T. Turrentine and A. Stein, *Household Markets for Neighborhood Electric Vehicles in California*, Institute of Transportation Studies, University of California, Davis, RR-95-6, May 1995, 200 pp.

⁶ Susan Shaheen, D. Sperling, and Conrad Wagner, "Car Sharing in Europe and North America. Past and Future," *Transportation Quarterly*, 52.3, 35-52, 1998.

⁷ Susan Handy and Patricia Mokhtarian, "The Future of Telecommuting," *Futures*, 28:3, 227-240, 1996.

⁸ Robert Cervero, *Paratransit in America redefining mass transportation*, Westport, Conn Praeger, 1997, 281 pp

these options with each other, with conventional cars and transit, and with ever-cheaper and more available communications and information technologies, synergies will arise that create the potential for greatly increased market share by these alternative modes. The challenge is to be ever mindful of the high value placed on personal mobility. In the next sections, the old and new alternatives are examined.

Well-Known Alternatives

Well known alternatives include non-motorized travel and mass transit. Both have floundered. Both have strong attractions and could be revived through enhancement of complementary mobility options.

The simplest and oldest alternative modes of transportation are walking and bicycling. These modes offer easy, reliable transportation for single persons in good physical condition for short distances. Conventional roadways are not necessary for these modes to function and the traveler's physical condition actually improves as a result of using them. They are inexpensive -- walking is free and bicycling requires only a bicycle -- and environmental impacts are minimal. These are truly zero emission forms of transport with low impact infrastructure. However, bicycling and walking account for only about 6% of trips in the US, and a much smaller share of passenger mileage.⁹ In most countries of Western Europe, by contrast, walking and bicycling account for about 40% of trips.¹⁰

Bicycling and walking are unsuited for many trips: during adverse weather, when distances are long, or when cargoes are large or heavy. In the US, the virtual absence of safe and convenient infrastructure forces bicyclists to compete with cars and trucks, considerably diminishing the attractiveness of bicycles. For these options to become viable, new attitudes and new investments are needed. The creation of viable and visible alternatives to full-sized vehicles could be instrumental in beginning the process of redirecting infrastructure investments and designs and altering attitudes toward non-motorized travel.

Another well-known alternative is mass transit, primarily comprised of buses, trains, planes, and other more specialized services (ferries, trams, etc). Surface transit generally provides less expensive service than cars and requires fewer physical and mental skills -- providing an essential service to the young, old, poor, and disabled. Transit also allows travelers to use their time en route more productively. And when ridership is high, transit uses far fewer resources per passenger-mile than cars do.

But transit utilization is dwindling, cars are becoming cleaner and more energy efficient (compared to the early 1970s), and in-vehicle entertainment and communication devices are becoming inexpensive. The result is that, on average, buses use more energy per passenger mile than cars¹¹ and are relatively less attractive.

⁹ US Department of Transportation, Federal Highway Administration, "Our Nation's Travel: 1995 NPTS Early Results Report." Oak Ridge National Laboratory, 1998.

¹⁰ John Pucher, "Urban passenger transport in the United States and Europe: a comparative analysis of public policies, Part I: Travel behavior, urban development and automobile use," *Transport Reviews*, 15 2, 1995, p 103.

¹¹ Stacy Davis, *Transportation Energy Data Book*, Ed. 18. Oak Ridge National Laboratory, 1998.

With the continuing dispersal of job and home locations away from downtowns, mass transit is becoming even less viable (as evidenced by shrinking market share). A fixed route system, dependent on dense concentrations of people, functions best in downtown areas of older cities built before the auto era. New mobility is a concept to enhance and personalize intermodal connections with conventional transit to better fit the demands of today's travelers. An important enabling technology may be travel planning devices that provide information and billing. These devices, linked to the internet and "personal digital assistants" (PDAs), can facilitate new mobility options.

Smart Paratransit

"Smart" paratransit is a potentially attractive alternative to conventional transit and conventional single-occupant vehicles. It is perhaps the greatest single hope for reducing vehicle use in suburban areas, where population density is too sparse to support fixed-route transit services. "Paratransit" refers to a broad range of services that do *not* have fixed routes or fixed guideways. It operates in the gap between large transit vehicles (buses and rail transit) and cars. It responds to the transportation dilemma posed by suburban development patterns. It represents another transportation alternative that might benefit from the availability of still other complementary transportation services and options.

Smart paratransit builds upon three earlier initiatives: the failed "dial-a-bus" demand response technology of the 1960s and '70s, shuttle vans that began serving many airports in the late 1980s, and specialized services for disabled travelers. Today, the introduction of communications-based technologies is beginning to make paratransit services a bit 'smarter'. Instead of requiring travelers to plan their trips a day or more in advance, 'smart' paratransit requires only minutes notice for trip scheduling. This is because each vehicle in a smart paratransit system is equipped with a real time vehicle locator, vehicle occupancy tracker, and communication device such as a CB radio or a cellular phone. When a traveler calls for a pick up, the real time vehicle locator allows the dispatcher/reservation service to automatically see if a paratransit vehicle is near the desired pick-up location. If so, the dispatcher can direct the driver to pick up the traveler via the communication device in the vehicle. If no vehicle is in the immediate vicinity of the desired pick-up point, the dispatcher can direct the next empty vehicle to the traveler. In this way, the dispatcher/reservation service can coordinate the paratransit vehicles on the road in real time, and the smart paratransit system becomes a more efficient mode of transportation for both the provider and the traveler.

In the future, the use of up-to-the-minute service and traffic information would eliminate the pre-trip reservation requirement of the old dial-a-ride concept and current airport shuttle vans. Travelers would request rides through telephones, cellular phones, interactive televisions, modem-equipped computers, and public computer terminals; the call would be routed to small transit vehicles passing nearby.

The challenge is to increase intensity and reduce costs (the operating cost per passenger for today's demand-responsive services is about \$13, versus about \$2 for fixed-route bus service).¹²

¹² Brian Taylor and William McCullough, "Lost Riders," *Access* No. 13, 1998, p. 27

One way to enhance its attractiveness and thereby increase demand is by complementing smart paratransit with car sharing, local telecenter options, and easy neighborhood travel. Likewise, the availability of smart paratransit will likely enhance demand for those other options.

Car Sharing

Another way to create diversity, reduce vehicle travel, and lower transportation and environmental costs is to make short term vehicle rental – car sharing – easier. Renting a vehicle from a conventional rent-a-car company usually means considerable paperwork, advance reservations, inconvenient access, and rental periods of at least one day. Car sharing, especially when combined with modern communication and reservation technologies, provides a low-cost, variable-time car sharing system with instant access.

Existing car-sharing programs are located mostly in Switzerland and Germany, but also elsewhere in Europe, in Canada, and recently in the US.¹³ The largest car sharing organization, located in Switzerland, has more than 1200 vehicles spread across 700 locations serving 25,000 members. Virtually all such organizations were established in the past decade, and most are neighborhood-based. Vehicles are located in small lots (usually 2-5 vehicles in each) dispersed throughout a community.

In Europe, vehicles are typically rented for round trips and returned to the same lot. In the U.S., sprawling land uses are likely to require either a dense multi-lot itinerary that allows members to rent vehicles from one lot and return them to another, or an “interrupted” one-lot rental that allows commuters to leave a vehicle at a transit station in the morning and return to the station for another vehicle in the evening.

When a traveler wants to use a vehicle, he or she makes a reservation through a dispatcher, either by telephone operator or telephone voice messaging (or the Internet in the near future). Until the past year, car sharing reservation systems depended on human interactions. The traveler goes to the car sharing lot and either picks up the vehicle key or, with new systems, gains access to the vehicle using “smart card” technology. Fees for vehicle use are levied per hour, plus a distance-traveled charge. These fees, along with the nonrefundable membership fee, cover all costs for the vehicles, including purchase, insurance, fuel, and maintenance. Most existing programs require vehicles to be dropped off at the lot where they were picked up.

Car sharing can have a number of formats, in addition to the neighborhood-based versions becoming common in Europe. They may also be located in downtowns, business centers, at office parks, near transit stations, and in small towns. Indeed, examples of many of these formats exist. Lufthansa created a car sharing organization for its employees at Frankfurt airport, Fiat established one with electric cars in downtown Turin, and Honda and UC Davis initiated one in conjunction with the Bay Area Rapid Transit District and Lawrence Livermore National Laboratory in the eastern side of the San Francisco Bay. The types of vehicles will vary depending on the nature and setting of the car sharing program. At office parks and other business settings where trips are short and air pollution a concern, vehicles may be small or low-

¹³ Susan Shaheen, D. Sperling, and Conrad Wagner, “Car Sharing in Europe and North America: Past and Future,” *Transportation Quarterly*, 52:3, 35-52, 1998.

emission cars, many of which could be powered by batteries. In neighborhood settings, some large sport utility vehicles and pickup trucks might be made available.

While careful evaluations have not been conducted of car sharing, initial evidence suggests that travelers who join car sharing organizations and reduce their household fleet by one vehicle end up reducing their overall vehicle travel by 1/3 to 1/2.¹⁴ These reductions occur for two reasons: car sharing makes transit more accessible (easier access to and from transit stations), and most vehicle costs are converted into variable costs (rather than the fixed costs of vehicle purchase, insurance and registration of individually owned vehicles).

Privately-owned vehicles in the US are used an average of only one hour each day. This means that the average American is paying the large fixed costs associated with unlimited vehicle use, but actually using the vehicle less than 5% of the time. Based only on this fact, it is clear that for some people, the cost savings of a car-sharing system could be considerable. Mobility CarSharing Switzerland, for example, charges approximately \$1.50 per hour of use plus \$0.50 per mile driven. The traveler who often wants to go long distances would probably find these rates to be high. On the other hand, the traveler who would only need the vehicle for a few hours each week to run errands or visit friends would find car sharing to be much less expensive than car ownership. Car sharing provides households such as these with the advantages of multiple vehicle ownership at less cost with less responsibility. Being a member of a car sharing organization that has cars located near home offers similar convenience to owning a vehicle at a lower price and a fraction of the social cost.

Car sharing results in some reduction in convenience. The car is not in your garage or parked at your doorstep. But in return for some inconvenience, one gains potential advantages of less cost, access to a greater range of vehicle types, and no responsibility for maintenance, registration or insurance. Car sharing is not for everyone, but it potentially appeals to large segments of the population

A lesson being learned in Europe is that car sharing becomes more attractive – economically and socially – when it is integrated with other transportation and business services. The more innovative and successful car sharing companies are creating partnerships with conventional car rental companies so that members can use those services at a discount when they need a vehicle for extended periods, with rail companies to gain discounts and enhanced intermodal connections, with car leasing companies so that an individual can make their leased car available to a car sharing organization on weekends or other peak periods in return for cash payments, with local businesses that provide discounts in return for advertising, and so on. In those instances, “new mobility” is being put into practice. The challenge in North America is to identify business partnerships, intermodal connections, appropriate market (and financing) models, and customer packages that fit the local settings.¹⁵

¹⁴ Ibid

¹⁵ The UC Davis CarLink demonstration is exploring three market models, which have been adapted from European experiences, to suit demands and travel patterns of a sprawling, job-rich suburb of San Francisco. Three models, and customer packages have been developed based in part on participant feedback from a longitudinal market study: 1) home-side user lease, 2) work-side commuter package, and 3) day user variable rate package

New (Small) Personal Vehicles

A key element in “new mobility” is small motorized vehicles. The first personal vehicle most Americans own is a bicycle. The second is a full-sized car. Few options lie between and rarely are they exercised. At the UC Davis New Mobility workshop, a number of major auto manufacturers and entrepreneurs spoke of a new class of small vehicles, sometimes referred to as neighborhood vehicles or community cars. One might categorize them more finely, from largest to smallest, as ultracompacts (just smaller than a subcompact), mini-vehicles, neighborhood electric vehicles, and electric bicycles¹⁶

As a group, these fill the personal vehicle gap between the bicycle and the full-sized car. They generally seat 1-2 people, though some carry 4, and have some space for cargo, with top speeds between 15 and 60 miles per hour. They weigh less than half that of conventional cars and use proportionally less energy to get around. These vehicles have the potential to offer the convenience of a full-sized car for short distances – or even greater convenience to many with limit abilities who are unable to drive full-sized vehicles – at less cost with less environmental and societal impact.

Inhibiting their introduction is high initial cost (as with any new product), limited utility, and safety concerns. But the potential benefits of these small vehicles are huge. They use far less energy, produce less pollution, consume less parking and road space, and are less expensive than conventional cars

At the upper end of the vehicle spectrum in terms of cost, size, and utility, are the ultracompact vehicles, with top speeds around 60 mph. These are designed to meet the safety standards of conventional full-sized vehicles and can travel on any road (though it may not be advisable to do so on high-speed roads). They do not need special rules. Because of the necessary sophisticated engineering, they are generally built by major automakers.

The Toyota e-com is an ultracompact electric vehicle that is in production-ready prototype form. During 1999 about 100 e-coms are being tested: 75 with Toyota employees in Japan and 25 in several demonstrations in the US. The e-com is a small, fully enclosed two-seater powered by nickel-metal hydride batteries with a driving range of about 60 miles on a single charge.

A vehicle with similar performance and size attributes and also close to production is the Think. This is a second-generation 2-seat plastic-bodied electric vehicle originally developed by Pivco, a small Norwegian company. In December 1999, Ford Motor Company purchased a controlling interest in the undercapitalized company. Earlier versions of the vehicle, known as the City Bee, were tested in a two-year station car program in the San Francisco Bay Area. Ford announced soon after that the vehicle could be sold in North America as early as 2000. A manufacturing plant in Norway has the capacity to produce as many as 5000 vehicles a year.

¹⁶ As part of the new mobility vision, we emphasize small vehicles that are electric. We do so because such vehicles have the positive attributes of battery electric vehicles – including zero tailpipe pollution and quietness – without the negatives of high cost. Costs are low because small vehicles, with reduced expectations for speed, power and range, do not need much energy. Thus, they use small and therefore relatively inexpensive battery packs. Small electric cars have the potential for much lower lifecycle costs than conventional gasoline cars.

Other major car companies have developed their own electric ultracompacts, with similar attributes. Two that have been publicly unveiled, in 1998 and 1997 respectively, are Honda's City Pal and Nissan's Hypermini. Neither company has indicated production plans.

In addition to these electric ultracompacts, many companies are selling gasoline-powered small cars. Most prominent is the DaimlerChrysler Smart, a two-seater which made its debut in 1998. It is powered by a 3-cylinder, 600 cc gasoline engine and is 2.5 meters long and 1.5 meters wide, about half the size of a conventional vehicle. The top speed is nearly 80 miles per hour. It is currently available for sale in many locations throughout Europe at prices starting between \$9,000 and \$10,000, but there are no announced plans to sell it in the USA

The next level is what we refer to as minivehicles. In this category are a number of small electric vehicles manufactured by small independent companies. This intermediate category of "neighborhood" vehicles, with top speeds between 25 and 60 miles per hour, is still ignored by regulators and therefore for liability reasons is untenable for major manufacturers. One company has sought to deal with this nebulous regulatory and liability situation by building a three-wheeler. A cross between a motorcycle and an electric car, the Gizmo is a three-wheeled, enclosed vehicle with one-seat, registered with the Federal Department of Transportation as a moped. The Gizmo has a maximum speed of approximately 40 mph, a range of 25 miles/charge, and is priced at \$6950.

The U.S. Department of Transportation officially acknowledged the existence of smaller, low-speed vehicles (what we might call the lower end of "neighborhood" vehicles) on June 17, 1998, by adopting safety standards and rules for vehicles operating under 25 mph.¹⁷ A number of states including California and Arizona have followed with low speed vehicle rulings of their own

Within this lower-speed category is the only four-wheeled small personal vehicle now available for sale in the US: the Bombardier NV (Neighborhood Vehicle). Introduced in 1998, it is a small, fully enclosed two-seater electric vehicle with the 'footprint' of a golf cart. It has a maximum speed of 25 miles per hour and a range of 30 miles per charge. Charging the NV (at 110 volts) takes about 8 hours and costs about 40 cents (less than half of the comparable fuel cost for conventional gasoline vehicles). The purchase price of the NV is currently \$6199, with plans for substantial reductions in price as production volumes increase

At the bottom of the size range are electric bicycles. An expanding number of companies are entering this market. In Japan, over 100,000 are now sold per year by Suzuki, Yamaha, Honda and others. Electric bikes mostly sell in the range of \$500 to \$1000, with ranges of about 15 miles at about 15 mph. By pedaling the range is extended. They can easily be pedaled even with the motor disengaged. They are legally treated as bicycles and thus there are no rules constraining their use.

In summary, only one enclosed small personal vehicle is currently being offered to North American consumers by a major manufacturer. But a variety of vehicles are available from small

¹⁷ Federal Motor Vehicle Safety Standards, 49 Code of Federal Regulations Part 571 Section 500, Federal Register, June 17, 1998

companies, and at least two major automakers are on the verge of marketing small electric vehicles. In addition, many major automakers sell small gasoline-powered personal vehicles in other countries. Indeed, over 20% of the Japanese automotive market are mini-vehicles (defined as less than 660 cc).¹⁸ The initial marketing success of the DaimlerChrysler Smart in Europe is leading to renewed global interest in small cars.

Two downsides of small vehicles are real and perceived safety concerns and high initial cost. As production volumes increase and designs are improved, costs will decrease to levels well below those of conventional cars, even when powered with batteries. The more fundamental, troubling and complex concern is safety.

Safety is influenced by government regulations, depends in large part on how and where vehicles are used, and is sensitive to perceptions. On the one hand, many of these vehicles are only capable of operating in low-speed conditions which are relatively safe. This ensures that they will not be subject to high speed collisions. However, if they share the low-speed roadscape with conventionally-sized vehicles, they are susceptible to low-speed collisions with vehicles of substantially greater mass. This risk invokes considerable concern for safety for many Americans.

From a liability perspective, motorcycles provide an interesting case. Although motorcycles are clearly more dangerous to ride than passenger cars, the motorcycle industry continues to thrive. Many travelers weigh the views, excitement, and exposure of motorcycles more highly than the greater danger. Liability law acknowledges that individuals recognize and accept the lesser safety of motorcycles. Would or should small vehicles be treated similarly? The uncertain liability is a major factor discouraging investments in these vehicles, and will only be resolved over time as case law evolves.

True safety is a more fundamental concern. The challenge is to design vehicles safely and create protected driving environments for the smaller and slower vehicles. One approach to creating safer environments might be to create "local mobility zones." Neighborhoods could create areas where safety – of pedestrians, children, and small vehicles – is emphasized. Harbors create "no wake zones" to maintain the safety of small watercraft, and parking lots are "zones" where pedestrians and trucks co-exist. Likewise, neighborhoods could impose low speed limits and enforce them with modern electronic monitoring and vigilant residents. The existence of these local mobility zones would create the perception and reality of greater safety, for pedestrians, bicyclists, and occupants of small vehicles.

In conclusion, small vehicles face a difficult challenge. They cannot accommodate long distance trips, highway driving or large cargoes. Marketed strictly as low-cost substitutes to conventional cars, they are unlikely to succeed – especially in North America where high-speed driving and wide roads predominate. For most people, even reduced costs are unlikely to balance the reduced convenience and safety. To be successful, it is likely that small personal vehicles will need to be complemented with other services and modal connections – such as car sharing to provide large vehicles on demand, conventional transit or smart paratransit for some trips, and

¹⁸ Automotive News, var

telecenters for occasional telecommuting – and must gain the commitment of local communities to create safe settings for the vehicles, and various incentives for their use.

Telecommunications as a Substitute and Complement

Another important component of the new mobility vision is telecommunications technologies. These technologies may be used to replace *and* complement travel. They complement travel by making it more convenient and less expensive, as indicated above in the case of smart paratransit and smart car sharing, and they replace physical trips via telecommuting, teleshopping, and teleconferencing

The most prominent form of substitution is telecommuting, whereby one works at home or at a local telecenter, rather than traveling to an office. About 6% of Americans telecommute at least some of the time, resulting in about 1.5% on any given day.¹⁹ The journey to work for telecommuters is eliminated or drastically reduced. However, telecommuters use some of their saved time to take personal, social and recreational trips during the day. Mokhtarian estimates that telecommuting could currently be eliminating, at most, 1% of total household vehicle miles traveled.²⁰ Although it has received considerable attention and has attracted many practitioners, telecommuting still plays a minor transportation role.

A related option is teleconferencing. This service could be provided from a neighborhood telecenter or main business office; eliminating a long airline (or car) trip. But in this case, as with other uses of telecommunications, the concept of a replaced trip is too simplistic. Many teleconferences don't replace a trip for an in-person meeting, but represent new communications that would not have occurred otherwise. And as with telecommuting, the time saved by teleconferencing is likely to be spent (at least in part) in making other trips that are more desirable or for which face-to-face interaction is more important.

Still another form for replacing trips is teleshopping, or electronic commerce (e-commerce) as it is now becoming known. E-commerce allows consumers to buy goods from companies directly through the Internet. In this way, consumers are able to read about products they buy in the comfort of their home or office and, for a small shipping fee, the products will arrive on their doorstep within a few days. In terms of travel, this reduces consumer trips to stores. Consumers are likely to value this new form of accessing goods.

The travel impacts are uncertain, mostly due to questions of how and from where goods will be delivered to people. When consumers shop on-line, they do not have a significant incentive to shop at web sites that sell locally-produced goods rather than those that sell goods produced elsewhere. Shipping charges are often small and uniform throughout the United States. Therefore, the cost and resources needed to deliver goods ordered on-line in a timely manner may actually exceed the cost and resources expended by a shopper traveling to and from a local store. The fact that many shopping trips are actually chained to longer trips made for other purposes reinforces

¹⁹ Patricia Mokhtarian "A Synthetic Approach to Estimating the Impacts of Telecommuting on Travel" *Urban Studies*, Vol 35, No 2, pp 215-241, 1998

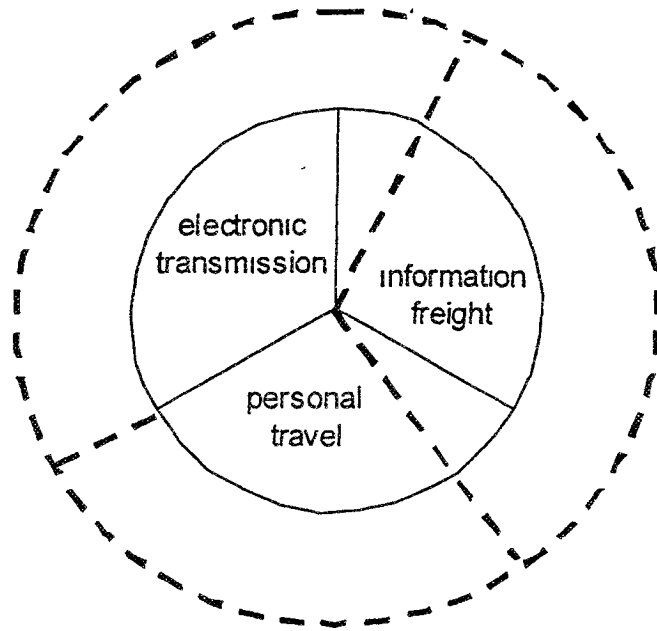
²⁰ *Ibid*

this observation. The extra travel required for a side-trip to buy goods at a store could be minimal compared to the overall trip.

But again, the shopper-traveler will often see e-commerce as a superior means of accessing goods – as more convenient, comfortable, and satisfying – even if it were to prove more expensive than making a single purpose or as part of a chained trip. And, as with telecommuting and teleconferencing, the introduction of e-commerce will not necessarily lead to less overall travel. In the case of e-commerce, not only are delivery distances likely to grow, but also the number of purchased goods is also likely to grow – the result of more and better information and easier access to goods.

Still another use of telecommunications is transportation planning services. Travelers would use devices (personal computers, PDAs, etc) to access databases for specific trips. The intent would be to access scheduling, cost, and other information on a wide range of travel modes. With easy access to this information, travelers would more readily use other services, from conventional transit to car sharing. The goal of “appropriate mobility” would be attained. Telecommunications technology would be employed for internet-based travel planning, providing a major boost to an array of transportation services and options.

In general, then, greater availability of telecommunications services will facilitate and increase overall communication, which in turn increases the number of people who learn of new activities, goods and services, which in turn leads to increased passenger and goods movement. Although some of the growth in telecommunications will serve as a substitute for personal travel, the absolute growth in the whole communications “pie” (see Figure 1) will dwarf these effects of substitution for personal travel. This observation should not be troubling. More travel is not necessarily bad. In fact, if the increased travel results in greater access to activities, goods, and services, and is accomplished at reduced economic and environmental cost – the goal of new mobility strategies – then quality of life is enhanced.



Absolute growth in total communication shown with relative substitution among modes of communication

Source Patricia Mokhtarian. "A Typology of Relationships Between Telecommunications and Transportation," *Transportation Research A*, Vol. 24A, No 3, p 237, 1990

The challenge is to devise strategies that accelerate the introduction of telecommunications technologies in a manner that provides the most benefit at the least economic and environmental cost. We hypothesize that use of these technologies can be increased and accomplished in a societally desirable fashion by linking them with other mobility options. For instance, if car sharing and/or smart paratransit were available, a traveler could use them for occasional trips to the office and airport. And perhaps a small inexpensive vehicle could be used for neighborhood travel and accessing a local telecenter for teleconferencing. Under this scenario, one can imagine the household reducing its fleet of vehicles by one (e.g., from 3 to 2, or from 2 to 1). The net effect may prove to be more overall travel, but if so it would be accomplished in a less costly fashion and would reflect expanded professional interactions.

The challenge in devising socially beneficial strategies to support expanded e-commerce activities may be greater. The problem is that the current package delivery system is ill-equipped to handle large increases in package volume for residential delivery. Residential delivery requires packages to be collected from their origins to a centralized package-handling facility. The packages are then sent to a centralized package-handling facility near their destinations. They are then distributed by local delivery trucks to the specific homes to which they are addressed. This last link in the package delivery process is the most time-consuming and costly. Often, package delivery workers need to return to a home more than once to complete a delivery. Packages left on doorsteps risk being stolen or damaged by weather or animals. If this costly link could be eliminated or simplified, it seems reasonable that package delivery would be more timely and less expensive. One way that this could occur would be through the creation of neighborhood package distribution centers. Rather than having packages delivered to residential doorsteps, they would

be delivered to neighborhood distribution centers, which could be dedicated centers or could be located at grocery stores, post offices, or even coffee shops. From there, some mix of options is possible. Recipients could be notified electronically and could pick up their packages in a small neighborhood vehicle, or perhaps new local delivery businesses could be created that use a fleet of small vehicles for local delivery (and pick-up). As e-commerce expands, the volume of business would justify these and other less costly and less intrusive local services.

In summary, telecommunications provide the opportunity to reduce the cost of accessing goods, services and activities, and doing so with less environmental impact. The benefits of easy and inexpensive access are potentially large. While the long term impact might be more travel, that travel could be realized in a very positive manner – resulting in enhanced quality of life.

Pathways and Synergies

We have described some potentially attractive alternatives to the single-occupant light duty vehicle. Others exist and still others will become apparent over time. None are flourishing.

One reason is that no single alternative can offer the versatility of the conventional full-sized car. Travelers opting to use alternative modes of transportation are usually sacrificing some level of convenience. Second, the alternatives are not widely available. Car sharing is only available to a few people in the US; only one company is selling small personal vehicles (and only in limited markets), smart paratransit is just taking hold in a few communities; telecommuting is more widely available but doesn't fit the needs of most workers and has minimal economic benefits (because telecommuters need to keep a car available).

For a new mobility system to function more effectively than single stand-alone alternatives, the alternatives must be coordinated so as to capture synergies, especially with respect to the user. These synergies will generally take the form of lower cost or greater convenience (as well as lower overall social costs). Lower costs are those that would result from replacing one car in a household's fleet with some combination of new mobility alternatives. Convenience benefits are more difficult to measure and cover a range of benefits.

Convenience benefits include greater mobility by people with diminished abilities, for instance those who cannot drive a conventional car but can now drive a small easy-to-operate electric car – and others who are too young or poor to own a car. Car-less people would gain access to a wider array of transport and communication services. Other convenience benefits might include easier access to congested areas where parking is limited and easier use of telecommunication options (such as using neighborhood cars to access local telecenters).

Transportation alternatives that fill the need for short trips include walking, bicycling, and small personal vehicles. Alternatives that meet the need for longer trips include conventional transit, car sharing, telecenters and telecommuting, and electronic commerce. Natural synergies exist between these two classes of alternatives. It would be impossible to provide a definitive analysis of alternatives, and we do not attempt to do so here. The cost to a user of replacing a car with some combination of car sharing, small neighborhood cars, smart paratransit, telecommuting and so on is sensitive to a variety of assumptions and conditions. For instance, if the traveler can substitute telecommuting for some long distance trips and mass transit for others, then local trips

can be easily served by bicycle or small personal vehicle. If the traveler normally only needs to travel locally, a combination of a small personal vehicle and car sharing might be sufficient. If the price of small personal vehicles could be lowered and car sharing became a widely available option, these combinations of technologies could provide a high quality of transportation service at a cost to the consumer that will be considerably lower than the present average cost of vehicle ownership.

In each of these cases, a transportation alternative that replaces long trips but still requires short trips to achieve the mobility and access characteristics of the conventional car is coupled with an alternative that provides easy transportation for short distances. In these scenarios, the short-distance transportation alternative completes the picture to turn inconvenient alternatives to the full-sized car into viable options for any person that has local access to long-distance transportation alternatives.

However, it is unlikely that making packages of transportation alternatives equivalent in utility to the conventional car will be sufficient by itself to bring about a transformation of transportation systems. Although the same trips that were possible using a privately-owned vehicle will be possible through an intermodal new mobility system, the new trips will have some undesirable attributes. The principal difference is greater need for trip planning. A traveler planning to take a short-distance mode of transport to a mass transit station must coordinate travel timing with the transit schedule. An unexpected event that delays home departure by even a few minutes could lead to significant travel delay. Even for travelers making predominantly local trips, using a small personal vehicle locks the traveler into making *only* local trips, and some level of travel spontaneity is lost. Although this traveler could switch to mass transit or car sharing if a sudden need for long-distance travel arises, use of these modes require more planning than simply using a privately-owned vehicle.

Strong synergies and large incentives are needed to accomplish a major transportation transformation. These synergies and incentives include building constructive relationships between car-sharing and “clean” technology vehicles, between telecommunications technologies and transit, and between telecommunications technologies and car-sharing. One can imagine implementing these transportation alternatives together with other community enhancement strategies. The goal is to allow people to match their mode of transport with their specific travel purpose. But no single model fits everywhere. And consumers are inherently conservative. An important first step is to demonstrate the variety of options available to reduce the cost and impact of travel, and to disseminate this information and knowledge. Education is critical to customer experimentation, adoption, and acceptance.

One strategy is to create demonstration sites and communities. This will require government and industry financial support at the outset. It will require leadership and vision. And it will require carefully constructed business models. These efforts are likely to be enhanced when founded on a linking of services and products: offering an alternative transportation *system*, not isolated technologies and services. Taken alone, none of the alternatives to the conventional car discussed here is likely to succeed. However, combinations of these alternatives, supported by

enlightened land use planning and transportation and parking pricing, could lead to the creation of economically vibrant and environmentally desirable communities.

Government and industry assistance for various new mobility technologies could come in a variety of forms. The most direct form would be financial support for system-enhancing technologies, such as “smart” versions of paratransit, car sharing, and even mass transit. An example of the latter are real-time information at bus stops indicating when the next bus will arrive. Government support for development of key alternative technologies such as small personal vehicles would be another example. At a more local level, government, technology suppliers, and local businesses could subsidize the start up of demonstrations based on a new mobility plan developed by the community. Indirect governmental support for new mobility could come in the form of disincentives for the privately-owned vehicle.

Partnerships between new mobility businesses, such as local car sharing organizations, bicycle retailers, and local bus and train operators, need to be fostered. These partnerships will create a strong new mobility core business community and will facilitate the intermodalism necessary for a new mobility system to thrive. The initial group of new mobility partners could grow to include manufacturers and retailers in the small personal vehicle industry, the “smart” technology industry, the personal computer industry, the package delivery industry, and more. Any city attempting to incorporate the concepts of new mobility into the lives of its residents must start small, but start systemic. None of the alternatives to the privately-owned vehicle can succeed alone. Their success in competing with this dominant mode of transportation will stem from synergies that exist between them. If only one or two transportation alternatives are available at first, these synergies will not be maximized and the public perception of new mobility will drop and an opportunity may be lost.

Conclusion

The workshop provided a forum and focus for those seeking innovative low-impact options for enhancing the transportation system. The outcome of the workshop and the evolution of new mobility options will not be known for some time. It appears that a variety of initiatives are being pursued: new research is being launched to determine why some services and options flourish while others do not; new local-based partnerships are being formed between local governments, businesses, community groups and technology suppliers; and new demonstrations are being designed that link car-sharing, small electric and very low-emitting vehicles, telecommunications, and reservation/communication technologies. Where and when they will bear fruit remains to be seen. We remain hopeful.

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new mobility

NEW MOBILITY WORKSHOP

Organized by:
Dan Sperling + Dan Sturges
Institute of Transportation Studies, University of California, Davis

MONDAY, NOVEMBER 2, 1998

- 9:30 **Welcome and Workshop Goals**
Dan Sperling
- 9 40 **Attendee Introductions**
- 9 50 **The New Mobility Vision, Overview of New Technologies & Systems**
Dan Sperling
- 10 10 **Small Personal Vehicles for Local Travel**
Dan Sturges, Presiding
Discussant; Pierre Arsenault, Gary Starr, Carl Watkins
- Urban EVs
 - Neighborhood Electric Vehicles
 - EV Bikes
- 10.50 **Shared-Use Vehicle Systems**
Susan Shaheen, Presiding
Discussant; Conrad Wagner, Marty Bernard
- European Experience
 - U.S. Experience / CarLink One-Year Field Test
 - Station Cars
- 11:40 **Telecommunications and the Digital Revolution**
Tom Horan, Presiding
Discussant; Pat Mokhtarian & James DeStefano
- Telecommuting (Telecenters)
 - Digital Communities
 - E-Commerce
- 12:20 **Experiences with Low-Technology Alternatives**
Paul Zykofsky
- Pedestrian & Bicycle Communities
- 12:30 **Lunch**

Continued....

- 1:30 **Toward New Systems and Pathways, Creative Linking of Technologies and Institutions:**
Dan Sturges
- 2:00 **Open Discussion**
- 2:30 **Break**
- 2:45 **Next Steps (Invited Comments)**
Mary Nichols
Anthony Lo
Paul MacCready
Cecilia Ho
- New Public/Private Partnerships
 - New Demonstration Programs
 - Public Education Initiatives
- 3:30 **Open Discussion**
- 4:30 **Closing**

ITS-Davis would like to thank the workshop's sponsors:

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November 2, 1998
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