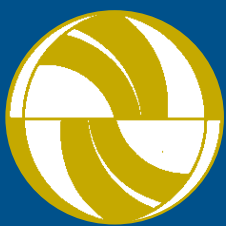


TRANSPORTATION RESEARCH



SPRING 2004
NUMBER 24



Transportation Research at the University of California

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Spread-City Everywhere

IT HAPPENED FIRST IN AMERICA, but by now spread-city is becoming the standard urban form worldwide. Ease of economic transaction and social interaction among distant partners has assured success for the new-style city, even though it diverges so far from city forms of the past.

First there was that historically extensive series of technological developments that, cumulatively, reduced the friction of geographic space: the astrolabe and compass, sailing ships, canals, telegraphs, railroads, paved roads, telephones, radios, automobiles, airplanes, the Internet. All of them connected people located in different places and, increasingly, permitted them to behave as though they were in the same place. Each technological development contributed to parallel institutional developments extending to ever-more-distant locales.

Recently, telephones and automobiles have permitted urbanites to leave the dense older sections of metropolitan areas for the more spacious and livable suburbs and exurbs. By now, most urban activities occur in those outlying areas. Service industries are becoming more important compared to once-dominant manufacturing industries. Steady improvements in freight services are reducing the roles of transport costs in production and locational decisions of goods-handling firms. Agglomeration economies are being achieved without physical proximity, as the economy and society become increasingly reliant upon information exchange that is independent of geographic location.

The resulting locational freedom permits people and companies in American metropolitan areas to locate wherever their fancies lead them. They can live and work in pleasant natural settings and perform more effectively than their grandparents did. Moreover, they are *choosing* to locate in low-density areas, clearly because the benefits of dispersed settings exceed whatever costs are associated with them.

Some critics of spread-city fear that spatial dispersion will mean cultural depravation. The rich cultural activities historically associated with the world's compact urban centers have been sources of much of the world's greatest art, literature, music, science, and technology. By permitting great minds to contact comparably great minds—by enhancing

accessibility—the form of those great urban centers helped stimulate the cultural enrichment that distinguished them as centers of civilization.

That was largely because close spatial proximity used to be necessary for close functional proximity. But that is no longer so. Members of the intimate communities of artists, scholars, scientists, technologists, and many other modern generators of cultural enhancement are today scattered around the world. In any single metropolitan area they may be scattered across the landscape. Even when they localize within a limited district, as they do in Silicon Valley, that district may be located in the distant suburbs. Witness the creative productivity of artists and scientists who live and work in such noncentral places as Brugge, Bangalore, and Berkeley.

The beneficial attribute of urban settlement has always been *accessibility*. Until recent times, accessibility required proximity. Now and in the future, accessibility can be to some degree independent of both location and density. The new-style spread-city can be economically more productive and culturally more creative than predecessor cities for which high-density spatial form was critical.

As economic development in countries of the developing South generates income streams comparable to those in the North, more and more people will use telephones, computers, airplanes, and the successors to today's automobiles. More and more will choose residential and work sites located at metropolitan edges and other outlying locations, just as they do in the North. The trend is unambiguous everywhere. There is no reason to think it can be diverted back to forms that characterized preindustrial and industrial cities and towns. Nor, I am contending, should it be.

Neither enhanced quality of urban life, nor economic efficiency, nor resource sustainability demand it. There are indeed serious problems of social equity manifested in megacities, because not all residents enjoy their advantages. That disjunction calls for serious adjustment of social and economic distributional patterns within post-industrial society. But not its spatial patterns.

Melvin M. Webber

BRAZIL'S BUSES: SIMPLY SUCCESSFUL

BY AARON GOLUB

DURING THE NEXT HOUR, about three hundred buses will come screaming down the avenue below my apartment here in the Copacabana district of Rio de Janeiro. Although three hundred buses an hour is a lot, many avenues in many cities in the world have even higher bus flows. But these three hundred Brazilian buses are different from most. They average less than three years of age, they're full size (forty feet plus), and carry 85 passengers each. The higher flows in other cities generally consist of older or smaller minibuses. The Brazilian buses are owned by private operators, many with fleets ranging in the hundreds—and a few in the thousands. Most important, they make a profit, receiving no support or subsidy from any public agency. Indeed, buses are big business in Brazil, and have been for decades.



*Station-level boarding
in Puerto Alegre*

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Over sixty million bus trips are made daily in Brazil, which has an urban population of roughly 110 million people. Compare that to the United States, where only about twenty million bus trips are made each day in a country whose urban population is over twice as large. This is to say: buses are relatively unimportant in the United States, but very important in Brazil. There, the national car ownership rate is about 23 per 100 households, compared to more than 92 per 100 households in the US.

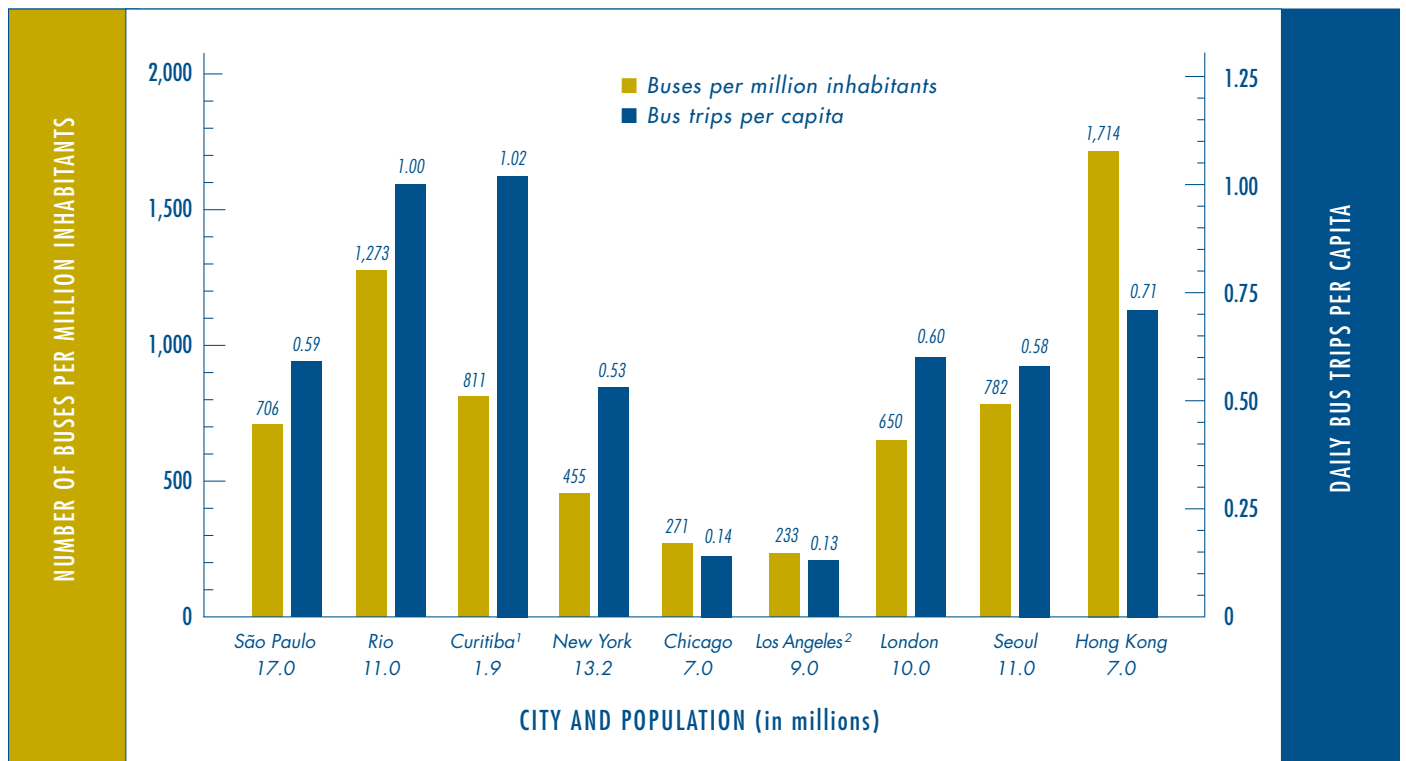
When compared to large cities worldwide, Brazil's intensity of bus use stands out even more. Figure 1 summarizes bus use in some of the largest cities in the world. Several of these cities have extensive subway systems, which reduces their dependence on buses. This makes the experiences of Rio and São Paulo even more impressive, because they also have subway systems, though small. Nevertheless, they are able to supply most of their public transit needs with buses. In Rio, the bus mode share of motorized trips is over eighty percent, and cars make only around fifteen percent of total trips. Only Hong Kong comes close to these numbers with bus trips at around sixty percent of motorized trips. Indeed, the number of bus trips made each day in São Paulo and Rio together roughly equal that of the entire United States, with ten times the population of the two cities. >



Tube station in Curitiba

FIGURE 1

Bus use in several large urban areas worldwide



¹ For the municipality of Curitiba only (over 70% of the metropolitan area). ² Los Angeles County

Number of buses for London and Curitiba include significant numbers of articulated and double-decker buses, while those for Hong Kong include significant numbers of both double deckers and minibuses.

Source: Author's data and Murthy V.A. Bondada, ed., *Urban Public Transportation Systems*, ASCE, Virginia, 2000.

CURITIBA AND OTHER CITIES



By now nearly every transit buff and urban planner the world over must have heard of Curitiba (pronounced: kur-i-*chee*-ba), the medium-sized, industrial city in southern Brazil. Although Curitiba is one of Brazil's wealthiest cities and has the second highest car-ownership rate in Brazil (about 55 per hundred households), it also has an extremely high rate of public transit use (roughly one trip per day per capita). The city's gasoline consumption per capita is also among the lowest of any large city in Brazil. Its transit system combines exclusive rights-of-way for bus corridors, express and skip-stop services, articulated buses, off-board fare payment, tube stations with station-level, multiple-side-door vehicle boarding, and land use zoning coordinated with high-capacity bus corridors. All this provides efficient, profitable, and popular public transit. It has made Curitiba the gold standard in public transportation and a favorite among New Urbanists for the past two decades.

Curitiba began its transportation projects in the late 1960s, when the city's population was a mere 400,000. In 1971, Mayor Jaime Lerner closed several blocks in the center of the city to automobile traffic and began constructing the first exclusive bus corridor, now called Bus Rapid Transit (BRT). This involves bus-only lanes that allow buses to travel efficiently along their routes without having to compete with other traffic. The bus routes also comprise the axes of the city's high-rise, high-density residential and commercial developments which parallel the busways as components of a unified urban development plan. Curitiba has shown the world how to plan land use and transportation systems as integral parts of the larger urban system.

The first bus corridor became the spine of a larger hierarchical system of express, trunk-line, and feeder-bus networks, with thirteen transfer stations throughout the city, completed in 1983. In 1992, the city introduced its now-famous tube stations with off-board fare payment, floor-level boarding, and articulated buses on the main corridors. Currently, there are 72 kilometers of exclusive bus corridor operating in the city, with plans for expansion. The pedestrian-only areas have grown and now include 24-hour open-air commercial areas with bars and restaurants.

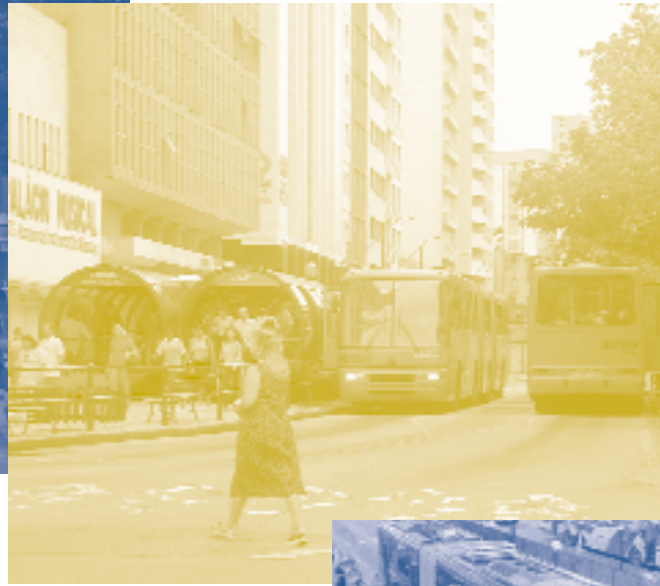
Other examples of foresighted Brazilian cities include São Paulo, also an innovator in bus corridors with over seventy kilometers currently in operation, an additional thirty under construction, and over a hundred planned over the next ten years. São Paulo's most successful bus corridor, the Santo Amaro corridor, is only fourteen kilometers long but carries over 200,000 passengers per day, and its 33-kilometer-long EMTU corridor carries 210,000 trips per day. Together, these two bus corridors carry thirty percent more passengers every day than the San Francisco Bay Area's BART system, which is over 160 kilometers long.

The concept of convoying a set of buses together into a dedicated lane was developed in the late 1970s for bus corridors in São Paulo and Porto Alegre. The convoy becomes a virtual train, with each car having a different destination. At the end of the joint corridor, the buses separate on to different trajectories. Bus stops are long to accommodate the complete convoy, and passengers enter buses simultaneously. Because the buses follow each other, they waste no time jostling for space in traffic and at bus stops. Signs and markings make it easy for passengers to know where to wait, so boarding happens quickly. These characteristics also make it possible to schedule frequent buses and frequent stops, which increase convenience. Convoys greatly

Tube station in Curitiba



Copacabana, Rio de Janeiro



São Paulo

increase the capacities of single-lane dedicated bus corridors in the city of Porto Alegre; the most successful is credited with carrying over 20,000 passengers per lane per hour at peak capacity.

Porto Alegre has also developed an integrated paratransit system. In the mid-1970s, the city began developing limited-stop express bus services to wealthier areas in an effort to curb growing car use for work trips. This service met with little success owing to high costs and limited demand. The planners, however, still wanted to cater to these higher-income markets somehow; so, in early 1977, they created a service called *Lotação*, meaning shared taxi. This fixed-route service proved very popular, charging higher fares than buses but offering comfortable seats and faster service with fewer stops. At first, vehicle sizes were limited to four-seat sedans, but by 1980, the standard was opened to seventeen-seat vans; finally, in 1994, 21-seat minibuses were allowed. Current legislation links bus fares and *Lotação* fares. A majority of users are female (65 percent), between ages 19 and 39 (57 percent), and upper income (55 percent). Over time, *Lotação* has become a successful and important part of the city's transportation system, with very high levels of service, including such amenities as air conditioning and on-board public cell phones.

Low cost is a common theme in these various approaches. The mass-transit systems, instead of costing from \$20 to \$100 million per mile like light rail or subways, squeeze out similar peak passenger capacities for only around \$5 million per mile. This is a consequence most obviously of necessity: Brazil is not a wealthy country; per capita GDP is around \$5,000. It is also a result of hard work by several generations of talented and creative engineers and planners, and a period in the 1960s and 1970s of excellent central planning and support from federal transportation agencies. Furthermore—in contrast to the United States, which spends billions subsidizing public transportation systems using local, state, and federal funding programs—the urban bus industry in Brazil yields positive net revenues of over three billion dollars per year. ➤

HISTORY

Until the 1930s, most cities relied heavily on privately run streetcars, with buses running on peripheral routes. By the 1950s, urban areas had far outgrown the extensive streetcar networks, and the United States model combining rubber-tired vehicles and suburban rail systems became attractive to Brazilian leaders. National industrial development also placed great importance on automobile and bus manufacturing.

As streetcars disappeared, small operators, like those existing today in much of the developing world, provided most bus services. National road-building and transportation planning agencies formed, and road infrastructure became a primary component of national urbanization plans during the 1960s. Rising incomes from the Brazilian “economic miracle” merged with added road capacities to expand demand for urban mobility.

The oil-price shocks in the early and late 1970s, however, soon led to a general slowdown in the Brazilian economy, a fall in public transit demand, rising costs, and a period of crisis and bankruptcies for the fragile bus industry. In response, national policy promoted increased size and strength of bus companies and instituted minimum fleet size rules for companies that wanted to provide bus service. Mergers and conglomerations of smaller transit companies were encouraged. In the late '70s, new national and state-level regulatory bodies promoted this new and more centralized model of urban transportation administration. Federal investments built bus corridors and terminals in many cities.

Minimum fleet sizes peaked in 1983 at around 100 vehicles per firm—though in some cities minimum fleet requirements reached 240 vehicles per firm, an astounding number considering that only ten years earlier most firms owned and operated only one vehicle. Today, several firms operate more than 400 buses each, and national-level holding companies often control groups of large firms. The largest group controls 1,350 buses, which, at roughly \$70,000 per bus, equals close to a \$100 million investment. Buses—and planning for buses—are thus very big business and a very powerful segment of the Brazilian economy. One of the largest bus conglomerates also owns GOL, one of Brazil’s major domestic airlines.



Bus convoy in Puerto Alegre

BRAZILIAN ENGINEERS

Brazilian innovations with bus systems haven’t exactly been lost on the world. For more than ten years, Brazilian transportation engineers have been exporting their bus expertise to the rest of Latin America and the world. Several worldwide consulting operations based in Brazil specialize in bus system engineering, including Logit, Logitrans, and Synergia. Specifically, engineer Pedro Szasz developed the bus conveying schemes used in São Paulo and Porto Alegre and was director of traffic engineering for the city of São Paulo with its nearly five million cars. Recently, freelancing for Steer Davis Consulting, Szasz engineered the various local, skip-stop and express services that make up the now world-standard Transmilenio Bus Rapid Transit (BRT) system in Bogotá, Colombia. Engineer Paulo Custodio, who founded Logit and has worked on numerous major transportation projects in Brazil such as the São Paulo metro, was chief of project design for the Transmilenio BRT system. He is now involved in bus corridor projects in Jakarta, Indonesia, La Paz, Bolivia, and Mexico City.



Buses without their own lane jockey for position in Rio de Janeiro



Bus lane in Bogotá

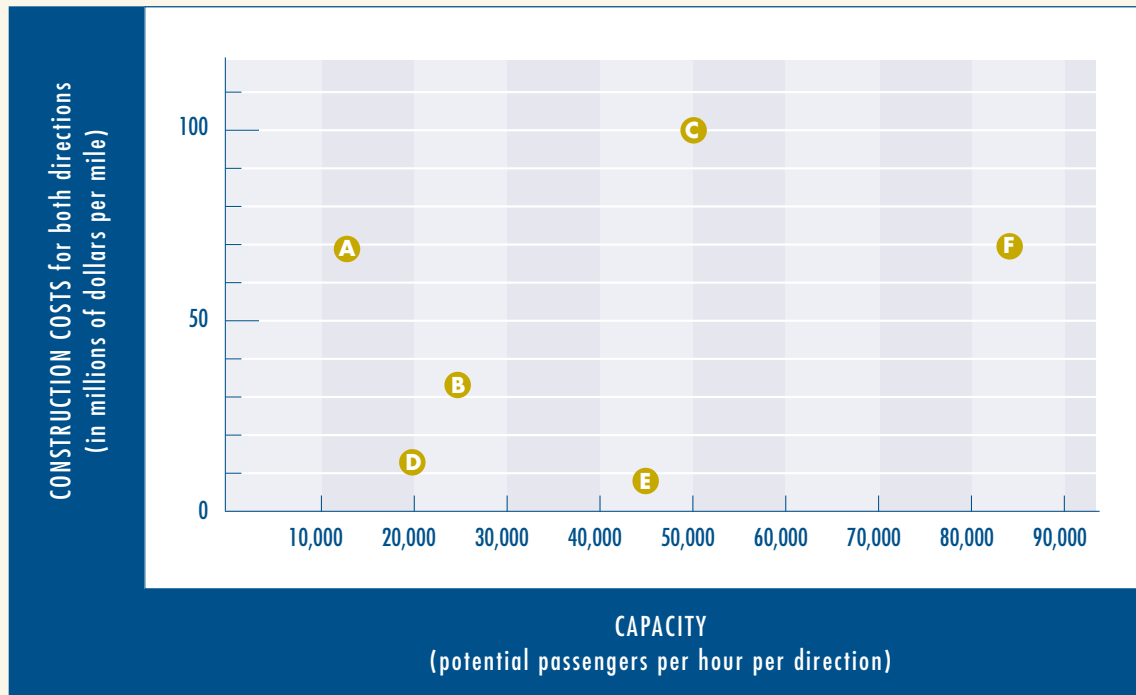
INTEREST IN THE UNITED STATES AND ABROAD

The success of the bus-based rapid transit projects in Brazil and other countries has piqued the interest of officials in the Federal Transit Administration. They started the Bus Rapid Transit Consortium and made official visits to Curitiba in 1999 and late 2000 to learn more. The cost effectiveness of the systems, combined with the budget crises in US cities, has made this interest urgent, and might even lead one to ask—what took so long?

The FTA's BRT Initiative program, created in 1999, provides small grants to agencies to explore BRT options. Over ten agencies have already received grants, including those in Boston, Charlotte, Cleveland, Washington D.C./Dulles Corridor, Honolulu, Miami, Pittsburgh, and San Jose. There are also other federal transportation funds available to build new bus rapid transit systems. As of late 2003, for example, fifteen cities >

FIGURE 2

Typical peak hour capacity vs capital costs



- A** **US 5-Lane Highway**
five traffic lanes
- B** **Light Rail**
typical to US
- C** **BART**
morning peak hour westbound across SF Bay
- D** **BRT**
single lane in each direction with convoy system
- E** **Transmilenio BRT (Bogotá, Colombia)**
two lanes in each direction
- F** **São Paulo Subway Line 1**
morning peak hour northbound

While acknowledging the difficulty in comparing costs and capacities among modes, the cost effectiveness of bus rapid transit systems is still clear. This table compares capital construction costs in current dollars per mile. It also compares peak passenger-carrying capacities per hour per direction among the several system types. The estimate for highway mode (A) is based on an average per-lane-mile cost of \$7 million, with a capacity of 2,750 passengers per lane (assuming 2,200 vehicles and an occupancy of 1.25 passengers per vehicle). Light rail (B) is based on the average cost as reported by the GAO of \$35 million per mile, with a peak capacity typically cited in the literature. The BART estimate (C) is based on the system-average capital cost of around \$100 million per mile, with peak capacity assumed to be crush-loads (180 per car) at current peak-hour headways, summing to around 50,000 per hour. However, in reality BART carries fewer than 15,000 passengers per direction in its busiest hour. The bus rapid transit mode estimate (D) is based on typical costs per mile as reported by the GAO (\$13.5 million per mile) with peak capacities experienced in single-lane BRTs around the world. The Transmilenio (E) estimate reflects two lanes in each direction, so the comparison is a bit unfair, although it is still remarkable to see how a second lane that allows high-speed passing can affect capacity. The São Paulo subway (F), among the most productive in the world, carries record numbers during its peak hour.

All costs are in US dollars, although projects in other countries had much lower labor and material costs than those built in the US.

with BRT project proposals have applied for funding under the New Starts program, and several have applied for Bus Capital funds. In 2004, the New Starts fund will award \$331 million to a BRT project in Boston.

One of the more notable demonstration projects is the first phase of Los Angeles' BRT system, called "Metro Rapid." While not including every element of the Brazilian systems, such as a fully segregated bus lane with off-board fare payment, the first Metro Rapid line was nevertheless successful. The line employs advanced compressed natural gas low-floor buses; it relies on new bus stops separate from local bus stops, priority at traffic signals, and an aggressive marketing scheme. In the Wilshire-Whittier corridor, travel time fell by 29 percent and ridership increased over 40 percent! Los Angeles' plans for BRT have greatly expanded and will combine 23 corridors with various levels of priority treatment into a fairly comprehensive network.

Unfortunately, most of the proposed BRT systems in North America don't incorporate the complete network characteristics that make the systems in South America so effective. The most comprehensive current development is the Transmilenio BRT system in Bogotá, Colombia, which will form a network of 22 segregated bus corridors, each with two lanes in each direction, totaling 388 kilometers. An estimated daily ridership of five million will use the service at a total cost of only two billion dollars. The first line, only forty kilometers long, opened in late 2000 and carries 800,000 riders per day at a farebox recovery ratio of 1.2—that is, it is turning a profit! Quito, Ecuador, is also planning a major bus corridor network, and Taipei and several major cities in China have constructed initial phases of large systems as well.

So, what will be around the next bend in Brazil's bus journey? São Paulo's current extensive bus system reorganization will add new BRT corridors, including one magnetic guided bus line due to be completed this year. Even Curitiba is undergoing a facelift, with projects planned throughout the city that will add additional capacities and increase travel speeds even more. And, as cities around the world follow Curitiba's lead in bus planning, other cities within Brazil are beginning to take notice. Rio de Janeiro, which until last year lacked even the most basic bus prioritization and has not even one kilometer of segregated bus corridor, is beginning bus prioritization projects on some corridors. On the technology side, Eletra, a Brazilian bus manufacturer specializing in electric motor-driven trolleybuses, is developing a fuel-cell hybrid bus, and has come to market with hybrid diesel-electric buses.

It is clear that North American bus operators have a great deal to learn from their South American counterparts. It is no surprise that Bus Rapid Transit has become a popular experimental mode in the US, jointly encouraged by FTA and the Brazilian experience. So, the next time you save fifteen minutes on a bus trip along an exclusive corridor, don't forget to say, "Obrigado, Brazil!" ♦

FURTHER READING

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São Paulo



Motorizing the Developing World

BY DANIEL SPERLING AND EILEEN CLAUSSEN

IN RURAL AREAS AND SMALL CITIES of China and India, millions of small locally made three- and four-wheel “rural vehicles” are proliferating. In China, the vehicles are banned in large cities because of their slow speed and high emissions, but even so rural vehicle sales in China outnumber those of conventional cars and trucks. These vehicles, which cost anywhere from \$400 to \$4,000 each, are the heart of millions of small businesses, transporting farm products, construction materials, and locally manufactured products. They also serve as the principal mode of motorized travel in rural areas.

Motorization is accelerating even more rapidly in cities. Personal vehicles, from scooters to large company cars, are improving access to goods, services, and activities, including an expanded array of job and educational opportunities. They provide unmatched flexibility, convenience, and freedom. For many individuals, vehicles are desirable as a secure and private means of travel, and as status symbols. For businesses, they are a means of increasing productivity.

But personal motorization also imposes enormous costs, especially in cities. The well-known litany includes air and noise pollution, neighborhood fragmentation, and high energy use. Motorized transport is the largest consumer of the world’s petroleum, making it central to international concerns over energy security and political stability in volatile regions. China is now the second largest importer of oil in the world, although its vehicle ownership rates are but one-fiftieth of the US’s. The developing world is an increasing source of greenhouse gas (GHG) emissions, which are rising faster in transportation than in any other sector.

Developing cities and countries are in a quandary. How can they accommodate the intense desire for personal mobility while mitigating the heavy economic, environmental, and social costs of motorization? For countries such as India and China, which look to automotive manufacturing as a pillar of economic development, the dilemma is extreme.

An earlier version of this paper was published as Daniel Sperling and Eileen Claussen, “The Developing World’s Motorization Challenge,” Issues in Science and Technology, Fall 2002, pp. 59–66.

THE NEW REALITY OF PERSONAL TRANSPORT: THE GOOD AND THE BAD

Motorization is soaring virtually everywhere. The number of motor vehicles in the world is expected to reach about 1.3 billion by 2020, more than doubling today's number. Fastest growth is in Latin America and Asia. In China, vehicle sales increased over fifty percent per year over the past few years, from 700,000 in 2001 to 1.1 million in 2002, and about 1.7 million in 2003. Beijing already has over two million cars.

These figures and forecasts, like almost all published data on vehicle ownership, do not include motorized two-wheelers, nor the rural vehicles mentioned above. China alone has more than fifty million scooters and motorcycles, and over twenty million rural vehicles. The costs of these vehicles are low and dropping—new mopeds and small motorcycles can be purchased for as little as \$200. They are found throughout Asia and are spreading to Latin America. Proliferation of these low-cost scooters and motorcycles is accelerating the motorization process, encouraging an early leap from buses and bicycles to motorized personal travel. No longer do individuals need to gather considerable savings to buy a vehicle. In Delhi, where the average income is less than \$1,000 a year, close to eighty percent of households nevertheless have motor vehicles, most of them two-wheelers.

The benefits of motorization are great, but the disadvantages are serious: more pollution, more energy use, and undermining of public transport services. Public transport is heavily subsidized in most cities because of its large positive externalities—reduced need for roadways, reduced congestion—but also because it ensures access by poor people. Nevertheless, even with low subsidized fares, many poor people still cannot afford transit services. Thus cities face pressure to keep fares very low, although in doing so, they sacrifice bus quality and comfort. Middle-class riders react by buying cars as soon as they can. With low-cost scooters and motorcycles, the flight of the middle class is hastened, transit revenues fall, and operators reduce quality further as they serve poorer clientele. Quantity of service often decreases as well. In nearly all cities worldwide, public transit is losing market share.

Motorization's enormous stress on city development and finances is troubling. A study by the US National Research Council asserts, "with very few exceptions, rapid growth in demand for motorized transport has swamped transport [infrastructure] capacity in the cities of the developing world." The World

Business Council for Sustainable Development, an organization of major automotive and other industrial companies, warns: "The major challenge in the developing world is to avoid being choked...by the rapid growth in the number of privately owned motorized personal-transportation vehicles...[Personal mobility] is deteriorating in many areas where it had been improving in the past." Many cities in developing countries, with a fraction of the car ownership of the United States, now experience far worse traffic congestion and pollution than exist in the United States.

The roadway construction and financing challenge is not just one of economics and financing. It is also political and social. Only a small minority of people in the developing world own cars and benefit from massive road-building budgets. In contrast, the vast majority suffer from increasing traffic congestion, noise, and pollution. In cities with many motorized two-wheelers, the vehicle-using population is larger but still a small share of total travelers. The solutions are not obvious. Desperate to keep traffic flowing, Shanghai, one of the best managed cities in the world and also one of the densest, has taken the controversial step of limiting bicycle use in downtown areas. Meanwhile, destruction of neighborhoods to build new expressways is starting to spark social unrest, as it did in the United States in the early 1960s.

Privatization has been one response to financing challenges. Many parts of the developing world, particularly in Latin America, are selling roads, ports, intercity railroads, and other facilities, or sometimes just operating rights, to private companies as a means of financing the operation and expansion of new and existing facilities. Even China is relying on tolls to finance intercity roads. Although privatization is an attractive solution to the funding woes of governments in developing countries, it creates a new mix of winners and losers that merits close scrutiny.

Air pollution's adverse effects are also attracting the attention of local policymakers. Motor vehicles play a central role, accounting for about half of urban pollution, even in places with very low rates of vehicle ownership. Santiago, Mexico City, Beijing, Katmandu, and Delhi are now aggressively imposing new laws to reduce air pollution. Lead removal from gasoline ➤



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has been successfully regulated almost everywhere. Its removal is motivated partly by health concerns but also because lead destroys the effectiveness of catalytic converters, which are crucial for meeting tighter vehicle emission standards. With more stringent emission standards, most cities will soon control air pollution, just as those in the US have done. Large international automotive and energy companies are key.

More troublesome, because solutions are not obvious, is petroleum use. Motorization leads to sharp increases in oil consumption. In most of the developing world, cars use about six times as much energy as buses per passenger-kilometer, and about twice as much as a small (four-stroke) modern motorcycle. These ratios can vary considerably, depending mostly on ridership levels.

While soaring oil use is not a compelling problem to local policymakers, it is of great concern to national governments and, even more, to the global community. The global transportation sector is now responsible for almost one-fourth of worldwide carbon dioxide emissions. The International Energy Agency projects that oil use and GHG emissions from developing countries will grow three times faster than emissions from the United States, Europe, and Japan over the next twenty years; others project an even greater differential.

Overall, about half the world's petroleum is used for transportation. Thus, greater transportation energy use translates directly into greater vulnerability to supply disruption, greater pressure on Middle Eastern politics, and greater emissions of carbon dioxide. Although the transport sectors of countries such as China and India are still small contributors with relatively few vehicles per capita, their emissions are increasing at a sharp rate. In China, for instance, transport accounts for less than ten percent of GHG emissions. In cities such as Shanghai, however, four- to sevenfold increases are anticipated in the next twenty years.

The challenge for these cities is heightened by the fact that uniform prescriptions do not work. Motorization patterns vary widely across the globe, particularly among developing countries. In some Asian cities, conventional trucks, buses, and cars account for only five percent of vehicles, compared with sixty percent in others. In Delhi and Shanghai, roughly two thirds of vehicles are motorized two- and three-wheelers, whereas in African and Latin American countries, almost none are. In South Africa, minibus jitney transportation accounts for a third of all passenger-kilometers of travel, but in others it plays a negligible role. Shanghai had 22 cars per thousand residents in 2001, whereas much poorer Delhi had nearly three times as many. Numerous factors influence motorization. Income plays a central role, but there are other factors more readily influenced by public policy and investments.

The challenge of dealing effectively with rapid population growth, rapid motorization, and large groups of low-income travelers would be difficult for cities with substantial financial resources and strong institutions. For developing cities with limited funds and planning expertise—and inexperienced institutions—effective transportation planning, infrastructure development, and policy implementation are extremely difficult. In many cases, the problem is lack of political will, compounded by lack of money and effective institutions. We have these problems to varying degrees in the United States as well.

The difference is that the timeline for transportation system development in today's developing countries is compressed compared with more affluent cities and nations. The rapid speed of development creates pressure for substantial investments within a relatively short period. Finding the resources to finance the needed infrastructure investments and the expertise to manage the growth is a challenge in many parts of the developing world.



LEAPFROGGING IS NOT THE ANSWER

Transportation systems are highly fragmented, with diverse technologies and a diverse mix of public and private investors, managers, and users. Frustrated policymakers reflexively turn to technological fixes, because they generally require less behavioral and institutional change.

Leapfrog technologies—advanced technologies that allow developing countries to skip over difficulties encountered in industrial nations—are the highest-order technical fix. The principal example of successful leapfrogging in developing countries is the use of cellular phones in place of extensive networks of telephone landlines.

Some leapfrog transportation technologies are being pursued in developing nations. Information technologies control roadway congestion and collect tolls in many cities. Electric bicycles and scooters in China and a number of other countries reduce urban air pollution. Some cities are switching buses, taxis, and other vehicles to natural gas; Mexico City and a few others are investing, with international aid, in fuel cell buses. And Shanghai built a maglev train, employing German technology that failed to find a market in developed countries.

In the end, though, the case for a leapfrog approach is far less compelling in transportation than it has been in telecommunications. Advanced transportation technology will not revolutionize the way people and goods get around. Some fuel, propulsion, and information technology options are currently available, and their deployment could be accelerated, generating modest emissions or energy savings. But they tend to be more costly than conventional petroleum combustion technologies and can require huge financial and institutional investments. Advanced transportation technologies are clearly an attractive option in developing countries, but great care must be taken to adapt to the setting, anticipate unexpected costs, and provide expertise and institutional investments to implement these technologies successfully.

BUSES REBORN

Entirely novel policies, investments, and technologies are not needed. There are plenty of examples of effective initiatives around the world, many of them pioneered in developing countries. What is missing in most cities are commitment and public resources.

Bus rapid transit is viewed as perhaps the most important transportation initiative today, not only in Asia and Latin America but even in the United States. A few bus rapid transit operations

have been able to move as many passengers in one bus lane as on a rail line, and at a fraction of the cost (see Aaron Golub's article on page 2 in this issue).

There are other examples of successful transportation initiatives in developing countries. Singapore coordinated land use planning and public transit investments so that businesses and homes are close to trains and buses. It also strongly discouraged car ownership by imposing very high registration fees on vehicle purchases. Shanghai also coordinated land use and transit planning and provided infrastructure for bicycles and pedestrians to encourage nonmotorized alternatives (but it is now reconsidering that strategy). Curitiba created an efficient bus rapid transit system in the 1970s, as well as a pedestrian-only zone in the city center. Bogotá is building a bus rapid transit system modeled after Curitiba's. Car use there is discouraged in a variety of ways such as allowing only certain cars into the city on any given day according to license plate number; similarly, a network of bike lanes and expanded sidewalks encourages alternatives to motorized travel.

ROLES FOR THE US

As motorization overwhelms cities of the developing world, the challenge for public authorities is twofold: to enhance the attractiveness and efficiency of collective and nonmotorized modes, and to reduce the negative effects of personal vehicles. The United States can assist developing countries in forging and implementing sustainable transportation strategies in a variety of ways:

Private investment and technology transfer. Most of the investment flowing from industrialized to developing countries is by private companies, not national governments or international development funds. The greatest challenge is to reduce investment risk and the high initial capital cost of innovative transportation strategies. One potential medium would be a public-private investment fund established by the Overseas Private Investment Corporation, targeted specifically to transportation needs in developing countries. A transitory fund that uses government funding to leverage private capital could mitigate financing risk and serve as a bridge to longer-term financing through private or multilateral lenders. Also, expanding the small programs at the California Energy Commission and the US Department of Energy could further assist private companies that invest in energy-efficient technologies in developing countries.

Multilateral and bilateral government support. Working through existing institutions, the United States could increase >



government lending and assistance for sustainable transportation strategies. For instance, it could work with multilateral lenders to increase financing for projects and support these efforts with technical and planning expertise. The government could also commit more sustained funding for the Global Environmental Facility, which serves as the funding vehicle for various multilateral environmental agreements. Priority should be given to projects that enhance nonmotorized travel, transit services, and vehicle technology (such as eliminating lead and reducing sulfur in fuels).

Capacity building. Perhaps the most important outreach from the United States could be to help strengthen the capacity of developing countries to analyze and implement transportation strategies and to integrate them with land use and broader sustainable development strategies. These efforts need not be undertaken exclusively or even primarily by government entities. The private Energy Foundation and the David and Lucile Packard Foundation, for instance, provide funds to US experts who work with government officials and nongovernmental organizations in China to develop energy standards.

Training of professionals and researchers by US universities plays an important role in capacity building and technology transfer. Historically, US universities drained the top students from developing countries, but that is becoming less true. Many now study in the United States but return to their countries permanently or intermittently, sometimes through collaborative ventures. Increasingly, US universities are forming alliances with universities in developing countries and participating in various cross-training and technology-transfer programs.

Other potential partners in capacity building could include large automakers or other major international companies. Many companies have the resources to assign and fund technical staff to assist in traffic management and in environmental, energy, and safety regulation. Because these companies have a significant stake in these newly emerging markets, safeguards against undue conflicts of interest would be necessary.

SETTING AN EXAMPLE

The US, as the world's largest economy, energy user, and greenhouse gas emitter, has a responsibility to provide leadership. Its ability to encourage sustainable development elsewhere will remain seriously compromised until it demonstrates a genuine commitment to addressing its own greenhouse gas emissions. The US withdrawal from the Kyoto Protocol and the

Bush administration's adoption of strategies that allow continued growth in US emissions underscore the perception in developing countries that the US is not serious about these issues.

Ultimately, the most cost-effective tool for reducing emissions is likely to be a trading system that caps emissions and allows companies to buy and sell greenhouse gas credits. The United States could create the domestic framework for such a system, making it compatible with other national trading systems and the international trading system established under the Kyoto Protocol. This could facilitate private investment in sustainable transportation in developing countries.

A related opportunity is the Clean Development Mechanism (CDM) established under Kyoto, which allows developing countries with emission-reduction projects to market the resulting emission credits. One promising approach is to recognize sector-based efforts. For instance, a comprehensive program to reduce transportation-related emissions in a given city or country could be recognized for crediting purposes through the CDM or a CDM-type mechanism linked to a domestic US trading system. Such an approach would provide a strong incentive to both US companies and developing countries to support more sustainable transportation choices.

In summary, the United States can do a great deal to support sustainable transportation in developing countries. Fortunately, many strategies and policies aimed at solving problems there can at the same time address global concerns about climate change and petroleum dependence. It is unlikely, though, that such assistance alone could ever be sufficient to the need. The United States can in the long run exert far more influence by launching credible efforts at home—to reduce oil use and emissions and to tackle climate change more broadly—and by creating incentives that engage the private sector. As the world's largest market for motor vehicles and other transportation services, the United States to a large degree drives the pace and direction of technology development worldwide. Policies that reduce greenhouse gas emissions from the US transportation sector will have a significant spillover effect in the developing world, both in generating cleaner vehicles and in shifting the orientation of multinational auto manufacturers.

Through it all, there can be no doubt that the developing world is racing to repeat the developed world's transportation history, and that the undesirable effects associated with that history will mitigate the many associated benefits. Worse, these undesirable effects will spill over the entire planet. Even as

nations everywhere support the right (and opportunity) for later arrivals to gain their full share of physical mobility, they must also recognize that it is in each nation's self-interest to call for an all-out international effort to modulate future history to dampen the negative outcomes.

No matter what else is done, the developing countries *will* be modernizing their transport sectors. The global consequences call for all countries to collaborate in efforts to temper the negative environmental, economic, and equity repercussions of modernization. Failure to do so could be costly for all. ♦

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Keeping Children Safe in Cars

BY JILL COOPER

Co-authors on this study include David Ragland, Director, Berkeley Traffic Safety Center; Kara MacLeod, Research Associate, Berkeley Traffic Safety Center; and Wendy Jameson, Director, California Health Care Safety Net Institute.

CHILD-SAFETY SEATS BAFFLE PARENTS, even the most technologically oriented and safety-conscious ones. Selecting the right seat is complicated because seat types change as a child grows. Seats and harnesses must be assembled and installed in the car, and that can be tricky or nearly impossible depending on the car's age and model. Finally, securing a child in the seat can be challenging, even if she cooperates. If the child is sleeping, wiggly, or impatient, it can be extremely trying. Securing the child and, for some, installing the seat may be repeated several times a day.

The effort saves lives, though. The National Highway Traffic Safety Administration estimates that properly installed child-safety seats can reduce the risk of fatality by 71 percent for infants and 54 percent for toddlers. Despite the effectiveness of safety seats, many children don't have them. In the year 2000, 75 California children age six and under died from motor vehicle collisions. Over half were not restrained in child-safety seats. During the same year, 7,473 children in the same age group suffered injuries in motor vehicle collisions statewide. Sixteen percent of these children were not in safety seats.

The universal difficulty in using the seats correctly makes matters worse. Data vary, but generally upwards of eighty percent of car seats are not used correctly, and many studies find almost every safety seat misused in some way. Types of misuse include using the wrong seat for the age and weight of the child, having the seat in the wrong location in the car (e.g., in the front seat of a car with an airbag), and not securing the seat tightly enough to the car or the child tightly enough in the seat. While there is a great range of misuses, two consistently emerge as among the most dangerous in a crash: a seat loose in the car or a harness loose on the child. In a collision, the car seat moves forward and the child can experience a secondary collision with the seat or the vehicle.

Clearly people don't purposely put their children at risk, but not understanding the risks and a difficult technology conspire against them. The problem is especially acute for low-income families. Not only are car seats expensive, but older cars do not easily accommodate them.

Consider the following example:

A woman with two children, aged two and four, needs to visit the grocery store. She doesn't have a car, so she gets a ride with a neighbor who owns an older two-door sedan. The car's back seats don't have shoulder belts and the bucket seats make an imperfect fit, so the two-year-old's car seat cannot be installed securely. The four-year-old weighs over forty pounds, so he's too big for most forward-facing car seats and, therefore, needs a booster seat. However, there are no booster seats made for cars without shoulder belts, so the four-year-old must ride in an adult seat with only a lap belt. This mother is doing the best she can. Given the family's resources, she's not able to comply with best practices—although she does meet the letter of the law, which allows for exceptions in cases like this one. Most important, the children's safety is compromised. ➤



*More than
eighty percent of
child-safety seats
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correctly*

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CHILD PASSENGER SAFETY INITIATIVE

Low-income children face twice the risk of dying from crash-related injuries compared to children from higher income families. To increase safety for these children, the California Health Care Safety Net Institute and the UC Davis Medical Center launched the Child Passenger Safety (CPS) Initiative with funding from the California Office of Traffic Safety. The initiative ran from April, 2001, through September, 2003, and had these goals:

- To increase safety seat use among families using public health care services;
- To decrease the rate of safety seat misuse among these families; and
- To increase awareness of the January 1, 2002 “booster seat” law which requires child safety restraints for children up to age six or sixty pounds. (Previously, the law required appropriate restraint for children up to four years and forty pounds.)

Public hospitals and health care systems were chosen as intervention sites because they see many of the state’s children who are at most risk—almost three quarters of public hospital patients are low-income and/or uninsured. Each year public hospitals also treat thousands of children injured in motor vehicle collisions. The CPS Initiative worked with seven public hospitals and their clinics throughout Northern, Central, and Southern California. The program reached over 10,000 families, distributed thousands of child-safety seats to low-income families, provided assistance fitting children into seats, and trained health care staff, parents, caregivers, and foster parents.

EVALUATION OF THE CPS INITIATIVE

The University of California Berkeley Traffic Safety Center developed and analyzed pre- and post-intervention surveys to evaluate CPS at three sites. The surveys consisted of interviews with parents or guardians at clinics and observations of children aged six and under in child-safety seats. Child Passenger Safety Coordinators conducted the surveys about one year apart, in the winter and spring of 2002 and 2003.

Interviewers asked questions to assess knowledge of the booster seat law and proper use of child restraints. Observers collected information on misuse regarding location of car seats, restraint type (i.e., for infants, toddlers, or young children), and how restraints were used.

RESULTS

We found that the initiative positively affected both amount of use and proper use of safety seats. Overall use increased by five percent, although booster-seat use did not. Specific types of serious misuse—such as not securing the safety seat tightly enough to the vehicle or positioning the harness clip incorrectly—dramatically decreased.

Misuse in this study confirmed widespread challenges with choosing and installing child-safety seats. The task is especially challenging for families who have more than one small child, who have older cars, or who do not own cars, characteristics shared by many low-income families.

While child-safety seats are underused or misused by all socioeconomic groups, specific barriers face low-income people. A short list of these includes: the need for



Low-income children face twice the risk of dying from crash-related injuries compared to children from higher income families



frequent transfer of the car seat; the problem of fitting car seats into older cars without recently mandated attachments to ease installation; the use of hand-me-down car seats which may be old, difficult to install, or perhaps even the subject of a product recall; the perception among some groups that children are safer on laps than in safety seats; and language barriers which make installation instructions difficult to follow.

The CPS Initiative addressed these difficulties by making available free or low-cost safety and booster seats, workshops in English and Spanish, and one-on-one installation assistance. These outreach efforts took place where the target population came to get health care services, and thus did not require a separate trip.

The Initiative focused on setting up systems to ensure program continuation over the long run; recruiting and training medical and nursing staff; integrating CPS policy into hospital service delivery systems; and acquiring ongoing funding to support outreach and car-seat distribution.

ADDRESSING THE BARRIERS: WHAT ELSE WE NEED TO DO

Reach underserved populations

Outreach and educational efforts that specifically target children in low-income communities can make a large difference in overall child safety. Such efforts should focus on increasing safety seat use by eliminating cost and access barriers and on decreasing the most serious and common types of misuse. Hands-on workshops—not just passive brochures—conducted in multiple languages are crucial. Activities should be conducted at public hospitals and health care centers, churches, day-care centers, community centers, and other institutions serving groups that are at risk. ➤

Integrate CPS into health care systems and continuing education efforts

Traffic injuries cost California \$20 billion in 2000. Motor vehicle injury deaths lead all other types of injury death for children over age two. Increasing children’s safety in cars can reduce emergency room and rehabilitation costs. Public health care systems thus benefit financially from a good prevention program.

Unfortunately, prevention programs often fall prey to budget cuts, and child passenger safety programs are no exception. Without clear protocols establishing it as part of regular health care and health education services—and lacking champions within hospitals—CPS will fall between the cracks. This risk is exacerbated by the fact that CPS falls outside traditional clinical health services and can be seen as “dispensable” given budget crises and stretched schedules. It is essential to acknowledge the role of CPS (and other injury prevention strategies) in preventing need for emergency and other treatment services; prevention saves lives and money.

Integrating CPS into continuing education for health professionals multiplies the chances that parents and guardians will learn about updated research on CPS. My daughter’s pediatrician, for example, already reminds me to always use a safety seat in the back seat of my car. With more information, she could also explain the urgency of correctly securing the seat in the car, and my daughter in the seat.



Research and evaluate safety programs and injury patterns

Further understanding types and severities of injuries related to misuse, attitudes toward use, and effective approaches would help guide CPS efforts. Research on vehicle and child-restraint design to protect children and improve the fit between vehicles and child restraints is needed. Regarding work with vulnerable populations, we must answer questions addressing outreach and policy efforts. Which approaches best reach vulnerable populations? What are the most important safety messages to convey to parents? What impact does integrating CPS into health care services have on use of restraints? Research has found that the most important correlation with safety seat use is the driver's use of seat belts: drivers who buckle up are more likely to put their children in safety seats than those who don't. How can this information most effectively be used to increase safety?

Pay attention to policy and advocacy

Policy and advocacy efforts should be part of any injury prevention effort. Laws often provide the muscle behind educational and enforcement efforts to promote public health. According to NHTSA, good laws include age and weight guidelines that reflect research on child development and injuries, cover all seating positions in a vehicle, require all vehicles to have safety belts, contain provisions for enforcement, and eliminate exemptions. One area for potential advocacy could be addressing the lack of booster seats manufactured for older cars without shoulder belts, which prevents many lower-income children from riding safely.

California's child passenger safety law SB 567 (the "booster seat" law) provided impetus to the CPS Initiative. Not only did it specify increases in the age and weight requirements for securing children, it included provisions whereby economically disadvantaged families could obtain child restraints, and it defined a public health education role for health care providers.

Collaborate through multidisciplinary coalitions

Child safety is and should be everyone's business. Health care leaders, law enforcement and traffic safety professionals, social workers, educators, business leaders, automobile and car seat manufacturers and retailers, and community members are all natural partners for child safety efforts. Broad-based groups focused on child safety reduce the stress on a single system—health care, for example—and promise more far-reaching results. Further, comprehensive programs that include legislation, training, enforcement, and community-oriented strategies such as seat distributions can increase use.

Great advances have been made to protect children, and all children should have access to these advances. The Child Passenger Safety Initiative has played an important role in reaching California's most vulnerable children. Even during times of budget crisis, it is crucial to remember the risk children face in vehicles and consider it our mandate to protect them. ♦



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SCRAPPING OLD CARS

BY JENNIFER DILL

STARTING IN 1968, rising federal standards have been reducing emissions from new automobiles. But all vehicles deteriorate over time; their pollution-control equipment breaks down and emissions rise as they age. So fleet turnover is crucial to reducing total vehicle emissions.

However, over the past thirty years turnover has slowed, and the personal vehicle fleet has been aging, in part because cars just last longer. Also, households today own more cars than they did thirty years ago. Instead of trading in an old car for a new one, they are now more likely to just add another, letting a teenager drive the older one or perhaps keeping it as a back-up. In 1970 only three percent of the automobiles on the road were fifteen years old or older; in 2001 sixteen percent were fifteen or older.

Older vehicles contribute disproportionately to overall air pollution. In 2000, the San Francisco Bay Area's pre-1986 light-duty vehicles (cars and light trucks) accounted for about twelve percent of vehicle miles traveled (VMT) by all light-duty vehicles. However, these older vehicles contributed more than half the reactive organic gas (ROG) emissions—a component of smog—from all light-duty vehicles. The problem will not go away soon. I estimate that in 2010, vehicles fifteen years old and older will contribute nearly eighty percent of ROG, though driven less than twenty percent of VMT. In addition, California no longer requires vehicles older than thirty years to pass a smog test. This exemption may have been a political trade-off to defuse opposition to a stronger smog check program, the reasoning being that there are so few vehicles older than thirty years that it wouldn't make a difference. However, the lack of a smog-check requirement may act as an incentive to keep driving vehicles past age thirty.

ONE RESPONSE: SCRAP 'EM!

In 1990, Unocal oil company launched the South Coast Recycled Auto Project, offering residents of the Los Angeles region \$700 for their pre-1971 cars, which the company then junked. It wanted to prove that scrapping older vehicles was a more cost-effective way to fight smog than were stringent new standards on stationary sources of air pollution like oil refineries. The program attracted national attention, in part because it introduced the concept of “pollution credits.” In this case, Unocal bought and scrapped the vehicles, supposedly reducing emissions by a certain amount. The company then applied that amount as a credit towards meeting emissions standards at its refineries. Several companies and public agencies throughout the country have since implemented similar efforts, and vehicle scrappage programs—also known as vehicle buy-back, vehicle retirement, or cash-for-clunkers—have been adopted in about a dozen other countries.

The programs did not evolve without controversy, of course. The most vocal and adamant opponents have been car collectors and related businesses, concerned that supplies of collector cars and parts would diminish. The environmental justice movement opposes using pollution credits to offset emissions from stationary sources, which are often located in poor and/or minority neighborhoods whose residents have little say in the matter. And some researchers have questioned whether emissions are reduced at all.

Buy-back programs are structured to help ensure that they result in real pollution reduction. They require vehicles to be in operating condition and to pass visual and operating tests to prove it. To prevent people from importing old cars, the programs require vehicles to have been registered within the region for a specified length of time. They must also have a valid smog certificate; a car that doesn't pass a smog check could presumably be repaired, in which case any emissions reduction could be credited to the smog check program, rather than a vehicle retirement program.

Air pollution benefits stem from two basic assumptions: (1) without the early retirement program, the vehicle would continue to be driven for some time and (2) the means used to replace travel will produce fewer emissions than the retired vehicle. To appraise the programs' effectiveness, we must question these assumptions, to wit: How early was the vehicle retired? If it were not scrapped, for how many more years would it be driven? How was travel replaced? What are the scrapped vehicles' emissions levels? What are the replacement vehicles' emissions levels?

Answers to these questions often depend on who owns the older vehicle. For example, older vehicles in higher-income households tend to be “extras” used only occasionally, such as an old pick-up truck for occasional hauling. Lower-income owners, on the other hand, are more likely to rely on their older vehicle for daily travel, driving more miles and making more trips in older vehicles than do higher-income owners.

So in trying to figure out how effective vehicle scrapping programs are, an important question to ask is *who* is participating? To find out, I surveyed over 1,200 people who sold older vehicles through the Bay Area Air Quality Management District's vehicle buy-back program, which is the largest publicly-funded scrapping program in the country. I also consulted surveys the BAAQMD asks all sellers to fill out when they scrap their vehicles. There were nearly 7,500 of these from June 1996 through August 2000. ➤

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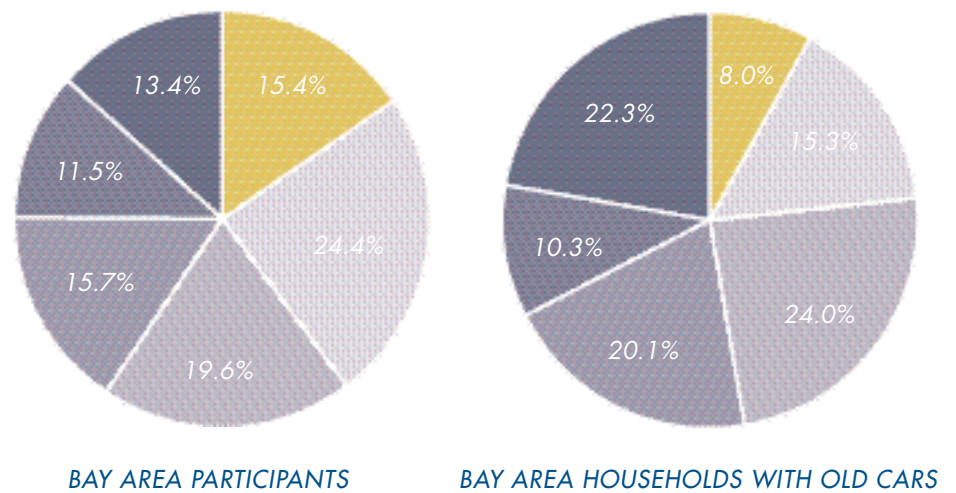




Who participates?

Household characteristics like income influence whether someone scraps a vehicle through a buy-back program. The same characteristics may also affect the vehicle's quality, how it is driven, and how much it is driven, thereby affecting emissions benefits. Because the programs offer financial incentives, it makes sense to assume that lower-income households might be more motivated to participate than others. On the other hand, program critics claim that it's just an easy way for higher-income households to get rid of extra vehicles. So one important question is which households are more attracted to the program. It turns out that households with incomes of \$30,000 or less are most attracted to the program, which means the programs are probably *not* disproportionately attracting seldom-used cars from higher-income households.

FIGURE 1 Incomes of participants vs. households with old cars



INCOME:

■ Under 15K ■ 15-30K ■ 30K-45K ■ 45K-60K ■ 60K-75K ■ Over 75K

How much were the scrapped vehicles driven?

Ideally, a vehicle retirement program attracts vehicles that are driven a lot and therefore pollute a lot. How much a household uses a vehicle likely affects its decision to sell it to a buy-back program, but the relationship may not be simple. Drivers are probably more willing to part with vehicles that are rarely driven, but a household that drives an older vehicle into the ground and needs to replace it may also find a buy-back program an attractive alternative to selling or trading it in. Since lower-income households drive older vehicles farther than do higher-income households, attracting high-mileage vehicles may be a simple matter of attracting lower-income households.

However, participants in the Bay Area program, it turns out, drove their cars less than the average in California. In other words, the most heavily used old cars were not being scrapped, perhaps because lower-income households that rely heavily on older vehicles can't afford to replace them. The \$500 incentive is not likely to buy another reliable vehicle, let alone a newer, cleaner one.

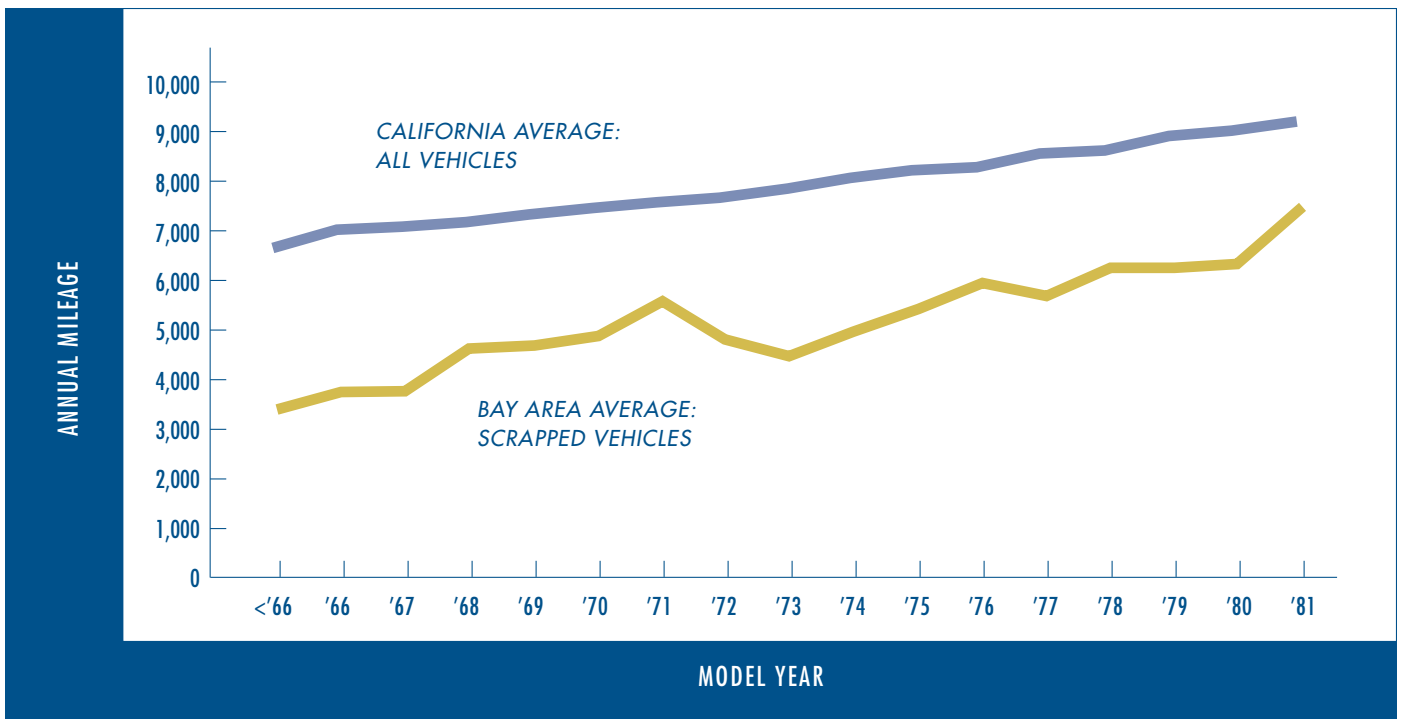


FIGURE 2

Annual mileage of scrapped vehicles by model year

What would happen without the scrapping program?

A vehicle retirement program reduces emissions only if vehicles are scrapped before they otherwise would be. Bay Area participants thought their vehicle would have lasted about three years longer, just what the state’s regulations assume.

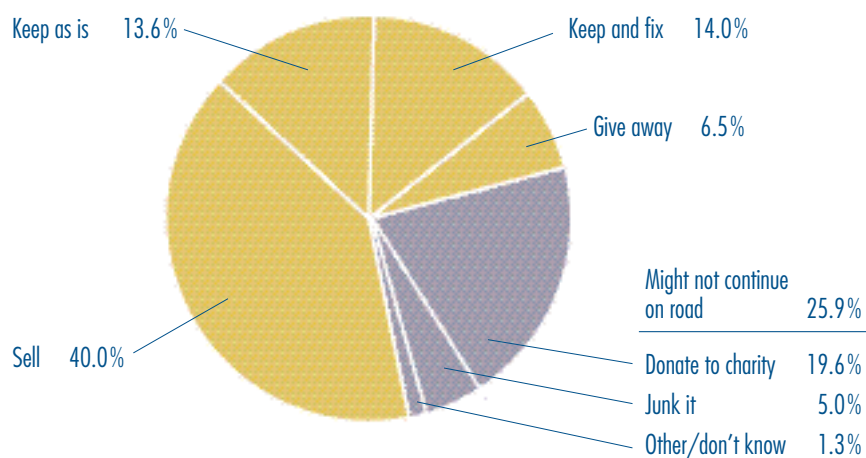
Some critics argue that these vehicles were headed to the scrap yard anyway, and therefore the programs do little to reduce emissions. But when we asked participants what they would have done had they not sold their vehicles to the program, a quarter said they would have junked them or donated them to charity. Some of those would have been scrapped for parts, the equivalent of being scrapped but without the paid incentive. On the other hand, a little over a quarter would have kept the vehicle as is or fixed up, and about forty percent would have tried to sell the vehicle. Some portion of these, however, might not find a buyer and therefore would perhaps end up either scrapped or driven very little. Those that did sell would have new owners, and possibly heavier use. All told, about three-quarters of the vehicles might have stayed on the road for about three years without the vehicle retirement programs. So most of the vehicles scrapped under the program are being taken off the road earlier than otherwise, as the programs intend.

How did people travel after scrapping their vehicles?

If a program participant uses the \$500 incentive to buy another old clunker, emissions won’t be reduced. However, that doesn’t appear to be what happens. Almost half the Bay Area participants are driving another vehicle they already owned. A slightly smaller number bought, leased, or were given a new or used vehicle. A few no longer drive for their primary transportation. Of those that purchased replacement vehicles, most spent far more than \$500; the median purchase price of replacement vehicles >



FIGURE 3 Bay Area participants' most likely alternative to scrapping



was \$4,500, indicating that the vehicles are probably in better shape than the ones they scrapped. Replacement vehicles average about thirteen years younger than the scrapped vehicles, and it's very likely that the replacement vehicles' tail pipes are cleaner.

Why do people scrap their old vehicles?

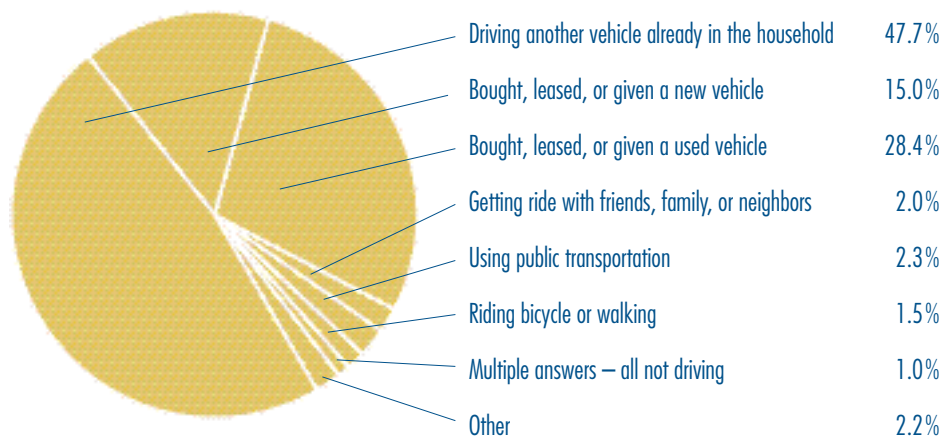
Scrapped vehicles are far more likely to need repairs, or paint jobs, or other cosmetic improvements than older vehicles not sold to the buy-back program, so it's likely that one reason people decide to scrap their vehicles is to avoid dealing with repairs. Over three-quarters of participants considered their vehicles reliable and safe, even if they needed repairs to run well, so they do not seem to be trying to get rid of useless vehicles.

What about the money? Participants were reimbursed \$500 for old vehicles. Over half the sellers said they believed they could have gotten more than \$500 if they'd tried to sell the vehicle through a newspaper ad; the median estimated selling price was \$600. While it's possible they were overestimating their vehicles' value, they still seemed to be choosing to forgo some cash. Why? The difference between the vehicle's estimated value and actual reimbursement could be interpreted as the value sellers place on the buy-back program, or on easing the transaction rather than selling the vehicle to a private party or getting rid of it another way.

Indeed, over a third of the sellers said it is an easy way to sell a car. When asked to write in their own words why they scrapped their vehicle, one seller commented, "We sold it to the program because my wife feels uncomfortable running ads and having people come to our home to sell the vehicle." Another stated, "It was a spare car. I used it occasionally. I sold it to the program because it was easy."

One unique motivating factor for a few people was the idea that no one else would drive their vehicle. One seller wrote, "I was told [the car] would be smashed into a small cube, and I liked the idea that, if I couldn't have the Bug, no one could." Another noted, "It was still reliable, but I was concerned that another owner might not know enough about its quirks to drive it safely."

FIGURE 4 Replacement transportation among Bay Area participants



Comments like these, and the costs of replacement vehicles, indicate that \$500 is not the primary factor motivating many participants. It appears that many participants have already decided to get rid of their older vehicle and use the scrapping program as an easy way out. This may be one reason the program is not attracting the high-mileage older vehicles that lower-income households rely on. Those owners place a high value on their older vehicles and are not motivated by \$500. It may take a higher incentive to scrap more of these vehicles.

WHAT DOES IT ALL MEAN?

Are vehicle buy-back programs reducing emissions? Yes—to some extent. The Bay Area’s program is attracting older vehicles that are driven regularly, though not the most heavily used ones. Most vehicles would have been driven for a few more years, and most participants do replace the vehicles with newer, thus presumably cleaner, ones.

It would be better if the program could attract higher-use vehicles. Lower-income households that drive their older vehicles a lot are not participating as much as expected and are unlikely to replace the vehicle with the least polluting, newest vehicles. Several options could help reduce emissions from these older vehicles: offer to repair or retrofit vehicles as an alternative to scrapping; offer more money, perhaps on a sliding scale based on income; tie the amount of the incentive to the emissions levels of the replacement transportation; identify higher-use, higher-polluting vehicles through remote sensing and motor vehicle records and market the program to those car owners.

Despite some opposition from old-car enthusiasts, the Bay Area’s vehicle retirement program is very popular, both with participants and the Bay Area Air Quality Management District. Programs in other areas have also been well-received. Given general support, the programs are likely to continue and they could expand in the future. By understanding older-vehicle owners better, we can more accurately estimate the benefits of the program and improve program effectiveness—and thus even reduce smog. ♦

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Reconsidering the Cul-de-sac

BY MICHAEL SOUTHWORTH AND ERAN BEN-JOSEPH

FOR OVER FIVE DECADES developers, homebuyers, and traffic engineers have favored the cul-de-sac, a basic building block of the American suburb. Despite its popular success, the “loops and lollipops” street pattern has been repeatedly criticized by many leading architects and planners, particularly New Urbanists, who strongly advocate the interconnected gridiron pattern. The cul-de-sac has come to symbolize all the problems of suburbia—an isolated, insular enclave, set in a formless sprawl of similar enclaves, separated socially and physically from the larger world, and dependent upon the automobile for its survival. Nevertheless, much can be said in favor of the cul-de-sac street as a pattern for neighborhood space.

THE CUL-DE-SAC PATTERN

A French term, *cul de sac* literally means “bottom of the sack.” It commonly refers to a dead-end street. *The Oxford English Dictionary* defines it as “a street, lane, or passage closed at one end, a blind alley; a place having no outlet except by the entrance.”

Since its early use in 1928 as part of the hierarchical circulation system in the design of Radburn, New Jersey, the cul-de-sac has been the preferred instrument for controlling through traffic. The town’s structure exemplified the ideal subdivision layout. As Geddes Smith stated in 1929 in Clarence Stein’s book, *Toward New Towns for America*, Radburn was: “A town built

to live in—today and tomorrow. A town ‘for the motor age.’ A town turned outside-in—without any back doors. A town where roads and parks fit together like the fingers of your right and left hands. A town in which children need never dodge motor-trucks on their way to school.”

The first suburban cul-de-sacs were short, straight streets with just a few houses. They were intended to provide a public realm for the residents while allowing safe, slow car movement to and from dwellings. Today, with increased auto ownership, the cul-de-sac has grown wider and much longer with more dwellings along it. A circular space terminates it, large enough for service and emergency vehicles to turn around (often more

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Radburn, New Jersey

than a hundred feet in diameter). In its pure form, all the houses in a subdivision are situated on cul-de-sacs, and as few as possible are placed on the busier and noisier collector streets.

A close cousin of the cul-de-sac is the loop street, which is similar in that it discourages through traffic, going nowhere other than to the homes along it. However, it has two access points, and is usually longer than the cul-de-sac. Both loops and cul-de-sacs are often found in the same development.

The cul-de-sac pattern has been strongly encouraged by traffic engineering and subdivision standards. Ever since one of the first engineering studies on residential street safety was done in Los Angeles between 1951 and 1956, the Institute of Transportation Engineers has recommended hierarchical discontinuous street systems for residential neighborhoods. The study showed that the number of accidents was substantially higher in grid-based subdivisions, so ITE established engineering standards using cul-de-sacs. The standards incorporated limited access to the perimeter highway, discontinuous local streets that discourage through traffic, curvilinear design patterns, cul-de-sacs, short streets, elbow turns, T-intersections, and a clear distinction between access streets and neighborhood collectors.

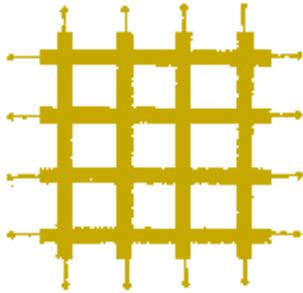
PROBLEMS WITH THE CUL-DE-SAC

The loops and lollipops pattern has been criticized on several grounds. Obviously, it lacks the interconnectedness of development patterns like the gridiron. One must always leave the cul-de-sac via a collector street to go anywhere. Route choices are minimal, so one is stuck using the same path day after day. Also, since so much of the street infrastructure is devoted to semiprivate dead-end roads, a heavy load of connecting and through traffic is forced onto a relatively small collector and arterial system, contributing to suburban gridlock during peak periods of travel.

For the pedestrian, walks can be long and boring, with inefficient connections to nearby destinations. One lacks the sense of being in a neighborhood or town with a civic identity. Main streets and tree-lined corridors that connect places and communicate the character and structure of a community are absent, and what's left is a string of dead-ends on faceless connectors that lead nowhere. The pattern as it has evolved is difficult for a visitor to comprehend because there is little apparent structure, no unifying elements, no clear describable pattern. Moreover, it is usually tiresome in its repetitiveness. Grid pattern developments, of course, can suffer from monotony as well, but they are easier to visualize and navigate because they form a clear, logical pattern. >

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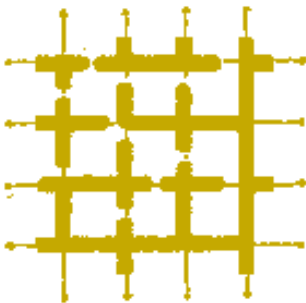
Street patterns



Traditional grid pattern



Cul-de-sac pattern



Grid pattern converted to cul-de-sacs for vehicles but not pedestrians



Pedestrian-connected cul-de-sacs



SOME ADVANTAGES

The cul-de-sac model has several advantages that are worth considering. From the perspective of residents, the pattern usually offers quiet, safe streets where children can play with little fear of fast-moving traffic. A discontinuous short-street system, unlike the grid, may promote familiarity and neighboring. The cul-de-sac street pattern is also supported by the market: home buyers often pay premium prices for the most isolated cul-de-sac lots. The pattern is popular with developers not only because it sells well, but also because the infrastructure costs are significantly lower than for the traditional interconnected grid pattern, which can require up to fifty percent more road construction. Cul-de-sacs, being disconnected, adapt better to topography. Since they carry no through traffic, they often have reduced standards for street widths, sidewalks and curbs. In Radburn, for example, the introduction of cul-de-sacs reduced street area and the length of utilities, such as water and sewer lines, by 25 percent as compared to a typical gridiron street plan. According to Stein, the cost savings on roads and utilities paid for the construction of open spaces and parks.

The pattern is not limited to low-density suburban development, but can support row houses and low-rise apartments as well. Radburn and London’s Hampstead Garden Suburb, for example, have relatively high densities by American standards (9.4 and 8 to 12 dwelling units per acre, respectively). Even higher densities can be found in historic urban patterns such as the residential courts of Boston’s Beacon Hill.

At sites of sensitive ecological character, the cul-de-sac pattern has distinct values. Unlike the grid pattern which can be very invasive, blanketing a neighborhood with infrastructure, the cul-de-sac pattern can work around areas of high ecological or historical value. Lawrence Halprin’s 1964 plan for The Sea Ranch on California’s North Coast employed a disconnected pattern of “reaches” and “closes” to keep vehicular traffic away from the ocean bluffs and to protect the meadows of the original sheep ranch. The site design for Village Homes in Davis, California, utilizes the pattern to protect a natural drainage system that serves as a community green space and pedestrian/bicycle connector. A more recent plan for Mayo Woodlands in Rochester, Minnesota, uses a similar pattern to preserve the meadows and woodlands of the former Mayo estate while allowing residential development.

Analysis of automobile accident data supports the notion that cul-de-sac and loop patterns are safer than other kinds of streets. Furthermore, hierarchical, discontinuous street systems have lower burglary rates than easily traveled street layouts; criminals will avoid street patterns where they might

get trapped. For example, the troubled Five Oaks district of Dayton, Ohio, was restructured to create several small neighborhoods by converting many local streets to cul-de-sacs by means of barriers. Within a short time traffic declined 67 percent and traffic accidents fell 40 percent. Overall crime decreased 26 percent, and violent crime fell by half. At the same time, home sales and values increased.

A comparative study of street patterns indicates significant homebuyer preference for the cul-de-sac and loop patterns. We examined nine California neighborhoods in terms of safety performance and residents' perception of their street's livability. The neighborhoods were matched demographically but represented three different street layouts—grid, loop, and cul-de-sac. The findings suggest that cul-de-sac streets, and especially the lots at the end, perform better than grid or loop patterns in terms of traffic safety, privacy, and safety for play.

Residents also preferred the cul-de-sac as a place to live, even if they actually lived on a through or loop street. People said they felt cul-de-sac streets were safer and quieter because there was no through traffic and what traffic there was moved slowly. They also felt they were more likely to know their neighbors. One resident's comment was typical: "Our pets and kids are safer when there is a no-outlet street; you feel kidnapping is less likely—there is more of a sense of neighborhood." Thus, the study generally corroborated earlier transportation research on the values of a hierarchical discontinuous street pattern. It also supported claims that cul-de-sacs are more frequently and more safely used by children.

However, residents thought neighborhoods composed mainly of cul-de-sacs were confusing and lacked a coherent structure and uniqueness. Social interaction and neighborhood sense were not necessarily stronger on the cul-de-sacs, despite perceptions to the contrary. At the neighborhood scale, problems associated with cul-de-sacs may stem more from land use patterns than the street pattern itself. The single-use zoning of most cul-de-sac neighborhoods puts schools, jobs, and recreation and commercial centers at a distance from homes. Separation is further exacerbated by the lack of a well-connected pedestrian/bicycle network. Only rarely is there an interconnected pedestrian pathway system linking cul-de-sacs with adjacent streets, open spaces, and other neighborhoods.

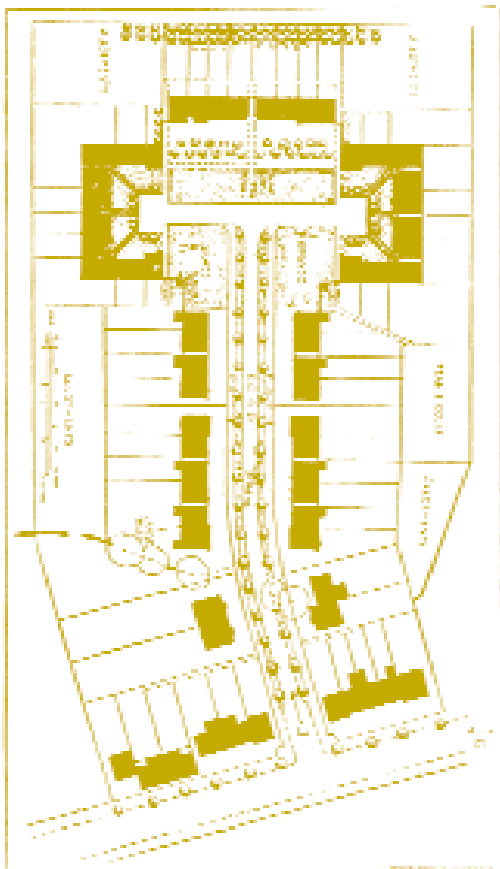
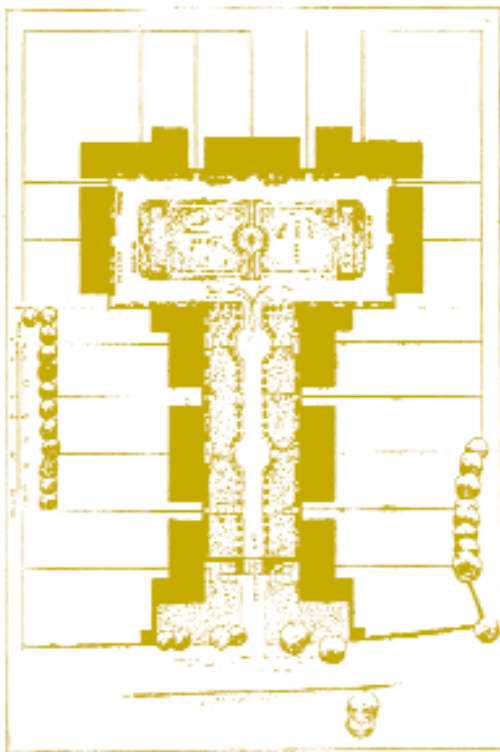
CREATIVE CUL-DE-SACS

The cul-de-sac pattern presents a dilemma for the designer committed to a more structured and conceptually clear design like the geometric grid. Might it be possible to satisfy both sets of criteria: privacy, safety, quiet, and lower construction costs, as well as connectedness, identity, and structure? The cul-de-sac certainly need not be an undefined street terminated by an amorphous blob. The benefits of the cul-de-sac could be achieved with more architecturally defined and ordered patterns. A review of historic urban patterns in Europe, the Middle East, and early American towns reveals a frequent use of such patterns. For example, courts, closes, and quadrangles are found in English, French, and German towns of the Middle Ages. The residential court is also found in many early American towns, from Philadelphia to Boston. Today such spaces are usually prized locations for their sense of privacy, their intimate scale, and their charm.

A century ago, Raymond Unwin and Barry Parker consciously emulated such patterns in their designs for Hampstead Garden Suburb in London. "For residential purposes, particularly since the development of the motor-car, the cul-de-sac roads, far from being undesirable, are especially to be desired for those who like quiet for their dwellings," declared Unwin. An act of Parliament was required to allow the use of cul-de-sacs in new development, since prior cul-de-sacs were associated with unplanned medieval cities and unhealthy living conditions. It was the first time a planned development systematically used the cul-de-sac and open court throughout.

In Hampstead's court and close arrangements, two- to three-story blocks of row houses or apartments border a central green space and are usually accessed by a narrow service road. This arrangement creates a relatively quiet, pedestrian-oriented environment removed from the public street. The cul-de-sacs achieve similar residential neighborhood values. Unlike amorphous American postwar cul-de-sacs, those in Hampstead are short and narrow, with no circular turn-around at the end, and the architecture defines the street space. Midblock pedestrian walks typically connect the end of the cul-de-sac to another street or cul-de-sac beyond, creating an engaging path network for pedestrians. Roads are designed to discourage through traffic; they vary in both layout and cross-section design according to function. Sidewalks are always present. Trees and shrubs, as well as >

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Hampstead Garden Suburb cul-de-sacs

architectural details such as walls, fences, and gates, make each street a unique pedestrian throughway. Hampstead Garden Suburb became an influential prototype for residential subdivision street design and road planning in Britain and North America. Sadly, however, the urban design qualities of the original have been lost in its offspring.

An ideal suburban residential environment might be based on similar courts and closes, each a defined space with its own special character, with limited automobile access, situated within an overall structure of treed boulevards and public spaces that create a sense of community. Automobile movement would be limited to collector and arterial streets, but pedestrians and bicyclists could enjoy the easy interconnectedness of a classic gridiron. The pedestrian network can parallel the vehicular routes, but can also connect cul-de-sacs and loops with each other, as well as with destinations such as parks, schools, and shops. A hammerhead or formal square configuration eliminates irregularly shaped lots and creates a well-defined relationship between buildings, street, and the open space at the end of the street.

The scheme used in Radburn, designed by Clarence Stein and Henry Wright, is a variant of this ideal. Houses are clustered around automobile-accessible cul-de-sacs. The pedestrian path system expands into greenways and parks, with paths connecting each home, as well as the school. Pedestrians can go almost anywhere with minimal interference from the automobile. Although the open spaces of Radburn are rather lavish, the same values could be achieved with much less open space if builders focused primarily on the pedestrian pathway system.

Today there is a surge of interest in traffic-calming measures across the country, and many communities are taking steps to make streets more pedestrian- and bicycle-friendly. Some traditional neighborhoods based on the grid pattern found in most older American towns and cities built before the 1920s are being retrofit to achieve some of the values of the cul-de-sac. These neighborhoods possess the connectedness, structure, walkability, and accessible land use patterns that many planners seek today in new residential developments. They are, however, subject to invasion by the automobile and often suffer from the noise and hazards that come with excessive traffic on local residential streets. Berkeley, California, is one community that has attempted to deal with the problem. Its grid system has been converted into cul-de-sacs and loops by placing bollards, large concrete planters, or planted islands as traffic barriers across some intersections. Pedestrians and bicyclists can easily get



Berkeley, California

through and continue to enjoy the interconnected grid. Originally an experiment, the scheme was strongly advocated by residents of some neighborhoods, although disliked by others. Nevertheless, support was broad enough to make it a permanent program.

Retrofitting an existing suburban cul-de-sac development to provide pedestrian connectedness would be more difficult. New pathways could be designed to interconnect cul-de-sacs, but in most cases they would have to be built on private rights-of-way along lot lines. To acquire such easements would probably be difficult, since residents are unlikely to give up a portion of their land and privacy. Moreover, most suburban developments of this type are single-use subdivisions so there is very little to connect besides houses.

Are walkable suburbs possible today? It is necessary to challenge the established street design standards and regulations that have emphasized vehicular access at the expense of pedestrian connectedness and community form. Traffic engineers and public officials need to review existing standards and establish new frameworks that support the pedestrian and bicyclist while taming and confining the automobile. However,

rather than tossing out the cul-de-sac as an urban pattern, it is worth reconsidering its values and possibilities in creative ways. It has a long history of use in a variety of geographic and cultural contexts, and could provide options that offer safe and quiet streets as well as pedestrian and bicycle access in a new spatial framework that avoids the problems of the open grid. ♦

Acknowledgments: We are grateful for assistance with the illustrations from Dipti Garg, Raymond Isaacs, Mike Larkin, Sungjin Park, and Swapneel Patil.

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