Policy Study No. 250

HOW TO "BUILD OUR WAY OUT OF CONGESTION"

INNOVATIVE APPROACHES TO EXPANDING URBAN HIGHWAY CAPACITY

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Executive Summary

Transportation planners project unbearable gridlock on urban freeways over the next two decades. The planners' conventional wisdom maintains that "we cannot build our way out of congestion." Yet the best they can offer is a menu of costly and ineffective alternatives—spend billions more on transit that hardly anyone can or will use, and try to force people into carpools that do not match their actual ways of living and working. All over the world people are increasingly choosing to travel by automobile, because this flexible mode best meets their needs. But a gridlocked expressway system threatens auto-mobility—and the conventional wisdom offers no good solutions.

The good news is that we can make significant improvements that will expand mobility for autos and trucks alike. To be sure, pushing new freeways through dense and expensive urban landscapes will seldom be economically or politically feasible. But we can make far more creative use of existing freeway rights of way to increase capacity and ease congestion. One key to doing this is to provide separate lanes for cars and for trucks. The former need much smaller dimensions; hence, cars-only lanes can be done as double decks, either above the surface or in tunnels beneath high-value real estate. Overseas, Paris, Melbourne, and Sydney are developing new urban expressways using some of these new concepts. Special-purpose truck lanes could permit larger, heavier trucks than are now legal in most states, and would allow trucks to bypass congested all-purpose lanes, thereby facilitating just-in-time deliveries valued by shippers and receivers.

Reconstructing freeways with some double decks and new tunnels will be costly—and could never be done as long as we rely only on today's federal and state fuel taxes. But charging tolls for such expensive new capacity is both technologically and economically feasible. New electronics technology (already in use on Toronto's Highway 407) makes it possible to charge users automatically, using sophisticated time-of-day pricing, without using any toll booths or toll plazas. Electronic tolling costs far less than labor-intensive toll booths, is far more flexible, and is more user-friendly. Demand-responsive market pricing has been found highly effective in keeping toll lanes from becoming congested in two Southern California projects.

In short, the combination of innovative highway redesign, separation of types of traffic, toll financing, variable pricing, and electronic toll collection will allow us to offer auto drivers and truckers real alternatives to gridlocked freeways. Using these methods in combination, we CAN build our way out of congestion.

Part 1

Introduction

Growing congestion on our cities' highways is being portrayed by government officials and transportation planners as inevitable. Plans for our major metro areas show projections for the year 2020, even after planned road improvements are made, in which average speeds on major arteries continue to decline, in rush hours that are extended to much of the working day. For example in the Los Angeles area in its latest draft Regional Transportation Plan, the Southern California Association of Governments (SCAG) says that daily commute times will "double" by 2020 and what it calls "unbearable" present conditions on the freeways will become "even worse."[1] At another point the plan says that "the future transportation system clearly will be overwhelmed."[2] The report says that three percent of the current freeway network is "extremely congested" (by which they mean average speeds in the 10 to 16 mph range), but those kinds of conditions are expected to apply to 70 percent of the freeway network by 2020. Drivers currently spend 56 percent of their time in stop-and-go and are expected to spend 70 percent of their driving time like that in 2020. Some metro planning agencies are not quite as strong or candid in their language as those in Los Angeles, but a review of transportation plans around the nation's 30 or 40 largest cities will turn up similar predictions that traffic is going to get worse, many saying much worse.[3] Almost none sees improvement.

America is traditionally a can-do nation of problem-solvers. However, in the matter of traffic, the United States seems to have lapsed into an uncharacteristic fatalism, as if conditions on our city highways are some kind of natural disaster we just have to endure, like an El Niño.

This paper brings together various ideas that have been advocated and occasionally applied singly but which if deployed in combination, offer hope and show why we need not be so pessimistic and defeatist about traffic. A large part of the problem is in the area of ideas.

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1 Southern California Association of Governments, "Community Link 21: Draft 98 Regional Transportation Plan," November 6, 1997, p. I-4.

2 SCAG, pp. 4–9.

3 In Baltimore, MD the adopted transport plan provides for a trebling of vehicle miles traveled on expressways at Levels of Service E and F (stop-and-go) to 55 percent of the total in 2020 as compared to 1990. See "Outlook 2020, Baltimore Regional Transportation Plan," Baltimore Metropolitan Council, draft March 24, 1998, p. 79.

Part 2

Alternatives to Driving?

A. The Congestion Lobby

Unfortunately, one school of thought positively favors defeatism about traffic congestion. They believe that the prospect of ever-worsening and insoluble congestion is the one way to break the "grip" of the automobile on the American consumer and to persuade people to carpool or take transit. Predictions of gloom and doom on the roads are seen by an associated pro-transit movement as the most powerful argument to get legislators to vote substantial tax monies to transit.[4]

Most levels of government have programs in place to suppress single-occupant car usage in cities and to encourage carpooling with favored service (such as uncrowded High Occupant Vehicle [HOV] lanes and HOV bypass of ramp meters). Cities heavily subsidize transit trips and make large investments in transit infrastructure without any expectation of financial return on the investment. Growing congestion on the roads is seen by many planners as their most powerful tool to pry people from their cars and get them into the multiple-occupant vehicles that planners favor. Transit agencies and ride-share publicists advertise their modes as a hassle-free way to fly past the congestion of single-occupant vehicles on congested lanes.

So there is, in effect, a Congestion Lobby.

But the major problem is the rigidity of the thinking and the institutional structures that govern urban transportation policies—the ineffectiveness of the Mobility Lobby, if we can call it that, in bringing together the smartest ideas, expounding them, and working to gain support for the reforms they suggest.

B. Transit's Track Record

Many opponents of highway construction suggest that transit is a substitute for the private car, that somehow people can be gotten out of their cars and onto buses or rail. The sorry record of the past half century in which some $340 billion of taxpayer money has been poured into capital and operating subsidies

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4 Randal O'Toole's, "The Coming War on the Automobile" on the website http://www.ti.org/~rot quotes a series on National Public Radio's "All Things Considered" in which Portland Metro government planners said they "are embracing congestion; (and) they want to create more of it" because it "signals positive urban development."

of transit, suggests otherwise.[5] Transit does have certain niche markets. It works well, indeed is indispensable, for certain kinds of trips—for example for commuters' suburb-central business district (CBD) trips to and from work in the older centralized cities like New York, Chicago, Boston, Washington, Philadelphia, and San Francisco. In these kinds of trips the cost or scarcity of parking almost rules out the use of cars for daily commuting. People who aren't able, or can't afford, to drive their own car are another natural market for transit. The trips of CBD-commuters and nondrivers constitute the great bulk of transit users. Unfortunately for transit, these represent a small and declining minority of the urban transportation task.

Almost everything is stacked against transit as a competitor with cars:

- Population growth is in cities without a tradition of transit (Los Angeles, Houston, San Antonio, Dallas, Miami, Phoenix, Seattle, Charlotte, Orlando) while the transit cities (New York City, Chicago, Boston, Philadelphia, Pittsburgh) have stable or declining populations;
- Commuting trips where transit can be competitive are in decline relative to trips for personal business, shopping, social occasions, spare time pursuits, etc, for which the car has overwhelming advantages;
- Central business districts are static or declining in jobs, with virtually all new jobs being in the suburbs, dispersing commuting destinations in a way that makes transit hopelessly uncompetitive for the overwhelming majority of people whose trips form a spider web plan over any metro area;
- With both husband and wife working in most households, many trips are now "chained," combining the hauling of kids and shopping with the commute, which virtually rules out anything but the use of a car;
- Investments in fixed-rail transit are high-cost/high-risk and require major continuing subsidies which limit service and coverage, whereas improved highways in urban areas, while expensive in capital cost, are low-risk investments with low operating costs;
- About 70 percent of transit service—notably that provided by buses—uses roads and is harmed by congestion along with cars, indeed may be harmed more, given that car drivers are able to organize more creature comforts in their car than on a bus;
- Work hours, work patterns, and work locations are becoming more flexible and less predictable, again favoring the flexible, go-almost-anywhere-anytime mode, the car.

Transit trips now constitute less than one in 50 person trips in U.S. urban areas, the latest hard number being 1.8 percent for 1990.[6] Far from increasing as predicted by transit advocates, transit has been steadily losing ground, despite taxpayer support that covers all its capital and about over half its operating costs. Only six years earlier transit held 2.3 percent of total trips. The decline of transit is virtually across the board and includes the settings where it has the greatest inherent advantage. In metro areas with populations of greater than 1 million and rail systems, transit provided 8.8 percent of total trips in 1983 but only 5.2 percent in 1990.[7]

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5 Taking USDOT and American Public Transit Association data, the Wendell Cox Consultancy reports that from 1960 to 1997 transit got $340 billion (1997-$s), approximately the same as was spent on building the Interstate highway system which was funded with motorists' taxes and which carries 25 times the passenger-miles (plus truck freight) as all the transit systems. "Urban Transport Fact Book" on website http://www.publicpurpose.com/ut-ussby.htm.

6 USDOT, "1990 NPTS, Nationwide Personal Transportation Survey: Urban Travel Patterns," June 1994, p. 4-2. As of 8/12/98 the corresponding results of the 1995 NPTS are not available. Tel: 202-366-0160.

7 Subsequent preliminary figures have been claimed to show some slight revival of transit. In a number of cities, including New York, which accounts for about a third of national transit usage, unlinked trips have increased. This

C. The Decline of Carpooling

The last 20 years have seen enormous effort to engineer higher vehicle occupancy through encouragement of carpooling and use of vans and buses. Recognizing that the objective is to "move people not vehicles" in the slogan of carpooling, the federal government has increasingly turned its urban highway enhancement funds toward HOV (high occupancy vehicle) lanes. But there is no sign this focus has stemmed the shift to solo driving either. Forming, operating, and holding together a carpool is tough to manage and adds to travel time,[8] and takes from the participants the flexibility of a solo-driver car, with its ability to leave whenever the driver is ready and to drive directly to the destination. Carpooling imparts to the car some transit-like constraints of a schedule, and for each rider a more circuitous route. In the commute carpooling has a larger mode share than transit. On the average day in 1990, 15 million carpooled compared to under 6 million in all forms of transit, compared to 84 million who drove alone. But carpooling is in decline, like transit, despite government and corporate programs to encourage it. In 1980 it represented almost 20 percent of work-trips with 19-million carpoolers/workday, but the 15 million in 1990 represented only 13.4 percent of work-trips.

Almost everything is stacked against transit as a competitor with cars.

Alan E. Pisarski, a leading authority on commuting statistics, writes bluntly that real carpooling "died" in the 1980s, but he suggests that those associated with the death are in a state of denial.[9] Almost 80 percent of carpool trips are now HOV-2 (driver plus one passenger), with HOV-3+ (three occupants or more) having almost halved during the past decade. HOV-3+s in 1980 were 5.8 million daily but declined to 3.3 million in 1990.[10] Bus and vanpools (HOV-5+) lost 40 percent of their riders during the 1980s going from about 1 million to 600,000/day. Over half of carpoolers now seem to be family members, most of whom would drive together whether there were government high-occupancy policies or not. Only a minority are organized carpoolers—strangers gotten together by an organized trip matching system. Pisarksi says most carpools would better be termed "fampools" because of their "fam"-ily nature, and he calls for more "honest" statistical work to capture the real effects of carpool policies.[11]

In some cases carpooling policies seem to have produced reasonable utilization of HOV lanes (in Los Angeles and Houston), but generally the program has been a large disappointment, and most HOV lanes are heavily underused, in many cases carrying fewer people than adjacent unrestricted lanes. Like transit, carpooling seems to work for declining niche markets—those with extremely long commutes from fringe-area communities who are working at very large institutions with fixed shifts.

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appears to be an increase in transfers and gets reflected in unlinked trip statistics. There is increased use of feeder services the use of which has been made easier and cheaper. But this indicates that the existing pool of transit users are transferring more, not that more people are using transit (which would be measured by 'linked trips' but linked trip statistics are no longer kept in the United States).

8 About five minutes per carpool member according to census data.

9 Alan E Pisarski, "Carpooling: Past Trends and Future Prospects," *Transportation Quarterly*, Eno Transportation Foundation, Vol 51., No. 2, Spring 1997, p. 6.

10 Alan E Pisarski, "Commuting in America II," Washington, D.C.: Eno Foundation, 1996, p. 49.

11 Pisarski, "Commuting...," Eno, p. 57.

Pisarski concludes his major research project on commuting in America with the statement that the transportation policymakers' decades-long assault on the single-occupant car has been "dramatically ineffective."[12] At best it has simply been pointless exhortation—a waste of breath and of money. At worst it has also been inequitable and counterproductive to planning aims. It has hurt "those on the margin of the (financial) ability to own and operate a vehicle," writes Pisarski. And rather than use transit, people have reacted to congestion and higher car costs by seeking savings in housing by moving to cheaper locations on the outskirts, increasing commute distances, and exacerbating "urban sprawl."

In summary, transit and carpooling have a role in small niche markets such as serving dense central business districts, but they are simply not competitive across the board with the automobile and roads for most city travel. The problems of the roads have to be tackled on the roads.

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D. The Inevitability of the Automobile?

This shift to the car is not peculiar to the United States, as sometimes claimed. The car has "a near monopoly in most west European countries" on growing suburb-to-suburb travel outside the dense city centers, according to European transport expert Christian Gerondeau who adds: "This is not in the least surprising. Densities for this kind of trip are far too low to justify (transit).... Inhabitants of suburban areas often think that if suitable modes of public (transit) existed they would be sure to use them. But on taking a closer look it is found that the term 'suitable' has a very specific meaning.…They actually want a mode (of transit) that would pick them up at their doorstep, would drop them off right at their destination, at any time of day or night, without any waiting or transfers ... a car."[13]

Given the double- and even triple-digit annual rates of growth of car ownership and major construction of toll motorways in the developing areas of major Asian and Latin American cities, the mode shift to the single-occupant car is a worldwide accompaniment of economic development and prosperity.

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[12] Pisarski "Commuting..." Eno, p. 100.

[13] Christian Gerondeau, *Transport in Europe* (Boston: Artech House, 1997), p. 263.

Part 3

Tools for More Productive Highways

A. The Problem of Space

Many people assume that "We don't have space for new roads." A lot of the easier methods of widening roads in American cities have indeed already been applied. Highways designed with wide grass central medians have generally been paved inwards. However, there are still opportunities in many U.S. urban highway corridors to widen outward. A recent review of major freeways in the Los Angeles area (I-710, SR-60, I-5 and I-15) looking for opportunities for widening to add an extra four lanes to existing eight- and ten-lane freeways found that about 118 miles out of 136 miles have space within the existing right of way or require only small land purchases for the necessary widening.[14] A rather similar situation obtains on the busy I-635 LBJ Freeway in the Dallas-Fort Worth area and on the I-10 Katy Freeway in Houston, where substantial widenings to double-digit laneage are planned. In most places sloped edges can be replaced by retaining walls and ramps can be rebuilt, though in all three cities some sections will require a choice between acquiring strips of adjacent land to maintain a single grade or going to a double-deck structure of some kind.

If going outwards is politically impossible or too expensive, the alternatives are going up or going down to find the extra space. If neighbors are willing to sell adjacent land then simple widening of major highways is an option that needs to be weighed against the extra cost of double-decking, or undergrounding.[15] Entirely above-ground freeways may go the way of early elevated transit lines (the " Els" of New York City) and be torn down to be replaced by sub-surface or fully underground roads—as is happening in Boston with the underground Central Artery replacing the elevated John Fitzgerald Expressway.[16] In Brooklyn, NY the Gowanus Expressway, built atop the structure of an abandoned Third Avenue BMT El rail line, is the source of studies and controversy over whether it should be renovated as an El-highway or torn down and replaced

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14 "Los Angeles: 220km Truck Pikes Planned," *Toll Roads Newsletter*, No. 23, Jan 1998 p. 1.

15 Robert W. Poole, Jr. and Yuzo Sugimoto, "Congestion Relief Toll Tunnels,"Policy Study No. 164 (Los Angeles: Reason Foundation, July 1993).

16 Underground sections of expressway are not really new. Perhaps the oldest in the U.S. is the 1920s Depressed Highway (NJ-139/US-1&9) in Jersey City NJ which links the Pulaski Skyway in the Meadowlands to the west bank Hudson approaches to the Holland Tunnel. Local streets are built atop it. In Chicago sections of Wacker Drive and Lake Shore Drive are below regular street level, having been decked over. In Washington DC I-95 was built in the early 1960s in a 1-km (3200') long tunnel under the Mall in front of the Capitol Building and beneath flanking U.S. government office buildings, although it has since been downgraded to I-395 because completion of the roadway further north was blocked by anti-highway groups. Expressways have been decked for parks and local streets in Seattle, WA, Duluth, MN, Manhattan and Brooklyn, NY, Rossyln, VA, Cincinnati, OH, Phoenix, AZ and a number of other U.S. cities.

with a tunnel.[17] Similar argument is likely over renovations of I-95 along the Delaware River through downtown Philadelphia. In Salt Lake City people seem happy with the reconstruction of I-15 as a 10-lane elevated. The double-decker Embarcadero in San Francisco got torn down, not to be replaced at all, but the double-deck I-35 through downtown Austin, Texas (four-lanes atop four-lanes) seems accepted, as does a section of high four-lane HOV just south of Los Angeles CBD (I-110). Such decisions properly must be made not only road by road but section by section, through the messy and raucous, but essential processes of local consultation and argument.

In Europe, Asia, and Australia there are some spectacular examples of urban tunnel highways being built where there is strong objection to land acquisition and construction of surface roads. Examples include:[18]

- Near Versailles west of Paris, a missing link in the outer A86 ring road involves a six-lane bored tunnel 6.3 miles long with an underground interchange midway;
- Southeast of the center of Melbourne, Australia the three-lane Burnley tunnel two miles long under parkland and housing and another—the Domain tunnel about one mile long (under parkland)—are currently under construction as part of the $1.2 billion City Link project;
- In central Stockholm, Sweden a 12-mile underground ring road with 28 interchanges (six underground) was designed. Political differences and cost increases have forced it to be scaled back by a third to a C-shaped tunnelled roadway;
- In Lyon, France four miles of a six-mile northern ring road are underground, most in deep mined tunnels under historic areas;
- In Sydney, Australia construction is under way on a double-deck (three-lanes atop three-lanes) tunnel being bored 3,000 feet long under a densely developed area immediately southeast of the central business district, and two other sections of underground motorway are in planning stages;
- Oslo, Norway has ten underground highway sections constructed during the past 20 years;
- Tokyo has the world's largest program for underground highway construction including most of the seven-mile long Shinjuku section of the Central Circular Expressway and two-miles of the Oji section. The Trans-Kawasaki and Omiya expressways within the Japanese capital also have substantial undergrounding;
- Haifa, Israel plans three miles of twin tunnels under Mount Carmel to improve crosstown movement. The planned tunnels emerge briefly to provide a local interchange in a high valley midway along the route.

Every one of these costly tunnel projects is being paid for by toll revenues, and many are being developed and operated by private companies under long-term (e.g. 30 years) franchises.

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17 The Regional Plan Association and local groups are pressing strongly for a tunnel while NY State DOT wants renovation of the elevated.

18 These projects have been covered in various issues of *Toll Roads Newsletter*.

B. Advances in Tunneling

Tunnels are expensive, but steady advances in tunneling technology have significantly reduced their cost. Many of the new techniques are described under the term New Austrian Tunneling Method (NATM). It is not very new anymore, indeed it was first applied in 1958, and most of its proponents and practitioners are not Austrians.[19] Some of its most ardent advocates indeed say it is not even a method but more an approach or a set of principles. NATM is widely credited with producing better bores for the buck.[20]

Prior to NATM, tunnels tended to be of rather uniform construction throughout their length, the structure being designed generally to the needs of the most difficult section. They were overbuilt. NATM emphasizes different techniques for different geologies along the way, making maximum use of natural support so as not to waste manmade inverts (horseshoe shaped frame sections) or other structural supports. It emphasizes moving quickly enough after excavation to prevent loss of natural support. A lot of rock bolts (forced like huge nails into native rock) are used to stiffen up the natural rock. Shotcrete, a stiff quickly setting concrete mix, is sprayed under pressure onto walls covered with steel mesh. Extensive instrumentation is installed so the tunellers get good measurement of pressures and movements in the natural walls, to be able to make informed judgments about further appropriate support.

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There have been major advances in tunnel-boring machines (TBMs), invented by the British engineer Marc Brunel in the 19th century. The past 20 years have seen TBMs built much tougher, more reliable, and to ever larger diameters. The availability of large TBMs is especially important for highways because they are the largest tunnels in cross section.[21] Until the 1960s the largest TBMs were about 8m (25 foot) diameter, hence most tunnels so built only had space for two lanes of traffic. Thanks mainly to Japanese innovation, TBMs are now common at 10m (and even go to 14m as in the case of equipment used on the Trans-Tokyo Bay tunnel) providing room for three lanes of full-sized truck traffic. Once the principal challenge in tunneling was breaking up the hard rock and getting the debris out. Now with “road header” machines, relatively simple machines that deploy a large grinder on an arm and a conveyor belt, and with simple mechanical excavators and precise explosives that move the toughest rock, expensive TBMs and large shields can sometimes be dispensed with.

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19 The Sauer Company, whose principal is the Austrian born and trained Gerhard Sauer, is a primary consultant on NATM, and operates out of offices in Saltzburg, Austria, Frankfurt, Germany, and Herndon, Virginia.

20 “Special Issue—the NATM Selection,” *Tunnels & Tunneling*, Summer 1990.

21 Most of the world’s tunnels are built for mining and for water supply and wastewater disposal, where a large cross-section is not vital. Rail transportation can generally make do with smaller diameter bores.

Another major advance in tunneling is the invention of the jet fan for ventilation. So named because they look like the jet engine of an aircraft, they are hung from the ceiling at intervals along the tunnel and simply move the dirty air along the tunnel. It can be vented out one end, taken to vertical exhaust risers, or diverted into treatment channels and reinserted cleaned into the tunnel.[22] On all but the very longest tunnels, jet fans allow the tunnel builders to dispense with the plenum or separate longitudinal ducting above a false ceiling that has traditionally been used to ventilate tunnels. That can reduce the quantity of excavation and construction by 10 to 20 percent, and capital costs by comparable amounts. Pioneered in Europe and Japan, jet-fan ventilated tunnels were long resisted by the U.S. Federal Highway Administration on the argument that fire might disable the jet-fans.[23] A breakthrough came in 1996 when live fire tests in an abandoned tunnel in West Virginia proved their safety, and they were belatedly allowed in the last designed section of the Central Artery project in Boston.[24]

C. Cars-only Parkways

Providing separate roadways for trucks and light vehicles is an old idea in the United States but one that has been overlooked the past 50 years, since federal regulations forbade it. The very first grade-separated, controlled-access roads were reserved for cars and called "parkways" in the 1920s and '30s—north of New York City in Westchester County, in adjacent Connecticut and New Jersey, to the east on Long Island and also on the fringes of Washington, D.C. The legacy of that period of road-building remains in parkways such as Sprain Brook, Sawmill, Bronx River, Henry Hudson, Taconic, Hutchinson River, Interboro, Merritt, George Washington, Mt. Vernon, Suitland, Clara Barton, and Washington-Baltimore. Many were built with low clearance overbridges, some as low as 11 feet so that large trucks cannot drive on them. They usually have short, sharp interchange ramps and narrow lanes, typically 10 feet as compared to the 12-foot that has been standard for mixed traffic laneage on U.S. expressways. They had no breakdown shoulders or median barrier originally.

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The parkways were sometimes built in broad (300 ft.) right-of-way, often along the floodplains of small rivers, something that the contemporary preservation of "wetlands" would never allow, but this set them in treed corridors, and caused them to wind sinuously left and right, giving them a pleasant verdant quality, utterly different in feel from an expressway or freeway. They tended to be designed by landscapers and nature-enthusiasts who made a major effort to fit them into a natural landscape, shaping and rounding slopes, maintaining and enhancing rock outcroppings, minimizing cuts and fills, and preserving trees and natural waterways. Herman Merkel, a landscape architect, was responsible for the first, the Bronx River Parkway (opened 1923) and in the 1930s some of the early state toll roads, notably the Hutchinson River and Merritt Parkways. They were highly successful financially, based on tolling cars only. Robert Moses, parks

[22] In at least one Japanese tunnel highway air is being scrubbed for dust and sulfur dioxide, and it is possible other pollutants might be capable of being collected in the future.

[23] The Pennsylvania Turnpike, not dependent on federal funds, defied the FHWA ban on jet-fan tunnels and built the first in the United States, the Lehigh #2 tube on the NE Extension between Philadelphia and Scranton opening 1991.

[24] "Tunneling advances," *Toll Roads Newsletter*, No. 12, February 1997, p. 3.

commissioner and public works coordinator of New York City for 44 years (1924-1968), oversaw the development of the dozen or so parkways that followed. The idea of parkways was to provide city people with links to beaches, parks, and other healthful recreation. They were designed with a special naturalistic quality, and most were intended not to cater to commercial traffic. They were deliberately built to truck-excluding width, height, and ramp geometry. Others were compromises like the 170-mile long Garden State Parkway (opened 1954), which was cars-only only in its northern third but mixed-vehicle elsewhere.[25]

D. The Fateful Move to All-Purpose Highways

Robert Moses in New York City was a larger-than-life municipal boss who midway through his career fell out with the landscape/naturalist crowd over his proposal for a bridge between the tip of Manhattan and Brooklyn (a tunnel was built instead). He subsequently embraced mixed-vehicle expressways. Since the 1950s, federal funding and regulations have dictated that almost no cars-only roads have been built in the United States. The big swing to federal funding of U.S. highways came under President Dwight Eisenhower, who as a young captain in World War I had been in charge of an army truck convoy moving from San Francisco to New York. It had taken Eisenhower 53 days to make the transcontinental journey, so poor were the nation's highways. After the Korean war, with communism seen as a military threat, the federal government was keen to accommodate the Pentagon's desire for all new roads to be built to standards needed to carry heavy military equipment. The full name of the Eisenhower-initiated 42,000 mile system of Interstates is the National System of Interstate and Defense Highways.[26] As defense highways, they have had to be built with lane widths of 12 feet, overhead clearances of at least 14 feet, breakdown shoulders of 10 feet, gradients generally a maximum three percent, and bridge and pavement design, sight distances, and curvatures suited to heavy trucks.[27] And trucking lobbies have played a major role, too, in insisting on unfettered truck access.

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The beginnings of a new kind of truck/light vehicle separation are evident in bans on trucks in the inner lanes of multilane (five or more) expressways or freeways. In Los Angeles there has been a major program in the past six years to squeeze extra lanes out of the existing pavement, by re-striping the old standard 12-foot freeway lanes to 11 feet. Studies have shown that both speeds and safety are unaffected by the narrowing of lanes, and in a standard eight-lane LA freeway this change alone contributes eight feet of extra pavement (the rest of what is needed for an extra pair of lanes usually being available in the median or on shoulders). In this "LA squeeze," prohibitions are usually imposed on trucks in the inside lanes. From the other direction, there is pressure to make lanes wider for trucks. The federal width limit on trucks was increased recently from eight to eight and one-half feet and with most truck engines now turbo-charged, trucks are also

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[25] Based on personal observation plus Robert A. Caro, *The Power Broker* (New York: Vintage Books, 1975), and (no named author) "America's Highways: 1776 to 1976," Federal Highway Administration, U.S. Department of Transportation, 1976.

[26] Tom Lewis, *Divided Highways: Building the Interstate Highways* (New York: Viking, 1997).

[27] Wolfgang S. Homberger, et al., *Fundamentals of Traffic Engineering*, Institute of Transportation Studies, University of California Berkeley, 1996.

travelling faster. A number of proposals for new highways (notably the NAFTA Highway Indianapolis-Houston-Laredo Corridor proposal) provide for truck lanes of 13 feet. Canadian experience with extra-wide timber-jinkers has shown wider trailers are safer as well as more productive than those which are made to fit in standard mixed-traffic lanes.

E. Truck Lanes and Truck Roads

In America as elsewhere large trucks are a hot-button political issue, with truck lobbies constantly pressing for more generous size and weight limits, and motorists' organizations and local activists fighting to stop further truck enlargement. A former federal highway official, James Ball, now a truck toll road developer at Transportation International, Inc., is an advocate of car-truck separation.

> *We have had this quite futile and unproductive fight for years in the U.S. between the motorists' organizations and the truckers, the truckers saying the economy needs to allow larger, heavier trucks and the motorists saying large, heavy trucks are dangerous. They are both right. On the major truck routes we need to build separate truck roads where we can cater to the special needs of trucks and provide the most economical mix of roadway dimensions and load carrying capacity for cargo movement. Yet we have to get the trucks out of lanes in which cars travel. This is the only way to make the major highways safe for small vehicles such as cars.*[28]

Ball formally proposed America's first trucks-only highway in early 1996 to go from near Winnipeg in Saskatchewan to Duluth, Minnesota—a wide-lane, heavy pavement structure designed to bring the wheat and lumber out of the Canadian prairie and the Dakotas more economically than the current winding and slow rail lines to Thunder Bay and Kansas City. He estimated he could undercut the railways and make a truckway business out of providing links to Great Lakes shipping at Duluth and Mississippi barges near St. Paul, Minnesota. Ball envisaged later extending a truckway southeast to Chicago then east to Detroit, Cleveland, and the east coast. Ball's proposal has been rejected for now by state authorities but he is looking for other places to sponsor truck toll roads.

"We have to get the trucks out of lanes in which cars travel. This is the only way to make the major highways safe for small vehicles such as cars." —James Ball, Transportation International

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The Pennsylvania Turnpike, which runs 25,000 heavy trucks a day (out of a total of 75,000 vehicles daily), has examined what it called a "dual/dual" concept, a 2/2/2/2 lane profile in which two lanes in each direction would be for heavy trucks and two for light vehicles, but so long as there are free parallel interstates for trucks (I-80 in the north of the state, and I-68 just south in Maryland) it seems unlikely to be a financially viable idea. John Hickey, manager of research for the turnpike, says giving heavy trucks separate roadways is a very attractive idea. He says that many motorists in their cars feel extremely uncomfortable on the four-lane turnpike driving right alongside heavy trucks, especially in bad weather when the trucks' tires spray their windshields with great showers of dirty water as they pass. The sheer size of trucks intimidates many

[28] Interview with James Ball, Transportation International, August 1996.

car drivers, and Hickey thinks the turnpike loses car patrons because of the heavy concentration of trucks in its present mixed-vehicle lanes.[29]

The main lanes of the turnpike are 1930s eight-inch concrete (the original pavement) covered with six to eight inches of asphalt overlays added over the past 60 years. The turnpike is beginning its first complete pavement rebuild. Hickey says the heavy trucks manage to rock the concrete slabs under all that asphalt overlay despite several years of the turnpike's efforts to stabilize them by pumping cementatious grout into voids as they develop. The new pavement for mixed-vehicle traffic will probably be 10 to 12 inches of asphalt.

If the turnpike could find a way to separate trucks from cars, such an expensive thick slab would only be needed on the truck part. Indeed the existing roadway would not be breaking up, Hickey says, if it were not for the pounding of the big trucks. And in new, well-drained construction, engineers say, roads used by cars-only would get decades of use out of a six-inch pavement slab. Most bridges for light vehicles would be cheaper, too.

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[29] Interview with John Hickey, Pennsylvania Turnpike, July 1997.

Part 4

Redesigning Our Expressways

A. Designs for Right-Sized Roads

Two west coast engineers see truck/car separation as a possible solution to the dilemma of building increased capacity in constrained expressway rights-of-way. Gary Alstot, a transport consultant of Laguna Beach, California, like many other southern Californians, has watched in awe as federal money has been used to build about three miles of double-deck down the middle of I-110 south of downtown Los Angeles as part of its High Occupancy Vehicles (HOV) program. Built as bridgework, on giant T-posts, the double-deck section of four lanes is generally about 65 feet high, because it has to go over the top of interchanges and overcrossings along the way, putting it up three levels (as shown in the top half of Figure 1). Not only is this height enormously expensive but it is intrusive. A highway authority could not get away with it most places.

Alstot, in a paper for the American Society of Civil Engineers, argued that on wide west coast urban expressways, with over 80 percent of the traffic in light vehicles, it is wasteful to build the whole cross-section to heavy truck standards.[30] He pointed out that I-110 could have been double-decked under its overpasses, instead of over them, if the space in the double-deck section was restricted to cars (see the bottom half of Figure 1). Alstot thinks 10-foot lane width would be adequate for passenger cars, with seven-foot overhead clearance, as in parking structures (see Figure 2). The average height of 1992 cars was 46 inches and two-thirds are less than six feet, he points out, compared to modern U.S. truck requirements of 14 feet high and 8.5 feet wide.

U.S. engineers are following with interest the Cofiroute tunnels for the missing link of the A86 Paris ring road in which similar tubes are planned west of Versailles, one for mixed traffic of two lanes, and the other a cars-only tunnel with two decks of three lanes each.[31] The cars-only tunnel, according to cross-sections provided by the French, will provide for ceilings at eight foot six inches and lanes of just under 10 feet wide, just a little higher but narrower than Alstot's notional cross-section (see Figure 3).

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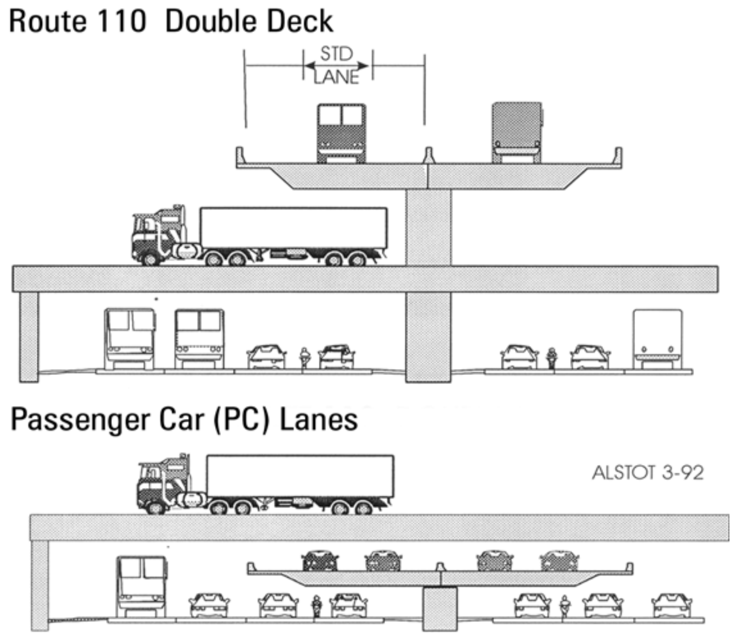
30 Gary Alstot, "Optimizing the Use of Urban Freeways and Rail Roads," presented at American Society of Civil Engineers Conference, San Diego, CA, October 22–26, 1995.

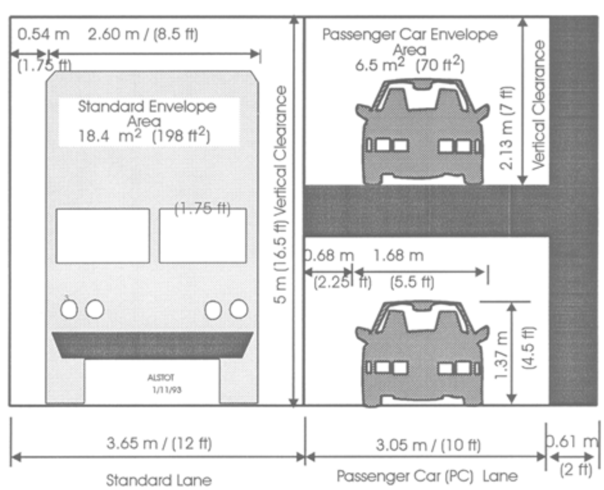
31 Described in presentations by Cofiroute at conferences and by Christian Gerondeau in his book *Transport in Europe*, Appendix B "Tunnels Reserved for Light Vehicles," p. 309, also "Metroroutes: an Urban Transport Innovation," *Transportation Quarterly*, Eno, Vol. 51, No. 2, Spring 1997, p. 63.

Figure 1: Double Deck Lanes vs. Passenger Car (PC) Lanes



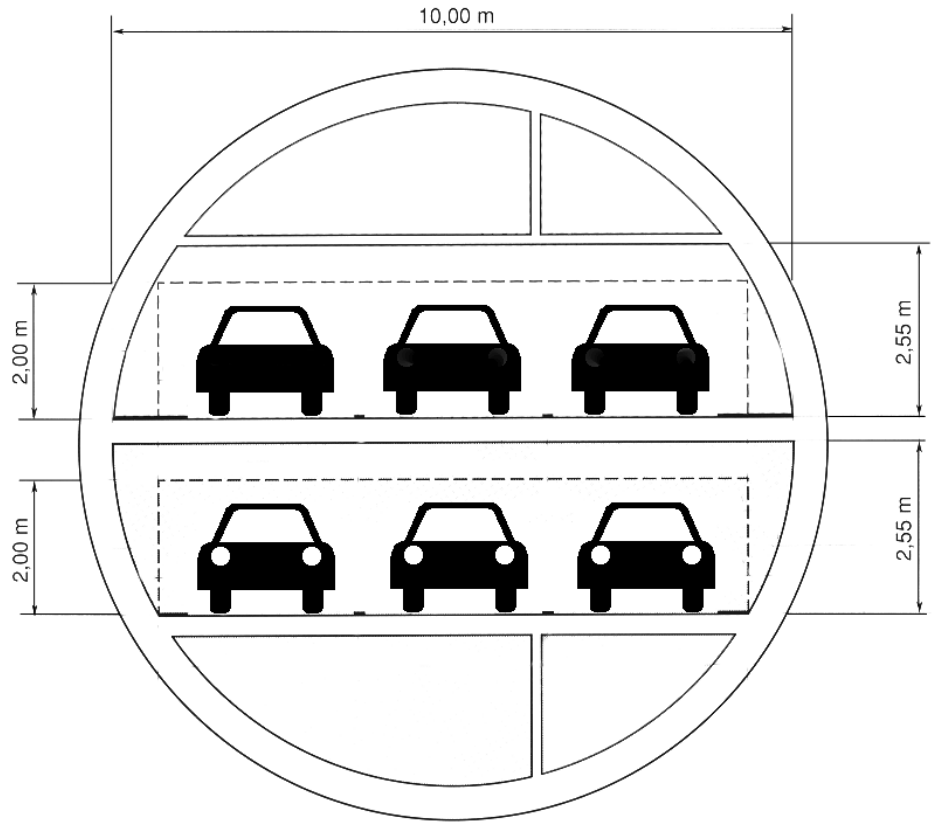
Source: Gary Alstot, presentation to the American Society of Civil Engineers, March 1992.

Figure 2: Standard & Passenger Car Envelopes and Vehicles



Source: Gary Alstot, presentation to the American Society of Civil Engineers, March 1992.

Figure 3: Metroroute Cross-section



Adapted from Christian Gerondeau, *Transport in Europe*, Artech House, Inc., 1997, fig. 14, p. 340.

Independently, Joel K. Marcuson of the Seattle office of Sverdrup Civil Inc., came up with similar ideas while doing research for the Automated Highway System project.[32] Heavy trucks and cars have such different acceleration, braking, and other characteristics that it is widely accepted they will have to be separately handled on future electronic guideways. Who would want to be electronically platooned in their car a few feet from a huge tractor-trailer?

Marcuson suggests that in designing rebuilds of America's urban expressways, careful study should be done of the potential for making more efficient use of the available right-of-way through separation of high-profile and low-profile vehicles. This would improve conditions now and also help prepare for highway automation. "A separate but parallel facility (for high profile vehicles) would allow for the different operating characteristics of small and large vehicles, allowing different speed limits and different design criteria, both structural and geometric," he writes.[33]

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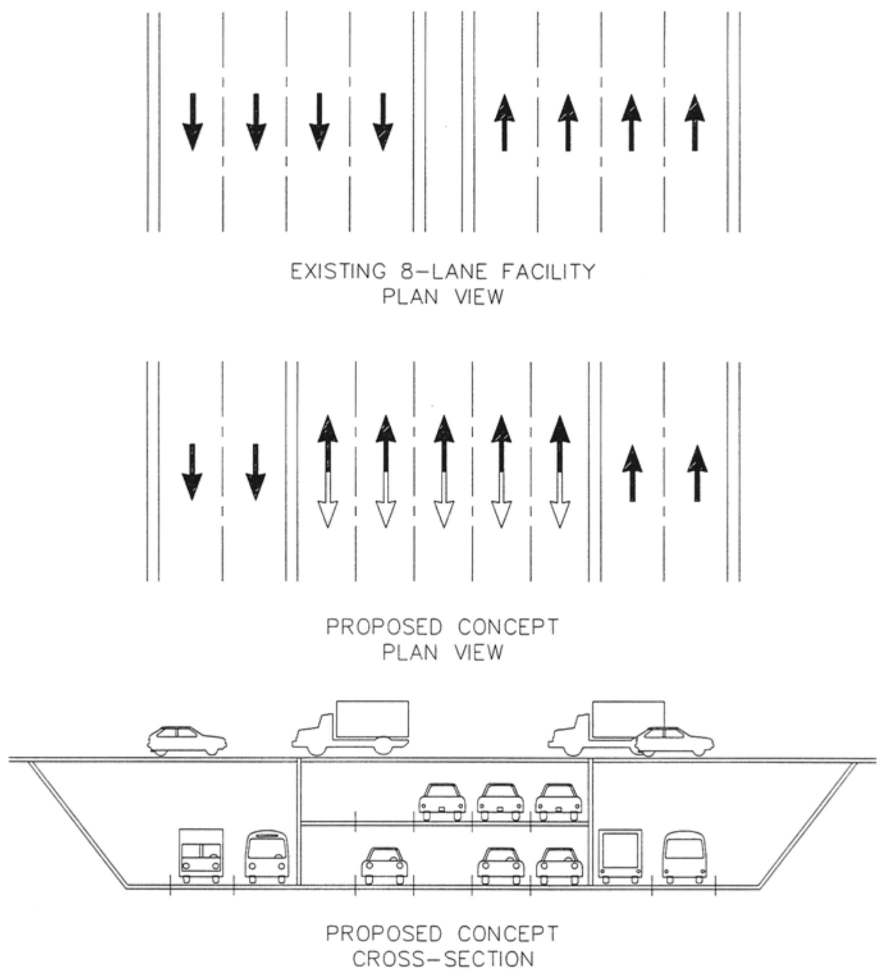
[32] Joel K. Marcuson, "Reformatting Urban Freeways for Greater Safety/Throughput," paper at the ITS World Congress in Orlando, Florida, 1996.

[33] Ibid, p. 2.

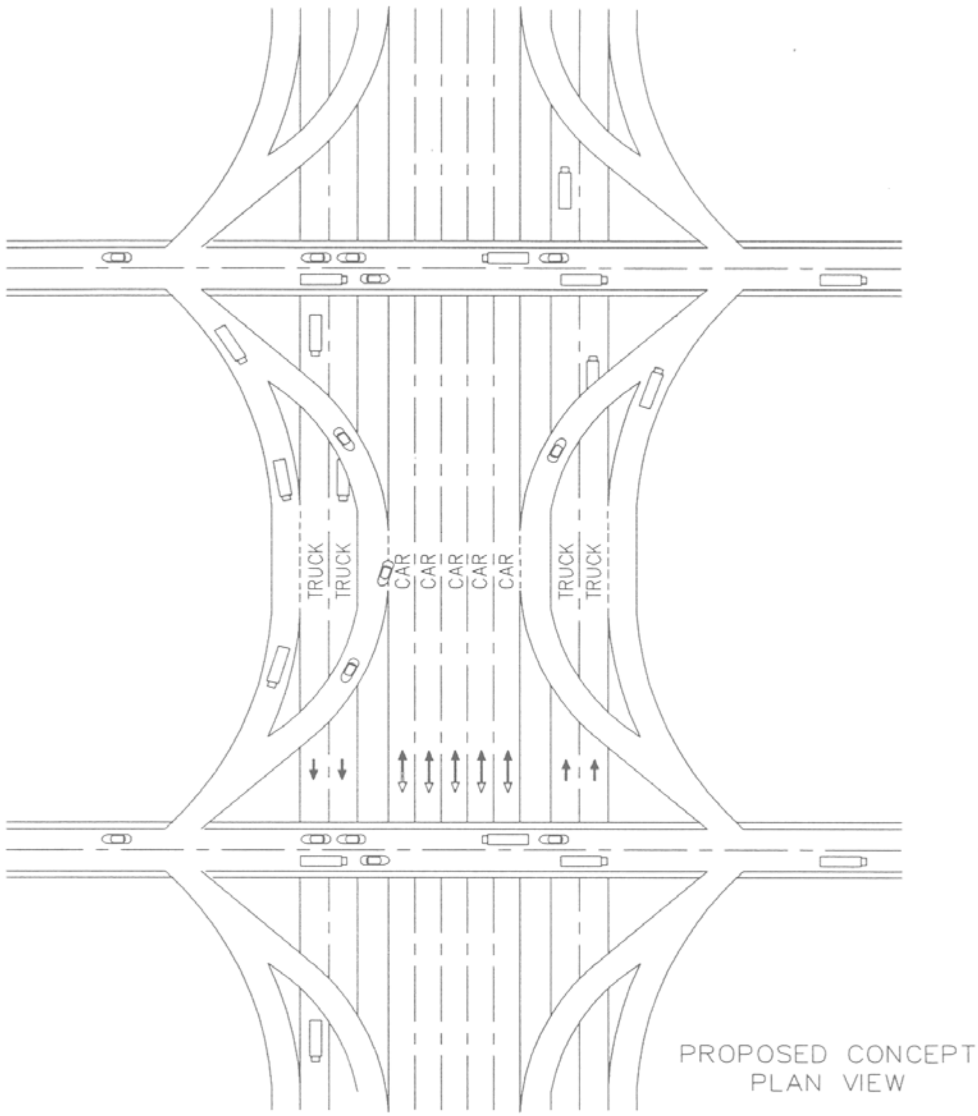
Marcuson has drawn up a set of notional highway cross-sections showing how high and low vehicles (trucks and buses vs. cars, pickups and small vans) might usefully be separated to provide more lanes and better safety in typical wide rights-of way. Figures 4 and 5 show a very standard Los Angeles right-of-way and how by double-decking the light-vehicle roadway in the middle, 14 lanes could be achieved in place of the existing eight lanes. Figure 6 shows an alternative with the double-decked cars-only lanes on the outside, gaining a 50 percent increase in laneage within the same right-of-way. Figure 7 takes a wider cross-section of the kind quite common in Los Angeles of an existing 10-lane right-of-way and puts a double-deck cars-only roadway alongside a four-lane facility for the high vehicles, yielding 16 lanes. Figures 8 and 9 show a Texan-style expressway of ten-lanes with frontage roads on each side and, by building structures in place of the frontage roads, getting 24 lanes in place of the existing 14 lanes.

Figure 4: Basic Concept: Separation of Trucks & Autos, and Reduced Vertical Requirements for Autos



Source: Joel Marcuson, Sverdrup, July 1995.

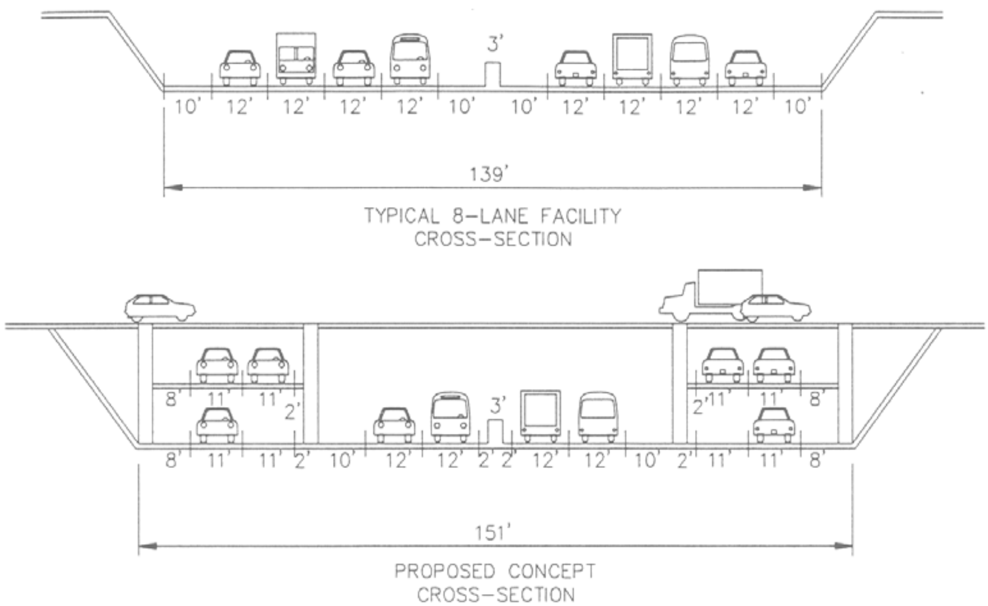
Figure 5: Proposed Concept: Possible Ramp System Design



Source: Joel Marcuson, Sverdrup, July 1995.

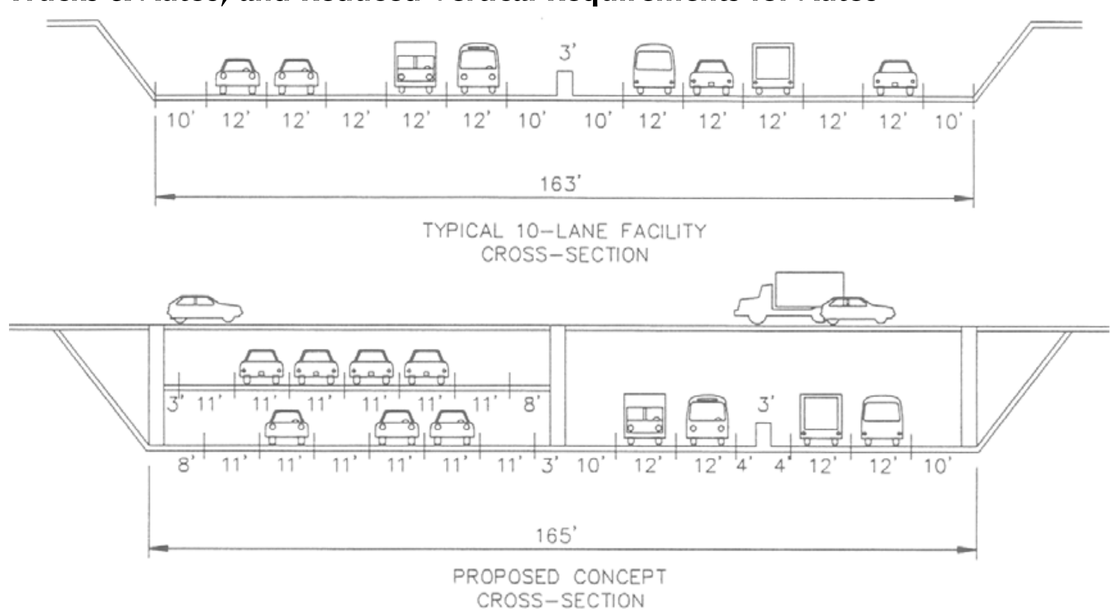
Other engineers point out that in places it will make sense to build completely separate truck and car roadways. A truckway might well have a standard two-lane cross-section with occasional passing sections and would then fit within an abandoned railway right of way or alongside major electric transmission lines. And a four-lane divided expressway built with 10-foot lanes for light vehicles only, as compared to mixed-traffic 12-foot lanes, would be considerably more compact, and less noisy and intrusive to neighbors, and therefore may arouse less local opposition.

Figure 6: Proposed Concept: Reformatting Typical 8-Lane Facility by Separating Trucks and Autos, and Reduced Vertical Requirements for Autos



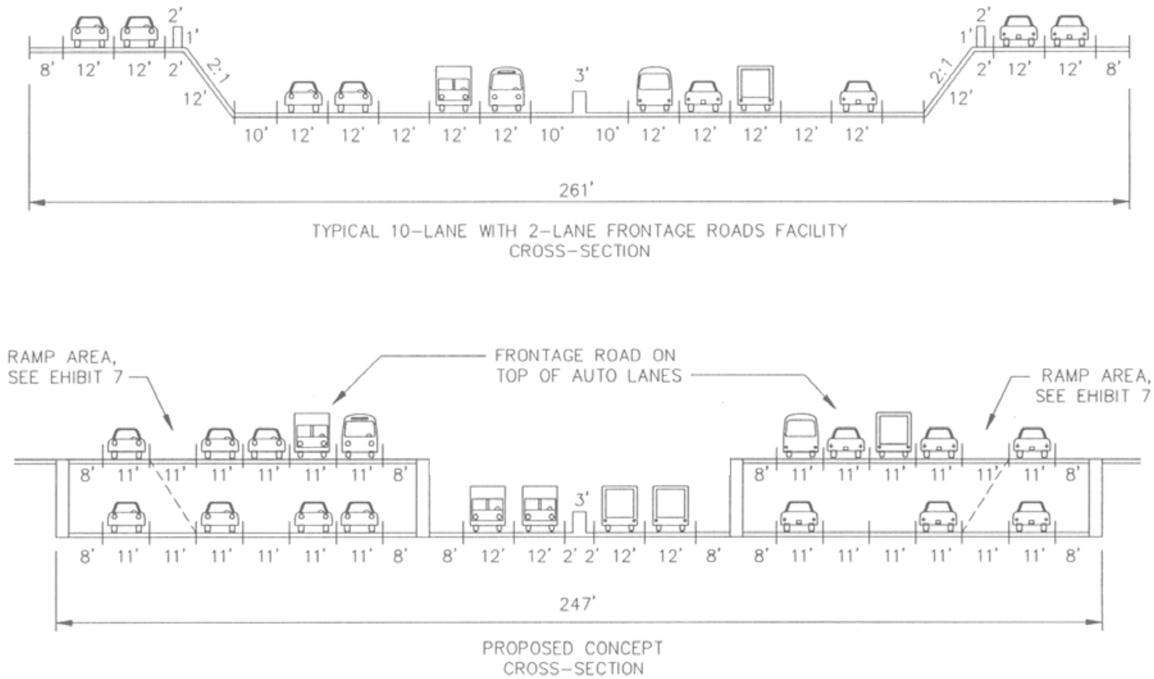
Source: Joel Marcuson, Sverdrup.

Figure 7: Proposed Concept: Reformatting Typical 10-Lane Facility by Separating Trucks & Autos, and Reduced Vertical Requirements for Autos



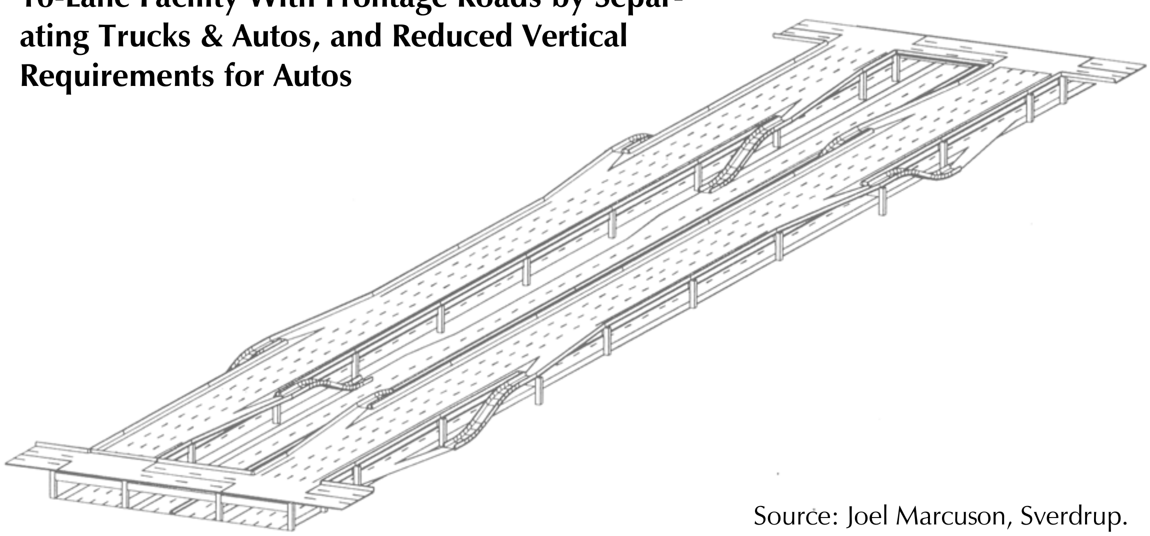
Source: Joel Marcuson, Sverdrup.

Figure 8: Proposed Concept: Reformatting Typical 10-Lane Facility With Frontage Roads By Separating Trucks & Autos, and Reduced Vertical Requirements for Autos



Source: Joel Marcuson, Sverdrup.

Figure 9: Proposed Concept: Reformatting Typical 10-Lane Facility With Frontage Roads by Separating Trucks & Autos, and Reduced Vertical Requirements for Autos



Source: Joel Marcuson, Sverdrup.

B. Pursuing Truck Lanes

The first application of these ideas may come in the Los Angeles area.[34] The Southern California Association of Governments (SCAG) in its latest Regional Transportation Plan is proposing an X-shaped network of truck toll lanes through the Los Angeles basin. One would go from the San Pedro ports area up I-710 to I-5 and SR-60 (Pomona Freeway) near the central business district. From there truck lanes would go northwest (on I-5) and east (on SR-60), then north up I-15. These would be two truck lanes each way, separated by barrier from the general-purpose freeway lanes, and equipped with flyovers for cars at on-ramps and off-ramps. Some LA-area freeways are projected to carry truck volumes of more than 40,000/day, more than enough to justify four lanes trucks-only.

The Los Angeles/Long Beach docks now constitute the busiest U.S. general freight port. Cargo ships from east Asia, which once took the Panama Canal for ports in the south and the east, now stop on the west coast and discharge their cargoes for transfer to road and rail for trans-continental trips in what are called land-bridge operations. The ports of Oakland, Seattle, and Portland are playing a similar if smaller role, taking cargo for the east and mid-west from ships and transferring it to rail and road.

Chicago, America's greatest railway hub and a major center for rail-road transfers, is another potential area for special truck roads. Other candidates include the great truck route east from Chicago including the Indiana Turnpike, the Ohio Turnpike, I-80, and the Turnpike in Pennsylvania. Any highway with over 20,000 heavy trucks/day would be a possible candidate for truck/car separation, say the advocates.

In 1996 Wilbur Smith Associates and Howard, Needles, Tammen & Bergendoff (HNTB) did a feasibility study of various types of roadway along the route Toronto-Detroit-Indianapolis-Evansville-Memphis-Houston-Laredo, the so-called NAFTA highway, designated a Congressional High Priority corridor.[35] The consultants found that by building the highway for heavy trucks of up to 132,000 lbs.—the Canadian standard—rather than the standard U.S. 80,000 lbs., at a cost of $6.2 billion, the project would yield a return of 16.5 percent on investment compared to the 9.9 percent estimated return on $5.5 billion building it only to the standard U.S. truck weight. The consultants envisaged outer truck lanes of 13 feet width for trucks up to triple-trailer configuration, as well as gentler interchange radii and longer climbing and merge and diverge lanes than normal. Similar advantages might inure to urban truck tollways.

On the east coast the largest port complex at Port Newark/Port Elizabeth, New Jersey will have a dedicated truckway system to link Newark airport freight, the ports and various intermodal or road/rail transfer yards in the Meadowlands to the north. The project, named Portway, was announced in 1998 by New Jersey Governor Christine Whitman.

On truck-only roads with vehicles of similar performance, passing may not be needed, and it may be possible to operate them safely with only one travel lane each direction and maybe a single central buffer median for breakdowns, making the total pavement only 34 feet wide—a facility that would fit many abandoned railroad rights-of-way. Long-distance trucks will be among the first vehicles to use various high-tech collision avoidance, intelligent cruise control and automatic lane-keeping devices.

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[34] "Los Angeles—220km of truck pikes planned," *Toll Roads Newsletter*, No. 23, January 1998, p. 1.

[35] "New Toll Road: Indianapolis-Houston 1,020-Mile Turnpike Link Proposal, $7 Billion," *Toll Roads Newsletter*, No. 1, March 1996, p. 1.

C. Metroroutes—Lower-Cost Auto Tunnels

The French have gone furthest in systematically studying car/truck separation because of their determination to improve mobility inside Paris. Acquiring space for surface motorways and gaining acceptance of elevated structures were so unlikely that the French were led to look carefully at high-cost underground construction.[36] In 1987 Francois Lemperiere of the GTM engineering company was credited with the idea of using a 34-foot (10m) diameter tunnel which could normally house just two lanes of roadway for unrestricted-size vehicles to provide a three-fold increase in capacity. He showed a design for using the same tube to provide two levels with three lanes each level for vehicles of six foot seven (2m) maximum height in lanes of about ten-foot (3m) wide (see Figure 3). He pointed out that this tripled vehicle-carrying capacity could transform the prospect of financing underground urban toll motorways. Out of Lemperiere's conceptual proposal came a government-organized commission to study safety issues and work to produce specifications for light-vehicle underground road networks.

In June 1992 the Center for the Study of Tunnels (CETU), central government officials, and city officials from Paris and Nice produced specifications translated as Recommendations on Reduced Height Urban Tunnels (known by the acronym RECTUR) suggesting three standards for what have come to be called "metroroutes." The name was a take from "Metro," the name of the Paris subway. Gerondeau and others saw this as a possible system or network of underground roads that could be applied under major cities to supplement and link together currently unconnected surface motorways.

GTM was credited with the idea of using a 34-foot (10m) diameter tunnel which could normally house just two lanes of roadway for unrestricted-size vehicles to provide a three-fold increase in capacity.

The three vehicle height standards set by RECTUR were:

1. Six foot seven (2.0m), which covers 85 percent of vehicle types in the Paris region excluding minibuses in which passengers can stand, and all existing emergency vehicles;
2. Eight foot ten (2.7m), which allows most ambulances and the minibuses;
3. Eleven and a half feet (3.5m) allows urban buses and most fire equipment, but not heavy trucks or long-distance coaches.[37]

RECTUR recommended 20 inches (55cm) above the height of the highest allowable vehicle for hanging signs and for psychological comfort, so in the case of 2m-max vehicle tunnels the ceiling would be at eight foot four (2.55m.) The committee also researched the lane width needs and offsets from walls. Cofiroute decided on the six foot seven (2m) standard for its six-mile toll tunnel for the A-86 West project in

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[36] Described in several papers at the International Road Federation conference in Toronto, Ontario in June 1997, especially paper 639-F by Michel Marec, "Reduced Height Urban Tunnels in France."

[37] For comparison, the Holland Tunnel in New York City which opened in 1927 has headroom of 12'6" and 10' wide lanes. The newer Lincoln Tunnel, the world's busiest, has three two-lane tubes with 13' headroom and 10'9" lane widths. Tunnels built in the era of the Interstate system have been built with full heavy truck clearance of 14'6" and 12' lanes.

Versailles.[38] Cofiroute found the benefits of the larger dimensions did not come near the extra costs. Special low-height emergency vehicles will be built. The company estimates that in rush hours, when such a toll facility will be in greatest demand, well over 90 percent of potential traffic will fit into the six foot seven (2m) gauge of the tunnel portals. It estimates the tunnel's six lanes will carry up to 8,000 vehicles/hour and average daily traffic of 100,000. Posted speed limit will be 70km/hr (43 mph) with automated speed ticketing at 80km/hr (50 mph). The tight dimensions will encourage this kind of low average speed driving, but the lower speed also maximizes vehicle throughput and is considered likely to produce safe travel. Another cost saving in excluding heavy vehicles is the ability to design for steep grades and tighter curves, especially helpful in reducing costs of ramps at interchanges. A maximum grade of 12 percent was specified by the RECTUR report.

The A-86 West small gauge tunnel will use air ducts, separate for each level. In case of fire or accidents stairways will allow motorists to use the alternate level as refuge from smoke, and emergency services will be able to block off the other level and operate from there. Cofiroute officials have said they will probably begin operations of the tunnel with only two travel lanes on each level with the third as breakdown buffer area and merge/diverge lane at interchanges, but may run all three lanes if traffic is heavy. Estimated cost of the whole project is now $2 billion or $360m/mile. This is about an 80 percent cost increase as compared to estimates made when the franchise was granted, though Cofiroute insists it remains financially viable.[39]

The Paris regional plan for 2015 lays out 62-miles of metroroutes, and they have also been considered for a new motorway to the Roissy Charles de Gaulle Airport, and as additional capacity for the southern part of the Boulevard Peripherique or inner ring road. Metroroutes seem to have considerable potential in a number of large dense European cities, especially in London. In the United States they would seem to be most applicable in developed areas with high land values and local antagonism to the intrusiveness of a new highway. Specific possibilities include:

- New York City, especially in Brooklyn and Queens where the elevated Gowanus and Brooklyn-Queens Expressways (I-278) are rapidly deteriorating;
- East-west under Manhattan to improve northern New Jersey connectivity to the eastern boroughs and Long Island;
- For the South Pasadena missing link of I-710, to connect with I-210 in Greater Los Angeles;[40]

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[38] Work started on the A86 West tunnel project in late 1996 but was halted in February 1998, when 10 percent built, by France's highest court on the grounds that the toll concession granted to Cofiroute back in 1992 had not been advertised Europe-wide in accordance with European Community rules. The French government then cancelled the Cofiroute concession and called for new bids, which are due November 1998. It is hoped work will resume mid-1999. At least one other major company is competing with Cofiroute for the new concession. Telephone interview with Cofiroute 8/13/98.

[39] At the other extreme of cost Norway has built some of the world's most economical tunnels, which *World Highways* magazine has called "startlingly cheap" at less than $8million per 3200 feet (km) for recent two-lane tube in rock. Because of its rugged mountains and fjords it is probably the world's most tunneled nation, with highly competitive tunnel tendering. Its tunnels are no-frills affairs with minimal lining and lighting. As of 1996 Norway's main road system had 814 tunnels totalling 385 miles (631km) in length. 177 Norwegian tunnels are over 3,280 (1km) feet long. 42 are over 1.8 miles (3km) long. The Norwegian tunnels use jet-fan ventilation.

[40] In April 1998 after decades of wrangling Caltrans got its Record of Decision from the FHWA for a conventional 2x4-lane freeway along this 6.2-mile (10km) route so all federal obstacles to this $820 million project are finally removed. As presently proposed the project is a regular Interstate standard highway in trench with other sections in cut-and-cover near-surface tunnel. But local groups continue to strongly oppose the scheme and there are lawsuits aimed at stopping it.

- To replace the portion of highway 101 that traverses city streets between Mission St and the Presidio in San Francisco;
- To revitalize Washington DC by completing as small gauge tunnels some of the abandoned radials (I-270, I-95) in northeast DC and adjacent Maryland;[41]
- US-1 through old-town Alexandria, Virginia to get major arterial flows off surface streets.

Americans have more large sports utility and high van-type vehicles than Europeans, and strict application of the French standards would probably exclude too many U.S. vehicles, so the somewhat more generous dimensions proposed by Marcuson would likely be needed here. But the principle remains the same—that dimensioning certain road structures for exclusive use by smaller vehicles which constitute upwards of 90 percent of rush-hour traffic flows can produce huge savings, as the French have demonstrated, and may well allow road projects that would otherwise be uneconomic to be financed with tolls.

Glib statements that we are "running out" of space for new roads are perhaps as misleading as the 1970s claims that we were running out of resources, given that ingenuity can create new kinds of space for roads.

Dimensioning certain road structures for exclusive use by smaller vehicles which constitute upwards of 90 percent of rush-hour traffic flows can produce huge savings.

D. Reversible Express Lanes

Many busy urban highways have "tidal" flows of traffic—typically into the city center in the morning, and out in the evening. Congestion can most obviously be relieved by reversing some of the central lanes of tidal-flow highways, adapting the number of lanes to the traffic during the course of the day. As central grass medians have been paved over they have generally been replaced by fixed concrete barriers. The barriers, pioneered by the New Jersey Turnpike, and often called "Jersey barriers," have been an enormous lifesaver in virtually eliminating cross-over accidents and head-on collisions. But in situations with such "tidal" flows, a fixed median barrier makes reversing the direction of inner lanes problematic.

A better solution on these tidal-flow highways is to build the pavement level and continuous across the whole width of the right-of-way, and eliminate median piers of over-crossings during reconstruction, so as to

[41] One concept design proposed for an I-395/I-95 Extension under New York Avenue NE in Washington DC involves a rectangular section cut-and-cover tunnel 76-feet wide and 16-feet high internally. The cut-and-cover method maximizes the problem of utility relocation and traffic maintenance during construction. Also the huge vertical cross-section of 1216 square-feet for just four travel lanes amounts to 304 sq-feet per lane. By comparison Alstot proposes a small vehicle gauge of 69.9 sq. ft. and Marcuson 107.5 sq. ft. per lane. The Metroroute scheme is between the two U.S. small gauge designs. It proposes 87.1 sq. ft. per lane, a cross-section 29 percent of the standard FHWA road dimensions followed in the New York Avenue NE proposal. Because of the huge costs involved in the standard FHWA cross-section and the disruptive near-surface construction the New York Avenue NE proposal is an idea going nowhere. It seems likely that a small-vehicle gauge bored tunnel would cost less than a half and perhaps as little as a quarter of the cost/ lane-mi. of the FHWA all-vehicles-plus shoulders design. Dimensions read off drawings titled "New York Avenue Development, Washington D.C.," October 1996.

allow use of a moveable concrete barrier.[42] These are Jersey-type barrier sections 40 inches long, held together chain-like by steel pins, and topped with a T-section, allowing a straddle truck to drive atop them, pick up the sections and move them laterally a full lane. The system has existed for nearly 20 years, and everywhere it has been tried it has been a success. On the seven-lane Tappan Zee Bridge, New York State Thruway officials say it allowed at least a 10 percent increase in traffic throughput, at an annual cost that is a fraction of the extra toll revenues being collected. But state highway authorities have generally been very slow to use the technology. Movable barriers make it possible to create reversible HOV or tolled express lanes, at a minimal cost in extra space.

Glib statements that we are "running out" of space for new roads are perhaps as misleading as the 1970s claims that we were running out of resources, given that ingenuity can create new kinds of space for roads.

E. What About Air Quality?

Air pollution concerns have thrown up major regulatory hurdles in the way of expanding urban highway capacity. The "conformity" requirements of the Clean Air Act and federal highway programs require that any new highway project that adds capacity must demonstrate that it is in conformity with the approved air-quality State Implementation Plan approved by the EPA, if the urban area in question has been designated as a "non-attainment area" by that agency (as many of the urban areas with serious traffic congestion problems have been).

It is unclear what effect additional highway lane-miles have on total vehicular emissions. On the one hand, smoother flowing traffic reduces emissions per-vehicle-mile (nitrous oxides being an exception—they rise with speed.) Any reduction in emissions from better flowing traffic might be offset by any increased demand for travel and the higher vehicle-miles traveled.[43] An important 1995 Transportation Research Board study concluded that changes in emissions from even major road improvements are likely to be so small on balance that they cannot be modeled to produce statistically significant results.[44] In other words, new and enhanced

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42 The major supplier of moveable concrete barriers in this country is a Carson City, NV-based company, Barrier Systems Inc., which has patents on a system it calls Quickchange Moveable Barrier. It has permanent installations on the Auckland Harbor Bridge in New Zealand, the Coronado Bridge, San Diego, I-35 Thornton Fwy in Dallas, I-93 Southeast Expressway in Boston, the Tappan Zee Bridge NY, and is due to be installed on the H-1 in Honolulu. It is increasingly used on major highway reconstruction jobs enabling safe construction work to proceed close by fast moving traffic, while allowing lanes to be 'borrowed' for construction in off-peak hours, then being quickly turned back to traffic in the rush hours. An ingenious scheme has been proposed by Barrier Systems to the Contra Costa Council in the Bay area for progressive phased construction of highly flexible HOT-lanes on I-680 where tidal flows of workers from the East Bay area to Silicon Valley cause gridlock on the existing freeway—see *Toll Roads Newsletter* No. 25, March 1998.

43 "Latent demand" is the economist's term.

44 "The analytical methods in use (in environmental impact assessments mandated by EPA) are inadequate for addressing regulatory requirements. The accuracy implied by the interim conformity regulations issued by EPA, in particular, exceeds current modelling capabilities. The net differences in emission levels between the (highway) build and no-build scenarios (for metropolitan transport) scenarios are typically smaller than the error terms of those models. Modeled estimates are imprecise and limited in their account of changes in traffic flow characteristics, trip making, and land use....The current regulatory requirements (of USEPA) demand a level of analytic precision beyond the current state of the art in modelling." From "Expanding Metropolitan Highways: Implications for Air Quality and Energy Use /

highways may increase or they may reduce air emissions, but in either case the effect seems likely to be small. This suggests that efforts to further reduce air pollution should focus more on the vehicles than on roads. Opinions vary on how much further emissions can be reduced with the internal combustion engine, but if there is a pressing health need for further improvements in air quality there are new propulsion systems (such as fuel cells powering electric motors) that can be phased into motor vehicles over time.[45]

In underground sections of roadway it is possible to alleviate ground-level air pollution. For ventilation purposes the exhaust air has to be pumped to expulsion points. It is common then to use strong fans to send it up several hundred feet above the surface. It is possible—at some expense—to treat the exhaust air in scrubbers to remove dust or pollutant gases. In some Japanese road tunnels the exhaust air is being cleaned and reused at various points in the tunnel using electrostatic precipitators.[46]

In principle private road operators could propose programs to mitigate air pollution on their roadways as part of gaining permits in air quality nonattainment areas. This could be done with programs to maintain good traffic flow and via detection of high-polluting vehicles to impose toll premiums or penalties. Highways in tunnels make air treatment easier.

Committee for a Study of the Impacts of Highway Capacity Improvements on Air Quality and Energy Consumption." Transportation Research Board Special Report 245, 1995, p. 6.

45 Fuel cells seem to offer the most promise for succeeding internal combustion engines. A National Research Council panel recently wrote: "Of all the technologies being considered in the PNGV program to convert fuel energy into useful power, fuel cells offer the best long-term potential for high efficiency and low emissions." (From the fourth report of the "Review of the Research Program of the Partnership for a New Generation of Vehicles," National Academy Press, Washington, D.C., 1998, p. 35.) Fuel cells eliminate NOx, the most intractable emission in internal combustion engines, and simplify removal of HCs and CO.

46 Longitudinal flow ventilation with electrostatic precipitators at various points along the tube are designed into three tunnels: the Kanetsu (11km long, 7 miles), Enasan (8.7km or 5.4 miles) and the Higo tunnel (6.3km 3.9 miles). Source: Japan Ministry of Construction "Michi: Roads in Japan 1995," p. 91.

Part 5

Dealing with Demand as Well as Supply

A. The Economics of Congestion

It is often said that "We can't build our way out of congestion." However, it IS physically possible. "Build it, and they will come"—the *it* being extra road space and the *they* being cars—is true in conditions of congestion-caused latent demand. But latent demand could be satisfied if the supply of road space were increased enough, since demand for road space is not infinite. If demand were infinite there would be no free-flowing roads at all.

But simply building our way out of the problem is financially infeasible and would be wasteful. The problem is the absence of a market to determine how much motorists value additional roadway capacity and the absence of flexible prices to limit their use to the trips they decide are worth more to them than the cost of producing the roadspace (as reflected in road prices). So long as our highways are paid for mainly by fuel taxes, registration fees, and other general imposts rather than by flexible road-use fees (tolls), it will be impossible for there to be rational decisions about what road space is needed and no mechanism to rationally manage the road space.

We have a "commons" problem on urban expressways. A valuable resource is open to all for free, and that resource gets over-used. English agriculture began to make the major technological advances that led to the industrial revolution only after the English in the Middle Ages had implemented "enclosure" on previously commons lands. Until enclosure—fencing which followed private ownership—there was no means to control overgrazing—the "tragedy of the commons." No individual had an incentive to husband the land. No one would reap any benefit from conserving and enhancing their land since in the absence of control over property, and without prices to control use, no one had a stewardship incentive.

Communism collapsed in Russia in large part because of the widespread effort to allocate resources by administrative fiat (by plan) rather than by markets, which led to chronic inefficiency, waste, shortages, and corruption. The economic failings of communism were dramatized in news reports of state-owned stores which sold out of goods soon after they received them, producing perpetually empty shelves, of hoarding of soap and toilet paper, buying whatever could be carried away to trade with friends and neighbors, and constant lines of shoppers, so desperate for common articles that they would devote hours of their lives each week to the tedium of queuing. The queuing that constitutes stop-and-go traffic on urban highways in the

United States is a close economic analog of the lack of functioning markets in Russia in the 1980s and in English agriculture pre-enclosure. It produces similar waste and similar frustration—part of which we call "road rage."

Roads are especially in need of pricing because of the nature of traffic flow. Traffic engineers have learned about the dynamics of traffic flows: beyond about 2,200 to 2,500 car-equivalent vehicles per traffic lane per hour of a freeway/expressway standard road, the entry of additional vehicles causes the capacity of the road to decline sharply. Traffic flow breaks down. Looked at from a helicopter above, a highway reaching capacity usually starts to exhibit concertina-like waves of motion. The wave-type phenomenon develops because drivers are comfortable being just a few feet from the car ahead when halted, but want progressively more space ahead the faster they are going. Beyond a point of around 2,200 to 2,500 vehicles/lane/hour (the precise number depends on the temperament and skills of drivers, weather, roadway geometrics, distractions causing turbulence, etc.), drivers progressively slow down to attempt to preserve a comfort space ahead, often until many are stopped and forced to wait. Sometimes the flow reaches a certain low equilibrium speed and everyone crawls along a while. In either case the admission of just a few extra vehicles has overloaded the roadway to the point where instead of responding to the increased demand the roadway actually is carrying fewer vehicles.[47] Overloaded this way the road is horribly inefficient for all and is a facility crying out for management (see Figure 10 on next page).

The queuing that constitutes stop-and-go traffic on urban highways produces waste and frustration—part of which we call "road rage."

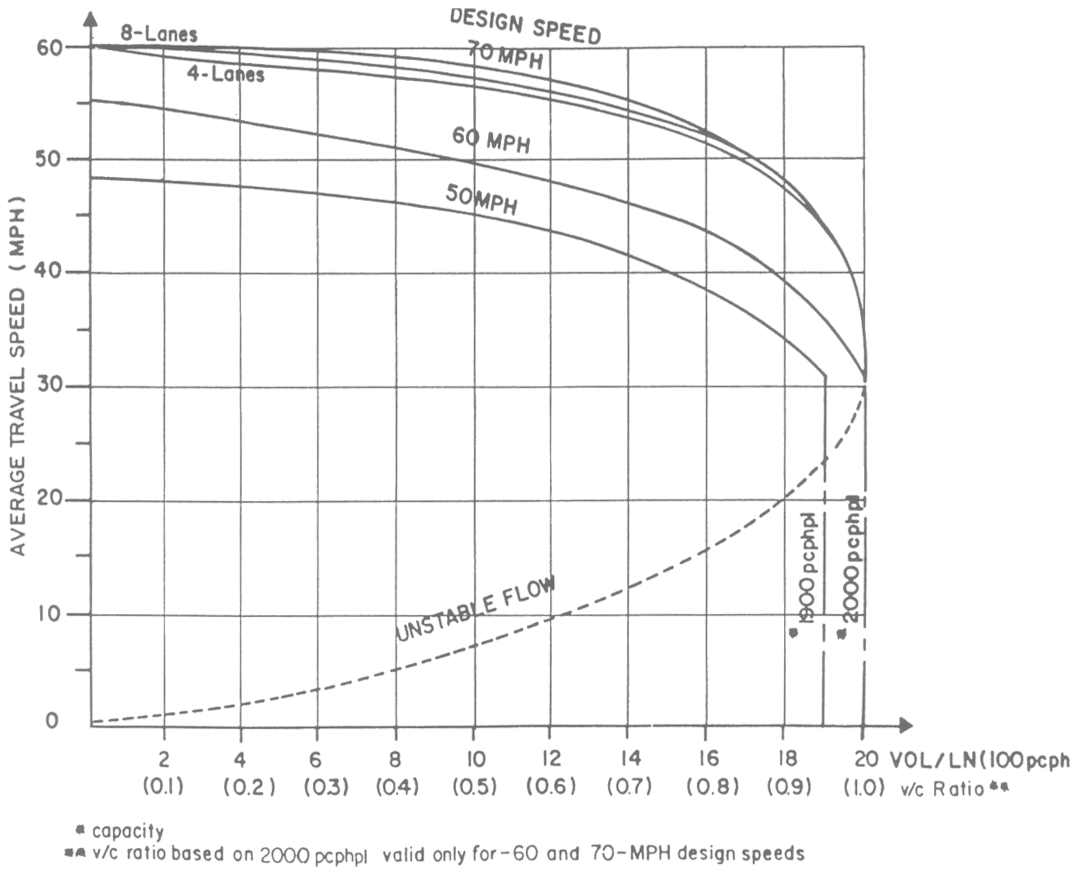
In some cities (notably Minnesota-St Paul, but also Seattle and Los Angeles) traffic engineers have installed extensive systems of "meters" on the on- ramps. These consist of a cycling red and green, the green designed to allow only one or two vehicles to proceed toward the main lanes while holding other vehicles in a queue. These ramps meters break up entering traffic making it easier for them to find gaps in the main lanes without disrupting main lanes flow. They also serve to limit the quantity of traffic entering the main lanes to limit overloading. Ramp metering does help preserve flow on the main lanes of the freeway. The Twin Cities in particular have some of the most efficient high volume freeways in the world (2,500 to 2,600 vehicles/lane/hour) due to their extensive ramp management.

But ramp meters can only be deployed to a limited extent, because without pricing, the traffic just backs up along the ramps until it threatens gridlock on the approach roadways. The queuing is shifted off the freeway onto the surface streets. Beyond a point, the meter cycling has to be relaxed at the expense of the freeway to prevent excessive off-freeway congestion. In Tokyo an even more drastic solution is imposed to prevent flow breakdown on city expressways. In rush hours certain ramps are simply closed to entering traffic with a

[47] The nose of a bullet describes the shape of a curve which traffic produces when graphing average speed on the Y-axis and vehicles per lane per hour on the X-axis. As more vehicles join the roadway, at around 1,800 to 2,000 vehicles/lane/hour speed begins to decline slightly but throughput will continue to increase. Speed will drop sharply somewhere in the region 2,200 to 2,600 vehicles/lane/hour and the addition of yet more vehicles will see both throughput and speed decline together as the curve turns back under. This is the point at which the roadway is so overloaded that it becomes a lengthening queue of slowly moving and frequently stopped vehicles. See the classic bullet-nose graph in Transportation Research Board "Highway-Capacity Manual," Special Report 209, Washington D.C. 1994, Figure 2-2, pp. 2–6.

tollgate-like barrier that can stay down for considerable periods. Again queuing congestion is transferred to city streets.

Figure 10: Speed and Flow Relationships Under Ideal Conditions (TRB, 1985)



Source: C. Jotkin Khisty, *Transportation Engineering: An Introduction*.

Freeway-type traffic flows are a classic case of an economic "externality" where a few extra motorists (inadvertently) impose on many others much higher costs in aggregate than they themselves incur, and so overload a facility beyond its optimum capacity. Only a managed flexible-pricing mechanism can internalize these costs and allow access to the facility by those who value the trip more than the going costs. Such a dynamic market for scarce city highway space will also have the huge benefit of generating signals and incentives to the highway managers to find efficient ways of enhancing throughput up to the point at which motorists are no longer willing to pay. They will also signal whether extra capacity is justified by way of a widened or parallel roadway.

B. From Theory to Practice

All of this has been well-established in economic theory but was technically difficult to implement until recently. Tolls of differing value can now be collected nonstop, without any need for cash to change hands. Miniaturization and mass production of short-range radio components, together with development of high-capacity fiber-optics and cheap computing power, make it feasible to levy trip-charges or tolls electronically by equipping cars with a $15 to $35 deck-of-cards sized “transponder” device. The system records the transponder’s account number and debits the owner’s toll account for the amount of toll in effect at that time and place. Alternatively, video and pattern-recognition algorithms allow license plate numbers to be “read” by a camera on an overhead gantry, motor registry databases to be accessed to find the name and address of the vehicle owner, and a toll bill sent in the mail. Changing toll rates can be posted on a highway variable message sign on the approaches to the toll lane or displayed in the vehicle, accessed by modem at the home or office.

Transponder technology has been in use since the end of 1995 to charge different rates at different times to users of the 91 Express Lanes, the investor-built toll lanes on the 91 Freeway in Orange County, California. The results of a four-year, before-and-after analysis of the Express Lanes became available in September 1998. Carried out by Edward Sullivan of Cal Poly San Luis Obispo, the report says that “value-priced” tolls on the Express Lanes have “worked well” and that the idea “merits consideration” elsewhere.[48]

A dynamic market for scarce city highway space will also have the huge benefit of generating signals and incentives to the highway managers to find efficient ways of enhancing throughput

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Fully automated toll collection made its debut in 1997 on the new Highway 407 Express Toll Route in Toronto, Ontario. Regular users with dashboard transponders who are charged electronically pay a lower rate than casual users without transponders whose license plate numbers must be imaged in order to send them a bill. These systems permitted this 29-interchange urban tollway to be designed and built without a single toll booth or toll plaza. Like the 91 Express Lanes, it also makes use of a toll rate schedule that charges the highest rates at rush hours, intermediate rates during “shoulder” periods, and low rates at off hours.[49]

The first full-fledged implementation of dynamic tolling, in which toll rates vary pretty directly with traffic conditions, is being tried out in a three-year demonstration project in the former HOV lanes of I-15 in San Diego. In 1997 paying customers were first allowed to begin using the large excess capacity of this reversible commuting facility, and beginning in March 1998, pricing shifted from flat rate to dynamic, with possible price changes every four minutes, based on the level of congestion in the lanes.[50]

Road pricing is most likely to be introduced into the United States in a piecemeal fashion. Underutilized HOV lanes, like those on I-15, are a good starting place, the flexible toll allowing the free-flow conditions to

[48] Edward C. Sullivan, “Evaluating the Impacts of the SR 91 Variable Toll Express Lane Facility, Final Report,” Sacramento, California, Department of Transportation, May 1998.

[49] “407 Opens 67 km and Passes 200k Trips/day,” Toll Roads Newsletter, No. 32, September 1998, p. 16.

[50] Covered in detail in various issues of *Innovation Briefs* and *Inside ITS* and in my *Toll Roads Newsletter*.

be maintained by limiting entry. The few HOV lanes that are actually successful as HOV-2 face the dilemma of tightening their eligibility to HOV-3 in order to prevent overloading that threatens their rationale of providing a better level of service than the unrestricted lanes. But in tightening eligibility administratively from HOV-2 to HOV-3 they will normally lose about three-quarters of their patrons, and soon be seriously empty. Without a price, the lane is either a flood or a drought! By allowing HOV-2s into the lanes on payment of a variable toll, the managers of the lane can avoid throwing all HOV-2s into the unrestricted lanes, worsening congestion there. Pricing gives the owner of the facility a sensitive tool to manage its utilization as compared to the crude balky choice between HOV-2 and HOV-3.[51] The general term for a lane that admits both paying customers and qualifying HOVs is high-occupancy/toll (HOT) lane.[52]

Existing toll facilities such as turnpikes and tolled bridges and tunnels in New York City, Chicago, Philadelphia, and San Francisco can also improve traffic flows and their revenues by time-, or ideally traffic-variable, toll rates. In France toll motorways outside Paris have operated differential toll rates on Sundays to better manage highly peaked vacationing traffic with success for several years. As noted previously, the 91 Express Lanes was the first to implement it on a simple on-off express-lanes facility within an existing freeway. Highway 407-ETR in Toronto is the first complete multi-interchange urban motorway system to incorporate remotely collected and variable toll rates into its planning from the start. Its high-tech toll collection system and time-of-day variable tolls are completely accepted and noncontroversial.[53] The road is an economic and political success and is now in process of being sold by the provincial government to investors. 91-Express is also popular and a political success, having gained three-to-one positive ratings in local opinion surveys since its introduction.

Adding highway capacity to existing roads in busy urban areas will often be extremely expensive, whether because of right-of-way costs or the structural costs of going above or below ground. But pricing of these roads is the key to getting them built. It will simultaneously (1) sort out which projects are worth doing from those which cost too much, (2) limit traffic to motorists willing to pay their full share of the costs of the expensive facility, thereby lowering the project's cost by reducing its size compared to what would be demanded if it were "free," and (3) provide the revenue needed to support its financing.

It is unreasonable to expect all motorists to agree to support increased gasoline taxes to support such a facility when many of them will hardly ever use it. It is as if all airline travelers were expected to pay a new air travel tax to build a supersonic airliner or new first-class boarding facilities at airports. The catch-phrase from critics of tolls that they force drivers to "pay twice" is not applicable to this scenario. The gasoline and other user taxes pay for what the existing system of federally supported and state-provided highway services can deliver. Tolls for using newly added express lanes or expensive tunnels or heavy-duty truck lanes would be extra charges for premium services, over and above what the current gas-tax-funded system can provide.

C. "Politically Impossible"?

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[51] This is being done on the I-10 Katy freeway HOT lane in Houston, Texas from early 1998 with the establishment of electronic toll accounts for HOV-2s.

[52] Kenneth Orski, et al., "High-Occupancy/Toll Lanes and Value Pricing: A Preliminary Assessment," *ITE Journal*, June 1998.

[53] People sometimes theorize that this kind of technology is "Big Brotherish" a threat to "civil liberties" and won't be accepted. And that they won't like being charged more in rush hours. Controversies about 407-ETR have centered on questions about its civil engineering—issues of crash barriers, ramp radii and pavement traction. Only a handful of patrons have opted for the anonymous transponder accounts being offered to those concerned about privacy protection.

Sweeping statements that road pricing is "politically impossible" are unjustified in light of these examples. It may be a political challenge to introduce pricing when people are so used to "free" roads or feel they are already paying. People are naturally skeptical that politicians are simply out to pick their pocket by another means, or that big government is trying to manipulate them out of their cars. And when motorists think they can get something for nothing, it is natural to prefer that.

Anti-road groups have an ambiguous attitude toward road pricing. To the extent they think they can control it, they will favor pricing precisely as a way to "tax" motorists and transfer the revenues to their favored causes such as transit. To the extent they see road pricing as supporting enhanced capacity, they are likely to oppose it.

As for the general public with no particular policy agenda, a body of case studies and surveys suggest what stands the best chance of gaining acceptance. The best chances for success in introducing road pricing are where:

- Congestion is worst;
- The road-price or toll is linked to provision of new capacity (extra lanes or a new roadway);
- Some 'free' alternatives are retained;
- There are one or two local champions of the project, able to articulate its case.

Kenneth Orski, a veteran transportation policy analyst in Washington, D.C. who recently led an Institute of Transportation Engineers task force on HOT Lanes, has proposed a valuable semantic distinction.[54] He suggests that the term "congestion pricing" is inappropriate for variable road pricing on tolled express lanes. He suggests that policy professionals distinguish:

(1) Adding pricing to congested facilities where there is no choice, appropriately termed "congestion pricing", versus

(2) "value pricing" where a free-flowing ride in uncongested conditions is priced alongside the unpriced and congested lanes.

Popular antagonism to congestion pricing seems to be based in part on the not unreasonable fear of many motorists that it is simply an attempt to make driving more expensive, and to attack their use of their automobile. Value pricing, by contrast, is clearly pro-driver in the sense that it offers auto users and truckers a new option—a way around congested conditions or a higher-capacity truck lane—in return for toll payments that help pay for the facility they are using.[55]

In some ways road pricing would be cleaner if introduced on a system-wide basis. This approach could overcome equity objections that one area has to pay while another does not. It could reduce problems of diversion of traffic onto unpriced facilities. And of course it could get us where we need to go quicker. But it

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54 Kenneth Orski, "Value Pricing: Paying Premium Price for Premium Service," *Innovation Briefs*, Vol. 9, No. 10, Mar./Apr. 1998.

55 K.T. Analytics and especially partner Thomas Higgins is the leading expert in public opinion on road pricing and has produced many papers and presentations on this subject. See his "Congestion Pricing: Public Polling Perspectives," *Transportation Quarterly*, Vol. 51, No 2, Spring 1997, p. 97.

seems more realistic and is perhaps politically safer to see pricing as an incremental process that is tried out in various places, and in various different forms, building acceptance by example. Road pricing does not need to be a comprehensive all-or-nothing reform. It is more likely to be introduced incrementally, with many early projects in the nature of experiments, some of which should be expected to fail.

Value pricing is clearly pro-driver in the sense that it offers auto users and truckers a way around congested conditions or a higher-capacity truck lane in return for toll payments that help pay for the facility they are using.

Some of the recent failed efforts to introduce pricing (for example, congestion tolls on the Bay Bridge in San Francisco, and HOV to HOT lane conversion on I-394 in Minnesota) may have failed to gain support because the proponents were seen as indulging in manipulative social engineering and income redistribution—as wanting to get people out of their cars while taking money from motorists to give to transit. The Bay Bridge congestion-pricing planning was accompanied by an open squabble among transit agencies for the prospective funds that the higher rush-hour toll would bring, with no acknowledgement whatever of the possibility that motorists might prefer their toll payments to go toward enhanced highways. In Minnesota the HOT lanes project was presented as a model for congestion pricing throughout the Twin Cities region rather than as a practical measure to solve traffic flow problems on the major western commuter corridor.

To the extent there is such a distrust of government motives, the private sector may be better equipped to implement road pricing. Business is understood to have the simple, straightforward motive of wanting to maximize its return on an investment. A toll-road business wants to keep motorists happy in their cars! Given that the investment in a roadway is a long-term one, people can see that a business-run road will have a strong interest in its reputation for safety and good service. So long as people have choices, they accept private operations. At the same time, the Federal Highway Administration and a number of state and metropolitan agencies see the case for road pricing and are pushing ahead with congestion pricing projects.

Part 6

Conclusion

Highways as we know them in America are an odd mix of socialism and anarchy—a Havana department store and the Wild West. Owned, designed, and built by state bureaucracies that produce five and 10 and 20 year plans, the agencies are constantly strapped for funds and dependent on the whims of various politicians. That's the "socialism." The Wild West or anarchy comes with the roadways themselves being common property and a free-for-all. These vastly expensive constructs are open to whoever shows up and for free. It is an irresponsible daily give-away, a derogation of responsibility to properly manage these valuable, vital, scarce assets.

We meter and charge for water, and electricity, and telephones, as they are used. Management of the utilities monitor all the time where there are shortages and make adjustments, without fuss. They know if these services were given away they would be overused, and they couldn't fund necessary upgrades to the system.

We would think it grossly wasteful to stock food in a tax-financed supermarket and then announce each day: "Come and get it," or to fund a state airline monopoly with taxes and offer everyone free plane rides. Yet that is precisely the craziness by which we manage urban highways, and it is no wonder they are a mess.

The challenge is to gradually take the highways away from socialism and anarchy and bring them into the normal businesslike world in which users pay, and service providers manage their facilities and fund themselves by satisfying their customers. This idea is gaining increasing acceptance in the profession. A striking example recently was a feasibility study done by Parsons Brinckerhoff, the nation's largest transportation engineering firm, proposing HOT lanes using dynamic pricing as the best way to enhance highway 101 in Sonoma County, California. The report stated as a general principle: "If a roadway facility provides enough economic benefits to justify its development, there usually is an efficient pricing structure that will capture these economic benefits and permit the facility to be largely self-financed."[56]

[56] "Final Report: Sonoma County US101 Variable Pricing Study," Parsons Brinckerhoff for the Bay Area Metropolitan Transportation Commission (MTC), June 6, 1998.

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