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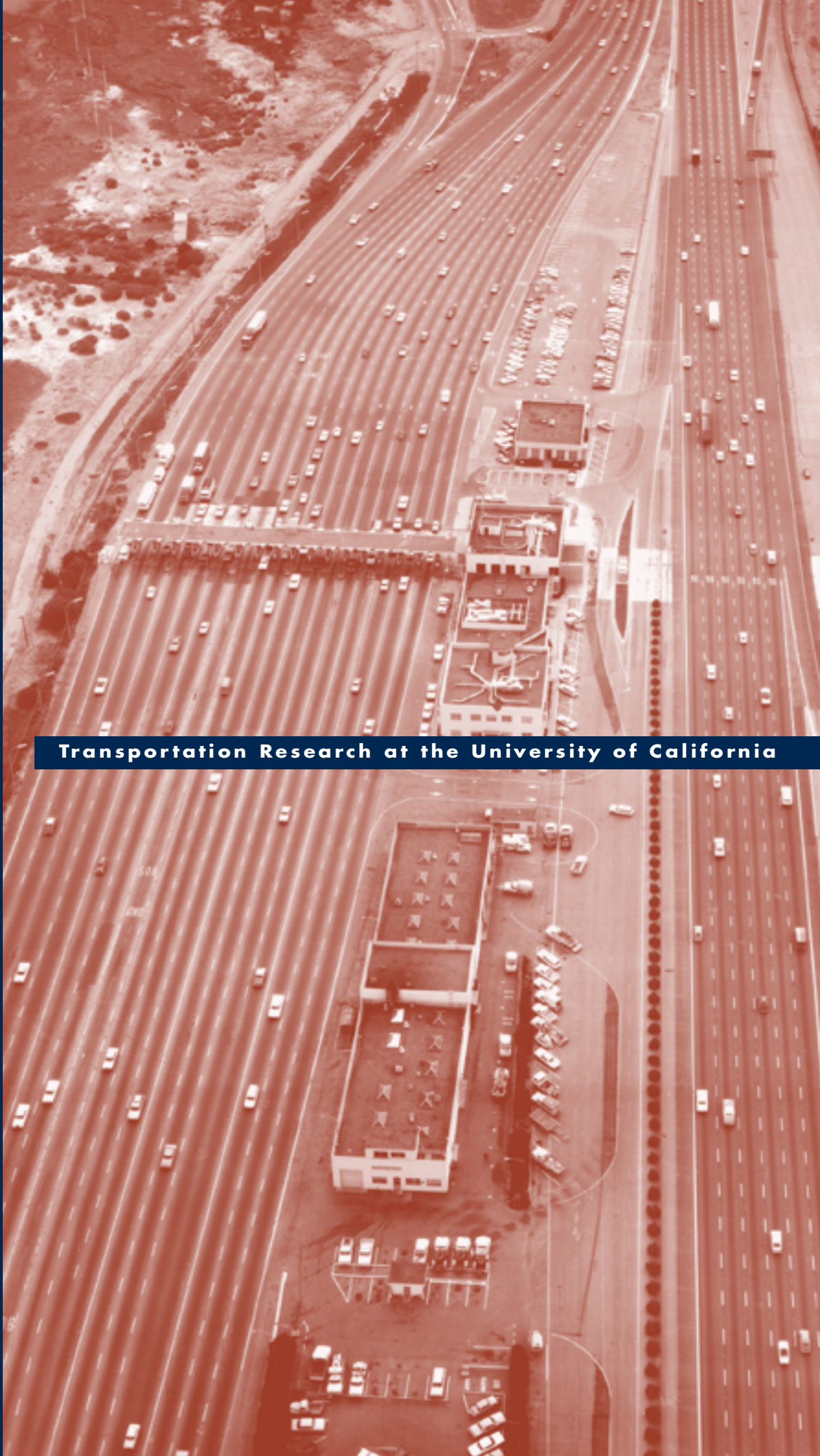
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TRANSPORTATION RESEARCH



FALL 2000
NUMBER 17



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The University of California Transportation Center, founded in 1988, facilitates research, education, and public service for the entire UC system. Activities have centered on the Berkeley, Davis, Irvine, Los Angeles, Riverside, and Santa Barbara campuses.



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Front Cover: San Francisco-Oakland Bay Bridge Toll Plaza

Autonomous Decongestants

DESPITE universal complaints and many proposed remedies, it seems there's still no cure for traffic congestion. As a mirror on a city's economic vitality and the pace of its social life, congestion is a built-in attribute of the prosperous metropolis. Heavy traffic volumes are a positive index of a city's range of opportunities and the richness of its residents' lives. The city with but little traffic is a city that may be stagnating.

Although congestion is an intrinsic attribute of successful cities, it is not also a lethal attribute. In common with other large and complex open systems that operate upon themselves to lighten their problems, cities react spontaneously to relieve their worst ailments, preventing them from becoming truly dreadful. Like other vexing city problems, congestion is self-limiting.

Although lots of traffic is a good sign, traffic congestion entails substantial costs—costs of living and costs of doing business. When persons or firms judge costs to be excessive, they have at least three options. As Albert O. Hirschman once put it, their choices are “exit, voice, and loyalty.” They can leave; they can complain; or they can stay and bear it.

They may choose to move into outlying suburbs or distant small towns where there's less traffic; but, of course, moving implies costs and lost opportunities as well. So individuals must compare the disadvantages of staying versus leaving. If the costs of enduring congestion seem too large, moving may be better than staying. Continuing expansion in the exurbs over a great many years is evidence that a great many people have found these costs too high. To be sure, many other motivations also induce people to relocate. It's also true that travel distances are greater in the outlying suburbs and exurbs and so are miles traveled. But commuting times are stable, and may even be shrinking.

Relocation and attractive public transit help to make traffic congestion self-ameliorating, even if not self-correcting. When commuters remove themselves from the traffic stream, they help reduce traffic jams to levels that remaining motorists may judge acceptable.

Or, instead of relocating, they may voice their displeasure politically, demanding that public officials be more resourceful in seeking therapies. In response, governments might build more roads, price the roads, push for effective transit, develop automated highways, or initiate other remedies that seem likely to make a difference.

So long as there's both freedom to relocate and freedom to revolt, congestion levels are likely to remain tolerable for the many who live or work in central areas, as well as for those who leave. So long as land markets and political systems are responsive to citizens' preferences, the adaptive behavior of individuals and governments makes it unlikely that the dreaded “gridlock” will ever occur in America—outside news-media exaggeration, that is.

So, where congestion is severe over an extended period and citizens neither rebel nor leave—where they continue to endure the costs of overcrowding—in effect they are individually and collectively saying they prefer to live with the congestion rather than change jobs or houses or take other drastic measures. That's not to suggest that traffic congestion is not annoying or costly or exasperating. It's obviously all these. But it's also a normal condition of urban life—a price people willingly pay for the many advantages of urban life.

We'll know congestion has gotten really bad when popular revolts compel political leaders to try taming it by building more roads and introducing congestion pricing. Until then, things can't be as bad as they seem.

Melvin M. Webber

Brooklyn's Boulevards

BY ELIZABETH MACDONALD



BROOKLYN is not known for its great streets. And yet, like Paris, it enjoys a remarkable legacy of several mid-19th century boulevards.

At the same time that Baron Haussmann was building boulevards in Paris, Frederick Law Olmsted and Calvert Vaux, landscape architects for the Brooklyn Park Commission, designed and supervised construction of two major landscaped thoroughfares in Brooklyn.

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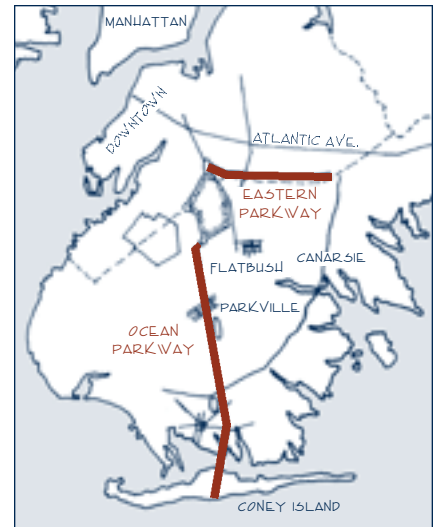
They called them parkways, and they didn't picture them lined with six-story empire style buildings as Haussmann's boulevards came to be. Olmsted and Vaux envisioned single-family houses on large lots. But the right-of-way cross section they designed for Eastern Parkway and Ocean Parkway was similar to that of the larger boulevards Haussmann was building in the western part of Paris, and almost identical to the extension of the Avenue des Champs Elysées west of the Etoile. These were wide and impressive streets with multiple roadways and many rows of closely planted trees.

A Grand Design

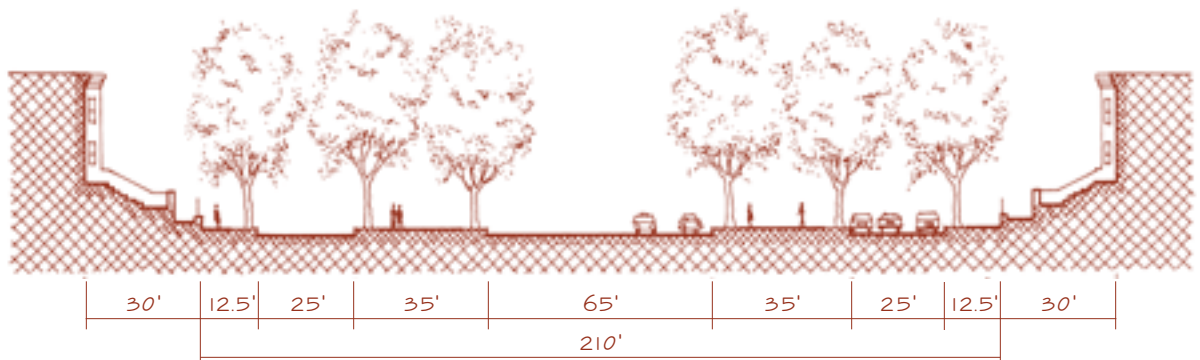
Like Haussmann, Olmsted and Vaux conceived their parkways as part of a grand design. Eastern and Ocean were the first pieces of an extensive system of parkways that would weave throughout all of western Long Island, connecting parks and other public open spaces and giving structure to the anticipated suburban expansion of Brooklyn. The rest of the parkway system was never realized as Olmsted and Vaux imagined it, but Eastern Parkway and Ocean Parkway were built in their entirety, over eight miles in combined length.

They function today as major traffic arteries in Brooklyn, and yet they are also friendly to pedestrians and do not impose barriers that divide the city. While carrying exceptionally large volumes of through traffic—between 50,000 and 70,000 vehicles per day—they also serve as local traffic carriers, neighborhood parks, and recreational greenways. In addition, they are valued residential streets, despite the traffic. Such multiple functions are unusual for heavily traveled streets in American cities. Indeed, accepted street-design practice today would not allow either of these parkways to be built because their physical form is too complex according to modern arterial street standards.

That form provides space for different activities to occur in close proximity but within separate zones. Both streets have essentially the same physical configuration. They are 210 feet wide and have three roadways: a wide roadway in the center (65 feet on Eastern Parkway and 70 feet on Ocean Parkway) and narrow roadways along each side (25 feet on both streets). Two malls (35 feet wide on one and 30 feet wide on the other) separate the three roadways, each lined with two rows of trees. There is another row of trees lining the sidewalks in front of the houses. ➤



Cross section of Eastern Parkway



**Ocean Parkway
in the 1990s**



The scale and diversity of activity along the six rows of trees is remarkable. Fast traffic moves in three lanes in each direction in the center roadway, while slower local traffic moves on a single one-way lane on each of the access roadways. But forget the traffic for a moment and look at the people.

The separating malls are much more than roadway dividers: they are the realm of pedestrians and bicyclists. Walkways run down the length of each mall, and one mall on each street also has a bicycle path. On Ocean Parkway the malls are lined with an almost unbroken line of concrete and wood-slat benches, each over twenty feet long, facing toward the center. Eastern Parkway has newer, more widely spaced benches. On both streets, people congregate on the benches in large numbers; at any given time there are lots of people walking or bicycling—older people, families with children, young people. The trees on the malls provide a transparent fence between these slower-paced activities and the faster traffic moving in the center roadway.

The reason it would be difficult to build Eastern Parkway and Ocean Parkway today is the very complexity of activities their design accommodates. Streets designed today to carry large volumes of through traffic are also designed to discourage other uses, the rationale being efficiency and safety. Eliminate complexity, and traffic will move faster, the planners say; remove pedestrians and there will be fewer traffic conflicts. With malls designed to encourage pedestrian use and a multiple roadway configuration that calls for complex intersections, these parkways defy conventional planning guidelines. And yet, our analysis of accident data for both parkways found no more accidents here than on comparable, normally configured streets carrying similar volumes of traffic. And, because it is given clear priority at intersections, traffic flows as easily on the center roadway as on modern arterial streets elsewhere.

Planned for an Unforeseeable Future

So, what can we learn from Eastern and Ocean Parkways? They may be anomalies, even curiosities, but they are not anachronisms. Today, many people—city planners, traffic engineers, and lay citizens alike—question the wisdom of building streets that divide cities, and single-purpose major traffic roads designed to today’s standards tend to do just that. Likewise, many are questioning the wisdom of planning streets solely for car movement at the expense of other uses.

Brooklyn’s parkways prove that complex major traffic streets can function well in today’s cities. Eastern Parkway and Ocean Parkway are working examples that manage to serve significant volumes of through traffic while also supporting different types of street use. They suggest we should expand our repertoire of major street designs to include a wider range of civic purposes than simply moving traffic.

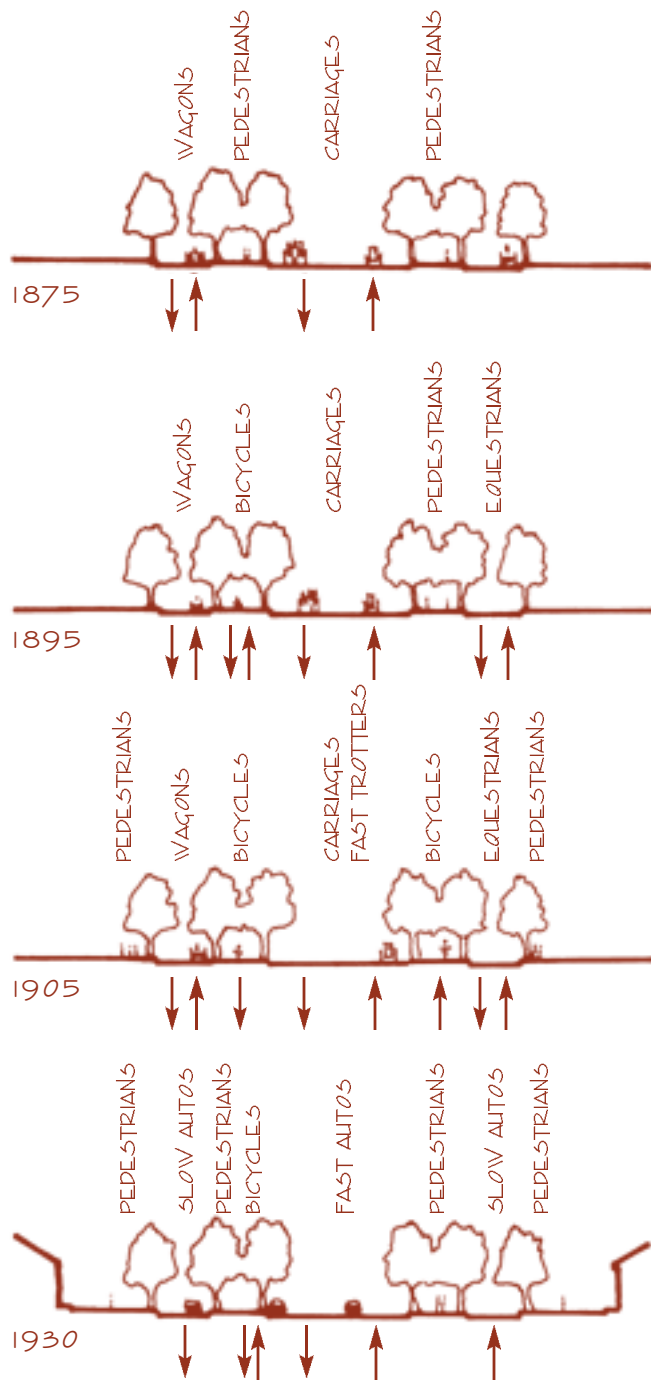
Eastern and Ocean Parkways are exemplars of public works designed for flexibility and adaptability over the long term. During the 125 years since they were built, these streets have accommodated a variety of traffic types, ranging from horse-and-carriage to automobile. Olmsted and Vaux specifically designed them to serve emerging roadway uses. The physical form has proved resilient as the differentiated zones have accommodated unforeseeable changes in transport technology and human activity without the need to reconfigure the roadways.

At various times, various groups of people with different agendas, using various means of transportation, have vied for rights to use certain spaces on the parkways in particular ways. Customs developed which eventually became codified into regulations. ➤



**Ocean Parkway
in 1894**

Evolution of uses on Ocean Parkway



On Ocean Parkway, the center roadway was originally the exclusive domain of fast horse-drawn carriages, while two-way commercial wagon traffic used one of the side roads. Equestrians filled the other, and pedestrians used the malls. Around the turn of the century, when bicycling became popular, the malls were designated exclusively for bicyclists, while pedestrians used the sidewalks. The current use pattern was established in the 1930s, after automobiles came into general use. Recently, people using rollerblades have joined bicyclists on the bike path.

The physical form of these streets allows them to carry lots of traffic without turning the area into a traffic wasteland. With trees, benches, and houses facing the street rather than turning their backs to it, the parkways are places that local people want to inhabit. These attributes also encourage those living in surrounding neighborhoods to claim the streets as their territory as well, and thus to value and care for them.

A Higher Purpose

The head park commissioner when the plans were proposed, James Strannahan, enthusiastically adopted the Olmsted-Vaux plan and pressed for construction. A lot of opposition initially raised doubts about the project's fate, however. Understandably, many opposed the tax assessments attached to the project. (There was more resistance along Ocean Parkway than Eastern, because the latter was built within the city limits while the former was built outside them. Also, Eastern Parkway lands were owned by real estate entrepreneurs, while Ocean Parkway's were held by farmers who favored a new roadway, albeit not such a wide one.) But once the assessments were transformed into a general tax, to be borne by all Brooklyn property owners, opposition declined. The shift of financial burden to the entire citizenry was in keeping with the spirit behind the parkways. Yes, they were intended to pave the way for suburban expansion, but their higher purpose was to serve as recreational promenades for all residents of the city. They were to be park-like spaces where gregarious, community-building activities could take place.

Under Strannahan's guidance, the streets were completely built within the space of just a few years, reaching out beyond the already developed areas of the city in expectation that expanding suburbs would eventually grow to require them. Imagine the undertaking—a right-of-way 210 feet wide, extending 2½ miles on Eastern Parkway and 5½ miles on Ocean Parkway. Imagine planting the six rows of trees—thousands of them spaced 25 feet apart in continuous lines through open countryside. This was surely an exceptionally farsighted civic achievement, especially considering that but little development would occur around either street for almost fifty years.

The Value of a Park

Initial jurisdictional arrangements fundamentally shaped the projects. When built, the streets were controlled by the parks department rather than the public works department. This arrangement lasted until well into the late 20th century, when the public works department took over roadway maintenance. The long-standing jurisdictional arrangement meant that engineers could not have their way with these streets as easily as with other streets. However, at various times, selected people simultaneously controlled both the parks department and highway construction entities—notably during the reign of Robert Moses. During these periods a bit of luck, combined with public understanding that the parkways were parks as well as trafficways, saved the streets from reengineering.

In the end, the value that local residents placed on the special qualities of these streets saved them from destruction. Ocean Parkway almost lost its malls in the 1970s because conditions attached to a federal paving grant required adherence to current arterial street standards. That meant adding about eighteen feet to the center roadway, thereby reducing each mall by nine feet and eliminating a line of hundreds of trees. The trees had, for years, not only shaded pedestrian activities on the malls, but also acted as a buffer between pedestrians and the fast traffic in the center roadway. Residents did not want these drastic changes and were willing to forgo repaving to keep the malls. It took a great deal of political engagement, but the residents won the day: they successfully fought the reengineering initiative as well as a compromise proposal that called for building twenty-inch-high concrete curbs along the edges of the malls. Incidentally, they also managed to retain the paving grant.

Can We Have More?

How might such streets get built today, given the enormity of the costs associated with wide rights-of-way and extensive tree planting? In some circumstances expenditures might be even less than for streets built for similar traffic loads—for instance, limited-access urban expressways that require expensive concrete structures. Further, the rights-of-way could be narrowed without losing all the qualities that make Eastern and Ocean Parkways desirable. There are many examples of Parisian multi-way boulevards that are only 120 to 150 feet wide.

Several appropriate locations and circumstances for such boulevards suggest themselves, such as New Urbanism planned developments, existing urban areas where ➤





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obsolete infrastructure needs to be replaced, and even existing suburban areas where citizens want to improve the physical quality of their environments. Or, more likely still, suburbs that, like Brooklyn in 1870, anticipate further expansion and insist that it be decent and humane, as well as efficient.

Because they were never "modernized," Eastern Parkway and Ocean Parkway prove that seemingly antiquated designs can be as desirable for our time as for theirs. More than that, the currently rapid pace of technological development and shifting life styles should be enough to induce considerable humility among those who would plan infrastructure that will last a long time. The success of these parkways, so long after they were conceived and installed, is evidence enough, if any were needed, that public works can be adaptable to large-scale changes.

None of us can yet predict what shapes the automobile's successors and their roadways will take or how they'll be used. So, we face a major challenge: to design public works in adaptive forms that will be likely to accommodate future surface transport as it evolves over the long-term. Olmsted and Vaux succeeded precisely because they designed the parkways to accommodate many diverse activities, thereby creating an infrastructure that could adapt to an unpredictable future. ♦

A Question of Timing



BY ROSELLA PICADO



TO HELP WORKERS avoid the peak-hour commute, employers have been adopting flextime work schedules. Some workers' jobs already permit flexible work hours, so a lot of employees should be commuting during off-peak hours. But, alas, the survey I've just completed finds it ain't necessarily so. Given the opportunity to avoid heavy traffic, I had to ask: why does anyone still commute during the peak hours?

RUSHING INTO THE RUSH HOUR

Perhaps the question is not as outrageous as it seems. Patricia Mokhtarian and Ilan Solomon reported in a recent issue of *ACCESS* that people don't mind commuting as much as conventional wisdom suggests, indeed that some rather enjoy it. To deal specifically with the flextime question, I surveyed faculty and staff at the Berkeley campus of the University of California, where both flextime and normally permissive work schedules make it easy to avoid the peak. The campus is a pertinent site also because most commuting routes are highly congested, making for further incentives to travel off-peak.

I asked a sample of people about their regular work hours, their work-scheduling discretion, the purposes and timing of their nonwork activities, their freedom to choose and schedule those activities, their travel times, and related matters. Only twenty percent of them are officially on flextime, yet more than two-thirds describe their schedules as flexible.

In keeping with popular understanding, I found that commuters with rigid work schedules do indeed travel during peak commute times. But, to my surprise, it turns out that the reverse isn't true. Many who are not limited to rigid work schedules also travel during peak hours. Why so?

In addition to paid work, the typical person participates both in optional nonwork activities and in obligatory personal activities. Optional nonwork activities limit the choice of commute schedules about as much as do paid work and mandatory personal activities, and all three are likely to put a commuter into the peak-hour traffic stream.

Only a *quarter* of commuters who have flexible work schedules successfully avoid traffic congestion. Despite the option of varying their work schedules, a few of the >

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people I surveyed choose peak-hour over off-peak-hour travel because of work-related considerations, such as the need to interact with colleagues, to make telephone contacts elsewhere, or to supervise subordinates. A few workers give up the option of off-peak travel in exchange for the preferential and less-expensive parking available to carpoolers. (At the time of the survey, only one useable freeway had high-occupancy lanes, so carpooling offered no significant time-saving advantage for freeway commuters).

For the majority of commuters with flexible work schedules, timing of the work trip depends on the timing of *nonwork* activities. These include driving children to and from school, dropping off or picking up a spouse, in-home leisure or family time, preferred sleeping schedules, and out-of-home activities such as a second job, exercise, religious meetings, and volunteer work.

On average, workers who commute in the peak hour, primarily because nonwork activities require it, are spending seven more minutes per day than are off-peak commuters. Although seven minutes may not seem much, it represents between 15 and 25 percent of a worker's one-way commute. Compared to workers without any flexibility, there's only a one-minute difference, suggesting that nonwork activities compel workers with flexible schedules to travel in about as much congestion as workers with rigid schedules.

A PERSONAL CHOICE

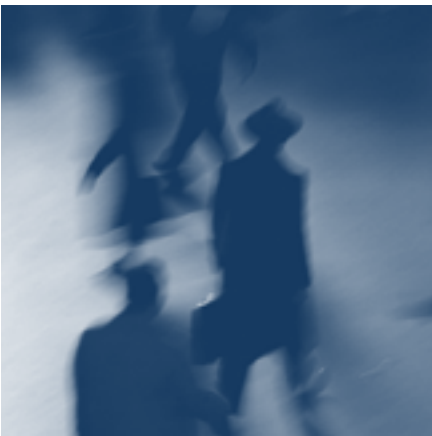
Four main factors seem to account for flextime's modest effectiveness: one's degree of freedom in choosing nonwork activities; one's discretion in scheduling those activities; personal preferences for spending one's time; and the timing and duration of peak traffic congestion.

Freedom to Choose Activities

Some nonwork activities are mandatory, and their schedules are determined by people or institutions a commuter can't control. For example, one of our subjects works as a research assistant. Although she has almost unlimited work-scheduling flexibility, she travels during peak hours both in the morning and in the evening because daycare for her son is available only between certain fixed hours—as it is for school-age children. Work-scheduling flexibility, however, does allow our subjects to time their work schedules to suit their children's transportation needs. Among workers with rigid schedules, it is common to drop children off at school thirty or even sixty minutes before school starts.

Discretion in Scheduling Activities

Some activities may be highly discretionary. Yet, once chosen, they must be performed at specific times of day. Some activities are offered only at a particular hour. For example, one of our subjects can shift her work schedule about thirty minutes, either earlier or later. A late shift would allow her to avoid heavy traffic, but prevent her from participating in her evening fitness class that meets at no other time. Or, one's schedule may depend on others.' Carpool members, for example, must conform to the schedules of fellow carpoolers. Tennis partners have to be on the court at the same time.



Personal Preferences

Some say they just can't wake up early enough to avoid the morning peak. Others say they leave work early to avoid walking to the parking lot in the dark. Others explain that their family members insist they be home in time for supper, and of course some must be home early enough to cook it. Obviously, each of us is beholden to others in our lives, and our schedules must conform to theirs.

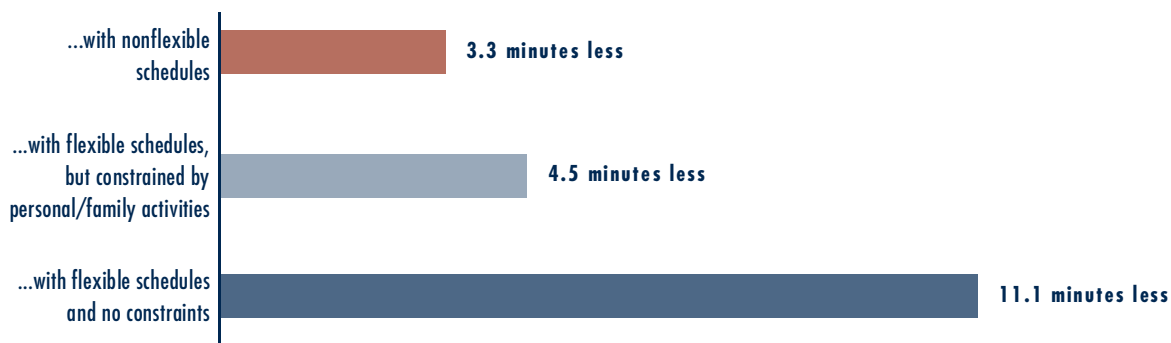
Time and Duration of the Traffic Peak

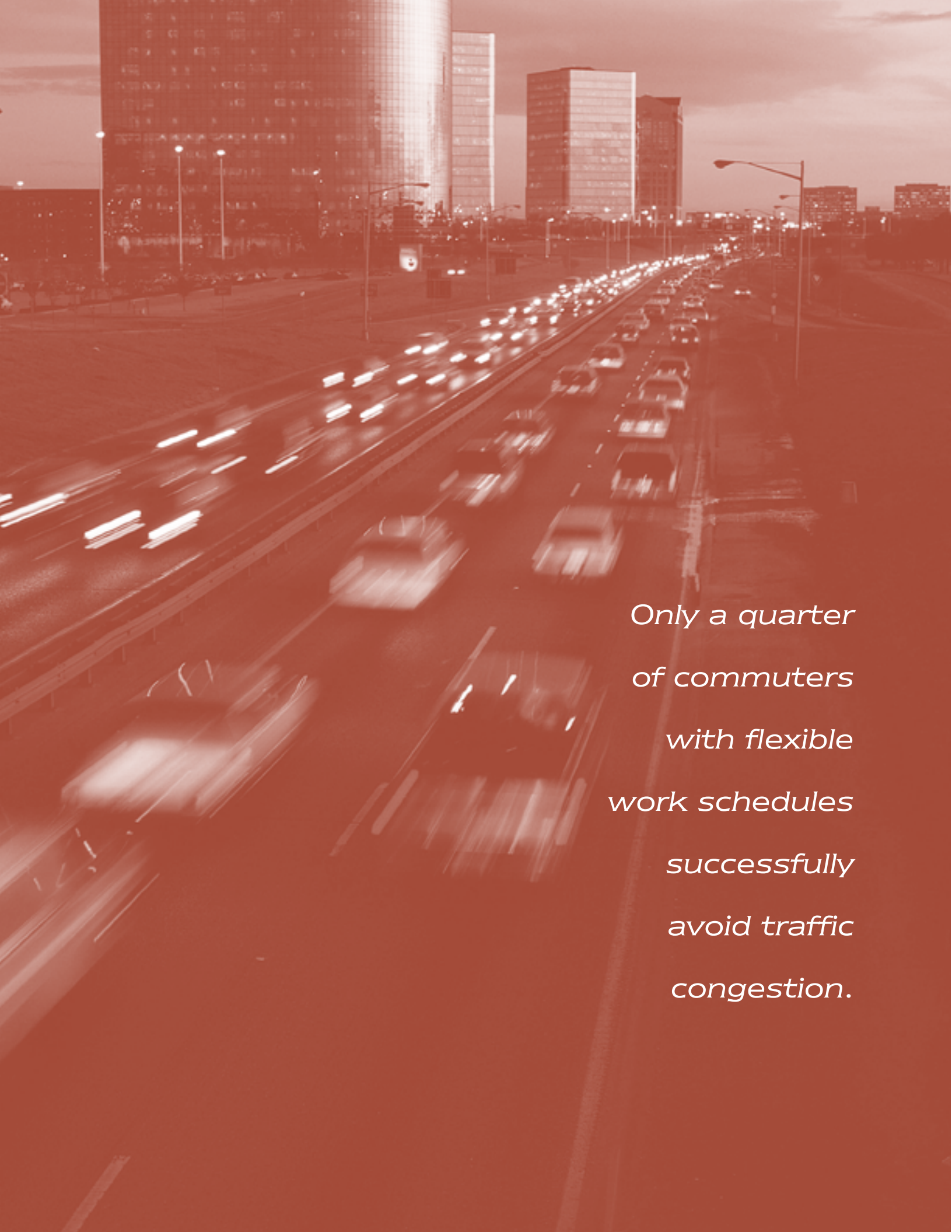
Characteristics of traffic flow—the interval between am and pm peaks and the duration of the peaks—interact with regular business hours to determine when individuals will choose to travel. If work hours differ from inter-peak hours, missing one peak may still not make it possible to miss the other. Consider the example of an upper-level administrator in my sample who comes to work before the morning peak in an attempt to get work done before others arrive. But he then finds he can't leave early enough to avoid the evening peak. He won't stay until after the peak, either. He says that, after spending ten or twelve hours in his office, he's ready to quit, even if everyone else is on the highway with the same idea in mind. It's become clear that the longer the duration of the peaks and the shorter the interval between peaks, the less likely it is that people like him will be able to reschedule their trips to off-peak hours.

For the most part, these factors are unrelated to scheduling requirements in the workplace. It's clear that policies aiming to relax constraints on work-related schedules are not sufficient to shift commuters into off-peak travel. Two-thirds of our sample said they have some flexibility in choosing their work schedules, yet less than twenty percent of them are able and willing to reschedule work so they travel during off-peak hours. Even if some people who currently lack this discretion were allowed work-scheduling flexibility, they would not necessarily choose off-peak commute times. In our sample, more than half these people participate in activities either before work or after, and they say they can't easily cancel or reschedule those activities. >

Why does
anyone still
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during the
peak hours?

Average time difference from trips taken in the peak of the peak for workers...





*Only a quarter
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WHAT'S TO BE DONE?

Positive remedies might include employer-based childcare facilities that allow workers to match daycare hours to their work schedules. At least one large manufacturer in Silicon Valley has talked about siting a public school on its own campus so employees and their children could commute together. With extended before- and after-school activities, parents would then have more discretion for setting work hours, experience less personal stress caused by mismatched children's schedules, and perhaps even get to travel at off-peak hours.

It would help too if firms offering consumer goods and services were to stay open longer hours. If there were more opportunities throughout the day and evening for shopping, daycare, exercise, visits to the dentist and other personal services, individuals would have broader scheduling options. In turn, traffic peaks might flatten somewhat and individuals' sense of well-being might rise somewhat.

Already, the timing of nonwork activities reflects the increasing number of women in the workforce and recent changes in workers' lifestyles. These trends seem likely to continue. Witness, for examples, sports facilities, supermarkets, and other retail establishments that open early in the morning and/or close late in the evening—or not at all! More and more personal business such as banking, shopping, and even medical advising can now be conducted by telephone or online 24 hours a day.

Increasingly flexible schedules of nonwork activities should reinforce flexible work schedules and thus increase flexibility in individuals' commute times. These changes may not help the majority of commuters. As some trips shift from present peak to present nonpeak hours, the peaks will shift even as they flatten. Moreover, a reduction in some types of peak-hour trips might be countered by increased trips for other purposes at those times as motorists fill vacated spaces. The net result might be little, if any, savings in average travel time. Nevertheless, those whose schedules are made more flexible will surely be better off for it.

So, although my study has found that flextime on the job has not turned out to be the magic wand many had expected, I'm nevertheless led to speculate that increased flexibility in the scheduling of both work and nonwork activities continues to hold out promises for improved quality of life for some. Schedules that are ever more elastic may yet lead to somewhat reduced traffic congestion during peak hours and, equally important, to wider ranges of opportunity in those fortunate individuals' daily lives as well. ♦



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TAKING TURNS: R_x FOR CONGESTION

BY CARLOS DAGANZO

Freeway congestion at bottlenecks is different from tie-ups caused by accidents and other random incidents. It's recurrent and therefore more easily diagnosed and perhaps even more easily controlled. Thus, at least in principle, we can reduce bottleneck congestion by modifying either the freeway's design or the management policies that affect freeway operations. Unfortunately, the most obvious modifications often redistribute benefits and burdens unevenly, so some people feel they'd

be worse off because of the so-called improvements. The resulting clamor often leads to inaction, leaving congestion unabated. So we need to find win-win strategies that everyone might like—lowering bottleneck congestion while garnering widespread support.



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Hypothetical toll

Tolls and similar pricing schemes are often proposed for reducing congestion, but monetary solutions are undesirable for people who are least able to afford them. Nonmonetary strategies that force motorists to take turns can lessen such inequalities, but they introduce other difficulties. For example, rationing schemes based on license plates, such as the odd-day/even-day approach that has been used in France and elsewhere, is burdensome for those who must travel on banned days. Pricing and coercive turn-taking penalize different groups of people, but a carefully designed hybrid of the two strategies might distribute burdens and benefits more fairly. The basic idea is for people to take turns having unpaid access to a facility; i.e. an individual who travels every day would pay a toll only on specified days.

To understand the distributive effects of any bottleneck management policy we must separate the population into groups, acknowledging that individuals are unique but have many commonalities. A simple division that is sufficiently descriptive for the purpose of illustration identifies two main classes, each with three subgroups. The two classes are distinguished by their access to money. Call them simply “Rich” and “Poor,” although that’s a pretty rough distinction. They are then subdivided according to the importance each person assigns to the trip through the bottleneck. The trip can be either very important (VI), e.g., if a commuter has no alternative means of travel; moderately important (MI), e.g., if there’s an alternative means but the traveler prefers the bottleneck; or not important (NI). People in the last group don’t use the bottleneck, perhaps because they have better ways of reaching their destinations, or they may not be >



interested in traveling at all. That group is usually the largest, and it's also the source of latent demand. The following table shows how a hypothetical population of 30,000 people might be partitioned.

<i>Hypothetical grouping of 30,000 people</i>		
GROUP	R (Rich)	P (Poor)
VI (Very Important)	2,500	2,500
MI (Moderately Important)	5,000	5,000
NI (Not Important)	5,000	10,000

Clearly, congestion at any bottleneck will decline if physical road capacity is expanded (at least temporarily) or if travel demand is curtailed, through either pricing or coercion. Each of these potential remedies will generate a distinctive incidence of advantages and disadvantages that affect each of the six subgroups.

Capacity expansion

If a road-expansion project is financed by a tax that falls on the entire population, then, clearly, group NI is negatively affected. A more targeted user fee, such as a gas tax, also has a negative effect on the motoring portion of group NI. Even with a perfectly targeted fee, such as a toll on a particular road under specific traffic conditions, it is practically impossible to compensate fairly all the neighbors bothered by the highway's negative environmental effects. It's not surprising that NI groups often and vigorously oppose capacity-expanding projects.

Pricing

The Poor are disadvantaged by pricing in two different ways. Many from subgroup Poor-VI must endure the toll, while many from subgroup Poor-MI might be discouraged into leaving the system. The burdens might be alleviated for some if toll revenues were invested in usable transit projects, but this is difficult to accomplish to everyone's satisfaction wherever origins and destinations are geographically dispersed. Congestion-pricing winners are mostly in the Rich class; for them the toll is an acceptable price for faster travel.

Coercion

The burdens from rationing, such as forcing people to take turns (on odd/even days for example), may also be unequal because they handicap the VI group. People in the MI group might benefit, but only if speeds on days when they are allowed to use the bottleneck are fast enough to counter the inconvenience of having to make alternate plans on the remaining days. The only clear winners of a rationing strategy are people in the NI group; some might even find it desirable to travel on permitted days.

In summary, coercion penalizes VI, capacity expansion penalizes NI, and pricing penalizes the Poor. Time-dependent extensions of these strategies—either tolls that vary with time of day or rationing that applies only during the most congested part of the day—have the same redistributive drawbacks. Fortunately, a hybrid approach can avoid some of these disadvantages.

Hybrid Strategy: Pricing with Rationing

Imagine that the population at large is split into five similar sets (A, B, C, D, and E). For our hypothetical population, each set would include 6,000 people, perhaps distributed as follows:

<i>Hypothetical composition of each set, A through E</i>		
GROUP	R (Rich)	P (Poor)
VI (Very Important)	500	500
MI (Moderately Important)	1,000	1,000
NI (Not Important)	1,000	2,000

Each set is allowed to drive through the bottleneck without paying toll, except on days of the week specified as toll days for that set.

<i>Designated days when, say, \$10 would have to be paid</i>					
SET	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
A	PAY TOLL	Free	Free	Free	Free
B	Free	PAY TOLL	Free	Free	Free
C	Free	Free	PAY TOLL	Free	Free
D	Free	Free	Free	PAY TOLL	Free
E	Free	Free	Free	Free	PAY TOLL

The scheme works its magic by creating financial incentives for drivers to change their individual travel schedules, whether by using different travel modes or by traveling at different times, and then compensating the affected drivers by reducing their travel times on free days. In our example, if the toll were high enough to dissuade fifty percent of each affected set from traveling on its toll-paying day, then traffic flow would be reduced by ten percent every day if no induced demand were created by the smoother flow. Such a reduction could be enough to eliminate congestion and associated delays. ➤

The scheme works its magic by offering drivers a financial incentive to change their travel schedules and compensating them by reducing their travel times.

*We need to
find win-win
strategies
that everyone
might like.*

In our idealized example, the numbers of traveling people in each set might break as follows:

Distribution of the number of travelers in a typical set					
<i>On the toll day (total=1,500)</i>			<i>On four free days (total=3,000)</i>		
	R	P		R	P
VI	500	400	VI	500	500
MI	600	–	MI	1,000	1,000
NI	–	–	NI	–	–

Instead of 15,000 people traveling each day, 13,500 would drive. You can see from the table that the result would have been accomplished quite fairly for all six groups. The scheme is obviously fairer than coercive turn-taking and, insofar as Poor people can continue to use the system on four out of five days, it is also better for them than pure pricing.

Note that the schedule could be constructed in different ways. For example, there could be two paying days and three free days each week. We could also create a chart with a column for each day of the month, or increase the number of sets among commuters. More sets and more days to play with will make the chart more complex, but also more flexible. By fine-tuning schedules and tolls, we could fine-tune traffic flows to achieve equitable distribution of costs and effective reduction in delay.

In situations where the peak is concentrated, one could refine the strategy further by charging the toll only at specified times of day or varying it by time of day. In these circumstances, drivers may, on paying days only, prefer to change their departure time to avoid the toll, with the beneficial effect of “spreading the peak.”

My colleagues and I have run computer simulations of large numbers of commuters at single bottlenecks to test these expectations. We find the total delay at bottlenecks can be reduced quite significantly and fairly in this way, even if there is latent demand. The inconvenience of the shift for all population groups is partly compensated by faster travel on “free days,” when some have rescheduled their trips so others can arrive in the middle of what used to be the crunch without having to pay a toll. The simulations also indicate that most people experience a benefit and only a few experience small inconveniences.

This double-barreled strategy should satisfy most travelers because it gives them more options than either pricing or coercive turn-taking alone, while reducing both travel delay and toll paying. The strategy could be implemented with electronic car tags issued to individual vehicles and coded by the traveler’s address, thus assuring that all cars in a single household are assigned to the same free days. With advances in information technology, other practical matters, such as issuing a limited number of annual exceptions for hardship cases, could also be easily incorporated into this system.



Conclusions

We recommend this hybrid strategy as an alternative to congestion pricing. Having passed the simulation tests with unambiguously high scores, the scheme now needs a full experimental field test. We expect travelers to realize substantial gains as a result, whether they are rich or poor, and whether the trips they take are very important, somewhat important, or not important at all. ♦

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What Can a Trucker Do?

BY AMELIA REGAN

TRUCKS play critically important roles in the US economy. Measured by its value, nearly seventy percent of freight is carried exclusively by truck while another eighteen percent spends at least part of its journey on the road. For most motorists, traffic congestion is a nuisance; for truckers, it can be crippling. If truckers are inconvenienced, costs rise for everyone. The strength of each region's industrial base depends on the ability of freight-transport companies to provide swift and reliable goods movement at tolerable costs. In addition, trucks caught in traffic congestion generate significant negative externalities including pollution, lost productivity,

accident costs, and stress.

Truckers are well-informed on the workings and failings of the US transportation system, and also are major political actors, constituting a powerful lobby on issues that affect their industry. Both their level of concern about the issue of congestion and their expertise on the ground give policymakers plenty of reason to seek their opinions on the subject, asking which policies truckers would be likely to support.



In an effort to discover how they judge various congestion-mitigation strategies proposed by traffic managers, analysts, and researchers, we conducted a study that just asked them. The trucking industry is diverse, not only in terms of sizes of companies but in the parts of the freight trip they handle and how they handle it. So to understand why they prefer certain policies over others, we first had to learn how trucking companies function.

We soon found some consistent links between types of trucking operations and truckers' opinions. It proved useful to identify these links because it allows us to see which truckers prefer which policies. With this information, government investments needn't favor one segment of the industry over another.

We also found that the industry is changing at a rapid clip. Historically the freight industry has changed slowly, but with the emergence of e-commerce, new information technologies, and advanced traveler information systems, trucking is undergoing a profound transformation.

DIVERSITY OF OPERATIONS

The trucking industry is already highly diverse. It includes companies with several thousand vehicles as well as owner operators who lease, own, or control only a single vehicle. Private fleets, typically under the control of a large company, account for a large portion of the industry. Some trucking companies move full containers or truckloads exclusively, while others move smaller shipments or manage networks of consolidation and distribution facilities. At the extreme, companies like UPS and FedEx move exclusively small shipments through vast networks and hubs.

Some companies provide specialized services, like moving refrigerated goods. Others manage fleets of tank trucks carrying various liquids. Others move high-value, expedited, or hazardous loads. Some, known as dray carriers or drayers, focus on short moves as part of intermodal operations—that is, operations involving ground-and-sea or road-and-rail operations. Other truckers focus on ground moves associated with air cargo operations. Companies may be engaged in local, regional, national, or international traffic. Some companies have long lead times (the time between requests for service and the time when delivery is required), while others primarily react to requests within several hours.

Truckload carriers move whole containers only, while less-than-truckload (LTL) carriers contract shipments of any size. Private carriers are typically part of a larger company, such as a grocery chain, while for-hire carriers simply provide transportation or both transportation and logistical services. For-hire carriers may be contract carriers, working under contract with one or more customers, or common carriers, available to serve any customer. Tank and refrigerated carriers have specialized fleets and high >

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operating costs. Household movers have rather long loading and unloading times relative to other carriers and typically make final deliveries with the help of at least one driver who is familiar with the delivery area. Bulk carriers move high-volume, low-value goods.

THE CHANGING INDUSTRY

Current industry changes are being driven by emerging e-commerce and related information technologies, including advanced traveler information services (ATIS) aimed specifically at commercial vehicle operators.

E-commerce is generating many changes in the industry. Some trucking companies are becoming full-service providers, managing warehouses, distribution channels, and in some cases even final assembly of goods. Others are taking advantage of on-line load-matching services, making it easier for small carriers and independent owner operators to find loads on a day-to-day basis. (These load-matching services may be fee-based or free. Some are managed by large trucking companies or consortia of trucking companies, who find it profitable to contract practically all loads that come their way but then subcontract unprofitable or excess loads to small carriers on a load-by-load basis. Others are simply web sites supported by modest fees or advertising.) In addition, niche carriers are emerging to support local same-day or next-day delivery of goods required by “e-tailers,” most of whom are not equipped to provide distribution services.

Information technology for commercial vehicle operators aimed at making travel safer and more efficient includes many commercial software packages. Examples include routing and scheduling optimization, fleet location and status monitoring, container management, marginal and average cost modeling and freight rating, and ATIS, which may be publicly or privately financed and managed. Automated message signs are an example of publicly developed ATIS. Automated weigh/inspection station bypass systems have been developed by public/private sector partnerships. More and more private ATIS technologies are being bundled with commercial communications and software packages.

THE STUDY

We wanted to understand the relationships between the characteristics of trucking firms and the policy measures they favor. We looked at many different characteristics, such as truckload vs. less-than-truckload (LTL), private vs. for-hire, contract vs. common carrier. We identified the primary service provided by these companies (general truckload, general LTL, tank carrier, refrigerated carrier, household mover, bulk carrier), and the types of services provided (all of the above plus high-value, just-in-time, rail, air and maritime intermodal, and hazardous materials movements).



Our survey asked truckers about alternative policies for mitigating congestion, essentially six strategies: (1) new dedicated truck facilities, (2) improved operations, (3) improved traffic management, (4) enhanced priority for trucks in urban settings, (5) increased road capacity, and (6) congestion tolls.

Class One: Dedicated Truck Facilities

This class includes special arterial lanes for trucks, special freeway lanes for trucks, and dedicated truck streets. In general, the larger the firm, the more likely it is to oppose this group of remedies. That's so because large companies make a high proportion of long distance journeys, so their drivers do not spend a lot of their time in congested urban areas, whereas small companies are likely to operate largely in town. The trucking firms that support these policies are typically the users of intermodal rail and maritime facilities, common carriers, and operators engaged in just-in-time deliveries.

Class Two: Improvements in Operating Efficiency

Such remedies would reduce waiting time at ports and distribution centers, speed vehicle clearance at weigh stations and border crossings, and create truck-only streets for access to ports and rail terminals. Some of these policies are already being implemented. Weigh stations and border crossings are moving quickly towards advanced vehicle clearance systems. Truck-only streets might have sounded unlikely a few years ago, but implementation of the Alameda corridor at the busy ports of Los Angeles and Long Beach suggest that large cooperative private/public projects are possible. Such investment naturally has the support of the system's users and may be an attractive option for other severely congested freight hubs. This class of policies is supported by users of all three types of intermodal facilities (rail, air, and maritime), by those engaged in long-haul operations, and by truckload carriers. Private fleets, on the other hand, are not as interested.

Class Three: Improvements in Traffic Management

Policies that fit freight-industry perceptions of improved traffic management include, first and foremost, traffic-signal optimization, followed by electronic pre-clearance systems at checkpoints, parking bans on some streets, and a database that tracks hazardous materials loads (for use in clearing accidents). LTL operators, and small operators in general, hold the most positive attitudes toward this class of traffic-management policies; but contract carriers and truckload operators don't favor them. Contract carriers tend to work established, familiar routes, relying on experience >



Truckers are well-informed on the workings and failings of the US transportation system, and a powerful lobby on issues that affect them.

and familiarity to negotiate traffic congestion; truckload carriers tend to spend most of their time on relatively less-congested highways.

Class Four: Priority for Trucks on Urban Streets

Truck priority schemes include those allowing trucks to preempt certain traffic signals, eliminating on-street parking during certain periods, and dedicating arterial lanes to truck-only traffic. Common carriers, long-haul operators, and household movers prefer this class of policies. Household movers in particular, who regularly negotiate unfamiliar residential neighborhoods and for whom parking may be extremely difficult, stand to gain from reduced urban congestion and competition for parking.

Class Five: Increased Road Capacity

Operators with short hauls strongly favor strategies that increase road capacity, while long haulers do not. LTL operators and household movers are somewhat in favor of such strategies while private fleet, truckload, and tank operators are not. Short haulers tend to spend much of their time near urban areas or between maritime ports and railheads; and, in California and indeed in most states, the areas around major ports are seriously congested. Long haulers tend to spend more time on the open road.

Class Six: Congestion Tolls

Congestion pricing, in the form of peak-hour tolls, has some support from carriers who provide just-in-time pickups and deliveries, those with short hauls and average loads, and household goods movers. Private fleets do not favor congestion pricing.

IMPLICATIONS

By concentrating on three classes of policy—those related to improved traffic management, truck priority, and better operational efficiency at truck facilities—planners can implement strategies promising to appeal to all industry segments. The first two seem to be most cost-effective, and all three groups can be implemented in small pieces and targeted to severely congested places. Our study elicits preferences from across the entire spectrum of the industry, allowing smaller companies to have more of a voice than they otherwise would. With this information, policy makers can choose investments that benefit large segments of the industry without favoring the most vocal sector at the expense of those without as much political muscle. ♦



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THE ROAD AHEAD: *Managing Pavements*

BY SAMER MADANAT

A NEW-LAID STRETCH OF PAVEMENT is not a finished product. Traffic pounds it; hot sun heats and expands it; water gets inside and washes away the soil beneath it. Depending on these forces and the quality of its design and construction, a pavement will last only a limited time before it needs repair or replacement. Because there are so many factors involved, it's not possible to just schedule a replacement in x number of years. The pavement has to be checked periodically for potholes and cracks and ruts. Visual and manual inspections can be slow, hazardous, and fraught with uncertainty. But that's the way it's always been done.

Now, however, there is a whole range of new technologies available that can quickly, accurately, and safely check the current condition of a pavement. Although the tools and techniques are not cheap, they can potentially save a lot of money by permitting accurate diagnosis and rational management, thus eliminating unnecessary repairs. But the technology itself is not enough. Agencies in charge of maintaining pavements need first to accept these technological developments and then the organizational changes they imply.

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*High-speed
surveying
systems
can provide
in-depth
pavement
inspection
with a level
of detail and
accuracy
never before
attainable.*

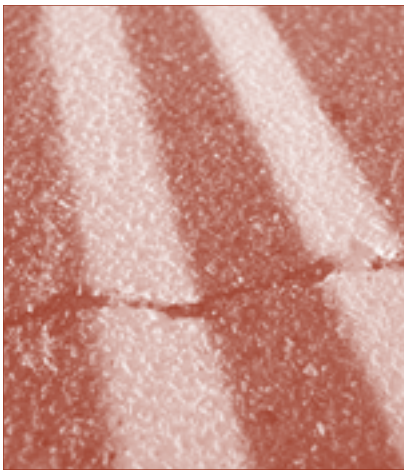
CURRENT PAVEMENT MANAGEMENT

Highway agencies developed what they call pavement management systems to provide systematic pavement maintenance and repair. Regular inspections record current conditions such as cracking, rutting, roughness, and skid resistance. A common way to use this information is to consolidate it into a single number, such as the Pavement Condition Index. Managers then correlate the PCI with the pavement's age and predict when the PCI will fall below a standardized level. Then, plans can be made for future maintenance, repair, or reconstruction of the pavement.

But there's lots of room for uncertainty in these methods. Surface conditions only hint at a problem's underlying causes. Although an experienced engineer can make a very good guess about what makes a road crack in a particular way, it's still a guess. The information that goes into the index is subject to errors, from sources as diverse as technological limitations of inspection equipment, imprecise data, and human error in processing. The performance-prediction models themselves create some uncertainty. These possible errors compound, increasing the likelihood of a wrong maintenance decision. Prediction models try to account for these uncertainties by creating a broad range of decision possibilities, but basically it's difficult to choose precisely the right repair. And any time a wrong choice is made, costs go up.

NEW INSPECTION TECHNOLOGIES

During the past ten to fifteen years there has been rapid introduction of automated high-speed pavement-condition inspection technologies. Commercial systems now available can continuously measure and record the type, degree, and intensity of cracking; the width, depth, and profile of rutting; and the thickness of the pavement layer, all at normal driving speed. These high-speed surveying systems can provide in-depth pavement inspection with a level of detail and accuracy never before attainable. ➤



Although an experienced engineer can make a very good guess about what makes a road crack in a particular way, it's still a guess.

Because they can collect information at driving speed, they dispense with the need to block lanes, disrupt traffic, and endanger workers. They also are not subject to the same limitations as older methods, as for example when estimating cracking, conventionally a slow process involving visual observation and manual measurement. Video and laser crack detectors now identify and measure cracks quickly and accurately. Ground-penetrating radar provides invaluable and heretofore unattainable information about pavement layer thickness. And rutting can be spotted and accurately measured with optical, laser, or ultrasonic sensors.

The revolutionary aspect of these new technologies, the thing that could change the way pavements are repaired and maintained, is the simultaneous collection of all these separate bits of information over a single stretch of pavement. No longer is it necessary to correlate piecemeal evaluations of separate factors and then guess at underlying causes. These new methods can create a complex picture of a pavement's condition, evaluating multiple factors over a specific distance.

THE INSTITUTIONAL CHALLENGE

Current pavement management systems work well enough, given the real limitations of equipment. Even the PCI is an acceptable, if cumbersome, way to use complex and uncertain information. But the advent of new technologies offers an opportunity and a challenge to highway agencies to do better.

Merely obtaining equipment and training is not enough to assure cost savings from these new methods. Instead, the pavement management system itself needs to be reformulated. I recommend four institutional changes to exploit all this newly available information and promote better maintenance decisions.

First, stop compiling and summarizing the information into a single index. Clearly, all the information pouring out of these new machines will go to waste if managers continue to reduce the information to one generic number. Instead, develop a 3-D image that connects the various kinds of information and gives a more complete picture of pavement condition.

Second, because we can see a deeper and more complex picture of the pavement, we can develop new computer-based predictions that eliminate much of the uncertainty managers must now account for in their plans. For example, cracking is caused either by fatigue or by rapidly changing temperatures. Fatigue is a result of strain in the pavement structure, which in turn is a result of load (vehicle number and weight), layer thickness, and layer stiffness. On the other hand, thermal cracking is caused by thermal stresses resulting from daily temperature variations. Since load, temperature, and cracking can now be continuously and accurately measured, there is enough information to determine the exact cause of cracking. As a result of better understanding the causes, we can also predict the future rate of cracking and thus allow managers to make more exact maintenance decisions.

Third, change the process of making maintenance decisions. With less uncertainty, the need for caution in planning is lessened, so managers will be less inclined to over-compensate by ordering repairs that are premature and too extensive. For example, if managers have more confidence in their ability to predict pavement life, they can reduce the amounts of funds that are often set aside for emergency repair work.

Fourth, and perhaps most useful, develop adaptive models that can learn over time, creating an institutional memory. That is, instead of relying solely on the practiced eye of a human inspector who, through experience, has learned the likely causes of pavement problems, create a self-learning system. Adapting to feedback from real conditions as they change, such a system can adjust its predictions accordingly. Thus more and more accurate predictions based on complex information will become available over time.

THE REAL FIX

As they must in virtually every field, technological developments compel the agencies that adopt them to also adapt to them. New ways of attacking problems call for new styles of management and hence new modes of organization. As pavement management shifts from visual and manual inspection to automated monitoring, the roles of inspectors will necessarily shift as well. With demands for different skills than were formerly sufficient, there will inevitably be demands for new staff equipped to supervise and apply the new electronics and optics. In turn there will be demands for revised methods of decision making and changed channels of authority.

These necessary changes will not happen simply because they should. There is a very serious need for the research community to assist state and federal transportation agencies to improve their data-collection schemes, performance-prediction models, and decision-making procedures. In the 1980s, substantial research effort was directed towards developing the first generation of pavement and bridge management systems. A similar endeavor is needed now to modernize these systems, so that they can make the most of new technologies.

It will no doubt take a while before the new pavement-management techniques can be fully adopted, because responsible agencies will need time to adapt themselves to the new tools and techniques. There can be no question that they will—preferably sooner than later of course. And, once the institutions do adapt, the potholes and cracks will get fixed sooner, the maintenance budgets will be smaller, and the ride will be smoother. ♦

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The Parking of Nations

BY DONALD SHOUP AND SETH STARK

*You don't know what you've got till it's gone.
They paved paradise and put up a parking lot.
—Joni Mitchell*

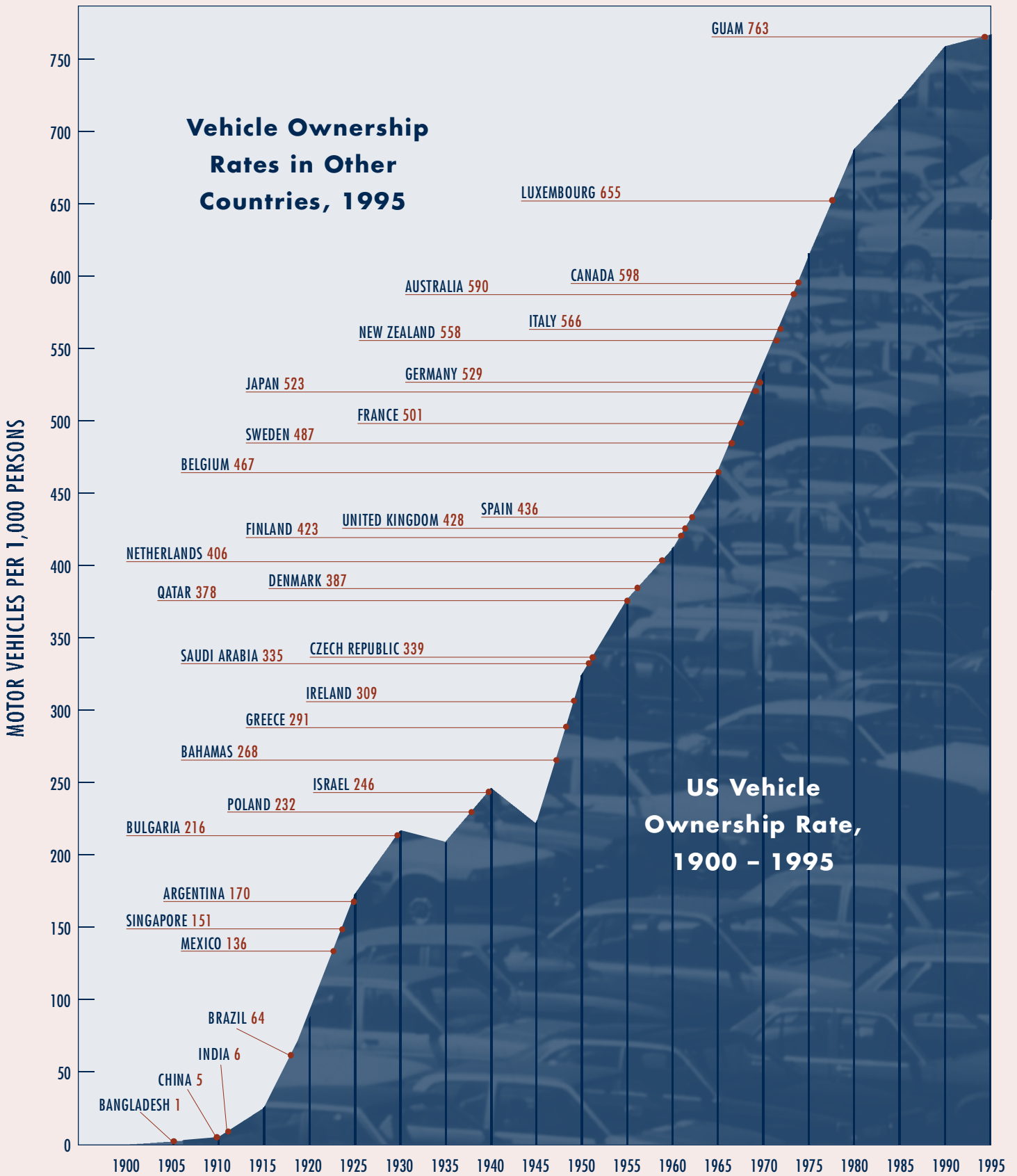
VEHICLE OWNERSHIP increased much faster in the US than in other nations during the 20th century. For every 1,000 persons, the US had 87 vehicles in 1920, 325 vehicles in 1950, and 767 in 1995. Ownership rates in 28 other nations in 1995 are noted in the accompanying graph to correspond with the year in which the US had the same rate. For example, in 1995 Bangladesh had the same vehicle-ownership rate as the US in 1905, Argentina the same as the US in 1925, and Denmark the same as the US in 1956.

There were 647 million vehicles on earth in 1995. If the rest of the world had matched the 1995 US ownership rate, there would have been 4.4 billion vehicles. Parking would be a global problem. How much space does it take to park 4.4 billion cars? A typical parking lot holds about 130 cars per acre. At this density, 4.4 billion parked cars require a parking lot about the size of England or Greece. There are currently at least four parking spaces per car in the US. At four spaces per car, 4.4 billion cars require a parking lot about the size of France or Spain. More cars also require more land for highways, service stations, used car dealers, repair shops, automobile graveyards, and tire dumps.

Fortunately, the rest of the world is still far behind the US in vehicle ownership. With only 5 percent of the world's population in 1995, the US owned 31 percent of the world's motor vehicles. The rest of the world had the average vehicle-ownership rate in 1995 that the US had in 1920—only 82 vehicles per 1,000 persons. The rate in the US was nine times higher than in the rest of the world in 1995, but other countries are following the vehicle-acquisition trail the US blazed through the 20th century. Outside the US, the number of vehicles grew 2.7 times faster than the number of people between 1980 and 1995.

Projections are not necessarily good forecasts, of course. For example, transportation created huge piles of horse manure in cities a century ago, and disaster seemed imminent. Then the horseless carriage came along and solved that problem. Horseless carriages now create a parking problem, but new remedies may yet arrive. After all, we don't want to pave France or Spain to put up a parking lot. ♦

Source: *World Statistics Pocketbook* (New York: United Nations, 1997)





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