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CONGESTION RELIEF TOLL TUNNELS

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EXECUTIVE SUMMARY

Changing urban land-use patterns have reduced the importance of traditional downtowns as the origin and destination of numerous vehicular trips. Much traffic on downtown-area freeways seeks merely to get past downtown, thereby worsening the level of congestion for those seeking access to downtown.

A number of European cities have begun to develop a new type of transportation facility: congestion-relief toll tunnels in downtown areas. These projects appear to be economically feasible largely or entirely from premium-price tolls paid by users. Hence, they are being developed by private consortia, operating under long-term franchises from government. Other keys to the feasibility of such projects are peak/off-peak pricing structures (congestion pricing), nonstop electronic toll collection, and restriction of use to auto-size vehicles only (to reduce tunnel dimensions and therefore capital investment).

Preliminary analysis indicates that congestion-relief bypass tunnels for downtown Los Angeles and San Francisco would be economically feasible as private business ventures, if developed along European lines. Similar approaches might be applied to other controversial freeway projects in both cities, and to restructuring Boston's huge and controversial Central Artery/Tunnel project.

Congress has already authorized public-private partnerships of this type, permitting private capital and private owner/operation to be used, both for new projects and to rebuild existing highway, bridge, and tunnel facilities. Six states and Puerto Rico have enacted private-tollway legislation under which such projects could be developed and operated.

This type of project is likely to be seen as politically feasible, since it offers a way to make significant transportation improvements in impacted downtowns with little or no public funding. While transit proponents may oppose the construction of toll tunnels, highway users are likely to support such projects, and some environmental groups may support this method of implementing congestion pricing in urban areas, because of its potential for reducing air emissions.

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I. INTRODUCTION: BACKGROUNDI. INTRODUCTION: BACKGROUND

Traffic congestion has become one of this country's most serious urban problems. The Texas Transportation Institute estimates that the annual cost of traffic congestion in the 39 largest urban areas was $43.2 billion in 1990.[1] These costs include the value of time wasted in stop-and-go traffic, extra fuel consumed, and higher insurance rates. The $43.2 billion does not include worsened air quality due to the higher emission rates of vehicles in stop-and-go traffic. Table 1 lists the annual congestion costs for the 10 most-congested urban areas as of 1990. As can be seen, for Los Angeles alone, the annual cost was $7.7 billion.

Table 1

COST OF CONGESTION IN TOP 10 METRO AREAS, 1990

Metro Area	Population (millions)	Congestion Index (RCI)	Percentage Change in Congestion 1982 to 1990	Annual Cost of Congestion $ millions
Los Angeles	11,420	1.55	27%	$7,670
Washington, D.C.	3,100	1.37	28%	$2,370
San Francisco	3,675	1.35	34%	$2,810
Miami	1,850	1.26	20%	$970
Chicago	7,510	1.25	23%	$2,280
San Diego	2,295	1.22	56%	$670
Seattle	1,730	1.20	26%	$1,140
San Bernardino	1,170	1.19	9%	$1,030
New York	16,780	1.14	13%	$6,560
Houston	2,880	1.12	-4%	$1,650

SOURCE: Texas Transportation Institute

Traditional central business districts (CBDs) are one focal point for traffic congestion. Many U.S. freeway systems were designed to bring commuter traffic from suburbs to the (presumed) single CBD. In many cases, a ring-road or beltway was later added to offer through traffic a way to bypass the CBD area's traffic.

By the 1980s, however, the urban/suburban landscape had changed dramatically. A 1987 Eno Foundation study documented the changing commuting patterns that resulted from an ongoing shift of employment locations to the suburbs.[2] By the mid-1980s, the majority of commuter trips were suburb-to-suburb, rather than suburb-to-CBD. Rising affluence and the trend toward two-income households led to much higher levels of vehicle ownership and travel in the 1980s. Moreover, changed demographics (including large increases in the numbers of working mothers and single parents) led to more complex trip-making, including a major increase in non-work trips during rush hours. By 1990, in Los Angeles, some 43 percent of the morning rush-hour and 56 percent of the afternoon rush hour consisted of non-work trips.[3]

These changes have had many impacts on the urban freeway network. Beltways originally designed as “bypasses” now serve as principal commuting (and non-commuting) arteries for today's myriad rush-hour trips among suburbs. And in many cases, much of the traffic on freeways in or near the CBD is not headed to or from downtown but is simply getting from one part of the metro area to another via the shortest limited-access route available. For example, an ad-hoc committee including Caltrans, the Los Angeles departments of city planning and transportation, and the Central City Association estimated that some *50 percent* of all the traffic on the freeways which circle the traditional Los Angeles downtown CBD is actually through traffic.

Heavy freeway congestion is one factor in the decline of traditional CBDs. By comparison with the traditional downtown, suburban employment centers are often considerably more accessible by car (the mode of choice of over 86 percent of Americans as of 1990[4]). Moreover, downtown freeway congestion is a source of noise and air pollution that reduces the quality of urban life.

These considerations have led a number of major cities—including Amsterdam, Boston, Madrid, Melbourne, and Paris—to consider a dramatic move: put a significant portion of expressway travel underground, in high-tech tunnels. The aim is to reduce the number of vehicles stuck in congestion, reduce noise and emissions at street level, and permit through traffic to bypass congested areas. Innovations in finance, pricing, and technology make this approach far more feasible than it may appear at first blush, as will be demonstrated in this paper. Congestion-relief toll tunnels offer significant benefits for many hard-pressed urban areas.

The only U.S. city currently attempting such a project is Boston. Its massive Central Artery/Tunnel is a $5.8 billion project to replace the ugly and out-of-date Central Artery expressway (I-93) with an eight-lane tunnel and several new bridges, as well as adding a Third Harbor Tunnel across Boston Harbor to Logan Airport. While this project offers Boston many benefits, it fails to take advantage of key innovations which are integral to the growing number of urban congestion-relief tunnels overseas.

II. OVERSEAS EXPERIENCE WITH URBAN TUNNELSII. OVERSEAS EXPERIENCE WITH URBAN TUNNELS

Urban design expert Gideon S. Golany of Pennsylvania State University is one of those calling for making increased use of the land beneath urban areas. “Cities everywhere have grown beyond the point of manageability, and their inhabitants now pay an invisible social and economic price,” he told *American City and County* in 1992.[5] Based in part on his study of underground construction in Japan, Golany has called for “the removal of most, if not all, urban transportation facilities to below ground in the form of subways, high-speed rail, and roads.”

Ironically, one American city attempted to do just that. At the turn of the century, Chicago constructed a system of underground tunnels to carry freight, fuel, and garbage into and out of the downtown Loop area—explicitly to relieve gridlocked traffic at the surface level.[6] The system included 60 miles of tunnels and remained in regular use until the 1960s, when their only remaining use was for access to utility lines. The tunnels were largely forgotten until 1992s break-in and flooding brought them back to public attention.

Overseas, however, the past decade has seen a dramatic revival of interest in urban tunnels to reduce traffic congestion and improve the quality of life and environment in downtown areas. Thus far, major projects are underway or under study in both Europe and Australia.

A. Oslo TunnelsA. Oslo Tunnels

Norway has extensive experience with road tunnels, due to its mountainous terrain. Economical tunnel construction is a point of pride to Norwegians, who cite their 218 miles of tunnels, including the world's fifth-longest. But the newest trend in Norway is urban congestion-relief toll tunnels.

Oslo, the capital city, is the focal point of this development. Like several other cities (Bergen, Trondheim), Oslo in the 1980s turned to tolls both to raise funds to improve its urban motorway system and to control traffic congestion. Some 70 percent of the new system in Oslo will consist of 16 tunnels, totaling 8.7 miles. The largest component of this system is the six-lane Oslo Tunnel, a two-mile bypass of a portion of the downtown waterfront area. Stage One of this project opened in 1990, Stages Two and Three are scheduled to open in 1993, and the final Stage Four will get under way in 1994.

The Oslo Tunnel's construction cost was estimated at $376 million in 1988–89 dollars. The project is funded as a public-private partnership. The Norwegian government is providing 40 percent of the capital, with the balance coming from commercial loans, to be repaid out of toll revenues. Electronic toll collection was introduced to the entire Oslo toll-road network in December 1990 to reduce the need for toll booths, and consideration is now being given to introducing higher tolls during peak-hours and lower tolls at nonpeak times (congestion pricing).

Environmental improvements are cited by the Norwegian Public Roads Administration as major benefits of the toll tunnel system. These benefits include:

- shifting traffic off downtown surface streets, thereby decongesting those streets and making them more hospitable for walking and bicycling;

- reducing local (ground-level) air pollution. Tunnel air is exhausted via ventilation towers equipped with an electrostatic cleaning system to remove particles; and

- reducing overall emissions by substituting nonstop travel for stop-and-go travel.

B. Dutch TunnelsB. Dutch Tunnels

In 1988 the Dutch Ministry of Transport and Public Works adopted a plan to dramatically reduce traffic congestion in the Randstad area—the urbanized region that includes Amsterdam, Rotterdam, the Hague, and Utrecht. One component was to introduce an area-wide road pricing scheme, beginning in 1992 and fully operational by 1995. To make the scheme acceptable to road users, a portion of the revenues would be rebated to motorists and the balance would be used to finance congestion-relief improvements to the road system. Among these would be five toll tunnels, costing an estimated $785 million. The tunnels would be developed and operated by private firms, operating under the well-known European concession approach called build-operate-transfer (BOT). The companies would be required to put in equity capital of 25 percent of the construction cost and to borrow the rest commercially, and they would be given 30-year franchises during which they could charge tolls, before turning the tunnels back to the government.

In 1989 the Dutch Parliament approved the contract for the first tunnel, a $209 million project near Amsterdam, and held the first stage of a competition for firms to develop the second and third tunnels. But a new government took office in November 1989, with philosophical objections to the use of private capital by one of the parties in the coalition government. In addition, both parties raised objections to the electronic road pricing scheme, and the auto lobby argued strongly against the toll scheme, as well.

In 1991, the concession for the second tunnel, the $250 million Wijker road tunnel, was awarded, but the future of the other three remained in doubt. In 1992, the Minister of Transport announced that instead of electronic toll collection, the Randstad area would implement a system of "area licenses" like that used in Singapore. This requires motorists to purchase and display a daily or weekly window sticker to be allowed to use the main urban roads during peak periods. The tunnel companies will be paid a "shadow toll" by the government for each vehicle that uses the tunnel, rather than a direct payment by each user.

C. Madrid TunnelsC. Madrid Tunnels

The city government of Madrid is considering several congestion-relief tunnel schemes. In 1990 the Paris-based engineering firm SETEC proposed that Madrid develop an underground ring-road, similar to a design the company had proposed for Paris, to reduce Madrid's chronic traffic-congestion problem. In 1991 the city asked SETEC to do a more detailed study on one component of the project, a $1.6 billion, one-mile tunnel linking the Madrid-Barcelona highway with Madrid's main avenue. According to Madrid public works director Luis Armada, the project would be financed via private capital on a BOT basis, with revenues generated from users via tolls.

D. Melbourne Bypass TunnelD. Melbourne Bypass Tunnel

Australia's state of Victoria is in the process of selecting a consortium for a BOT project to finance, build, and operate a tunnel connecting two freeways which serve the city of Melbourne. The new link between the freeways, via a tunnel beneath the Yarra River in the city, will enable traffic to bypass the congested downtown. The cost is expected to be between $470 million and $650 million, depending on whether or not the project includes a spur line to link the main western exit road from downtown with the southeastern freeway.

Two consortia were short-listed by October 1992, with the winner expected to be selected by the summer of 1993. Like the Dutch tunnels, Melbourne's may employ “shadow tolls,” rather than direct payment by motorists (though conventional tolls are also being considered). Under the shadow-toll concept, the state government would pay the consortium a fee for each user of the tunnel, derived from increased gasoline taxes in Victoria.

E. Marseilles and Lyons TunnelsE. Marseilles and Lyons Tunnels

France's first congestion-relief tunnel is being developed in the port city of Marseilles. The project is a 1.5-mile, $221-million project to convert a no-longer-used railroad tunnel into a four-lane toll tunnel. It will connect two autoroutes (expressways) which feed traffic into the CBD, taking significant amounts of traffic (4,000 cars/hour at peak times) off of congested city streets. Because the rail tunnel is only wide enough to accommodate two vehicle lanes, the winning consortium proposed to deepen it sufficiently to permit double-decking; hence the two eastbound lanes will be directly above the two westbound lanes. The limited height (12' 9") will limit usage to cars, vans, and light trucks.

The consortium, SMTPC, consists of eight banks and three Paris-based construction firms. It was awarded a 30-year BOT concession by the city in September 1990. The project is being funded with 20 percent equity and 80 percent debt. The tunnel is expected to open for traffic late in 1993. No government funds or guarantees are involved, but the franchise agreement gives the city the right to approve the initial toll rates, which will then be permitted to increase in accordance with a formula spelled out in the franchise agreement. Tolls will vary by time of day (congestion pricing), and an electronic toll-collection system will be used.

North of Marseilles at Lyons, additional congestion-relief tunnels are being developed as part of the city's 5.3-mile northern ring road. Some 3.8 miles of the project consist of tunnels. The project consortium is headed by French construction giants Bouygues and Lyonnaise des Eaux-Dumez. They were awarded a 35-year BOT concession for the $470 million project.

F. Paris Tunnel ProjectsF. Paris Tunnel Projects

The most dramatic and far-reaching urban congestion-relief tunnel projects have arisen in Paris. During the late 1980s the major French highway developers and city officials began envisioning a large-scale network of privately financed toll tunnels that would draw traffic off Paris's highly congested streets as well as permitting through traffic to cross beneath the city center, rather than adding to congestion on either the inner ring road (the Peripherique) or the outer ring road (the A 86).

By 1988 plans evolved to the point where two detailed BOT proposals were put forward by competing consortia. The first was called LASER (Liaison Automobile Souterraine Expresse Regionale). Proposed by a team headed by private tollway operator Cofiroute and construction giant GTM-Entrepose, this $3-billion project consisted of 31 miles of tunnels radiating from a central ring beneath the center of Paris to five suburban locations outside the Peripherique. The tunnels would be double-decked, with three lanes above and three below. Only autos and vans would be permitted, to limit the tunnel dimensions and to permit steep (10 percent) slopes for entrance/exit ramps. The number of cars using the system would be controlled to permit speeds to be maintained. The consortium estimated that LASER would reduce traffic on central Paris streets by 15 percent.

The competing project was originally known as 3R (Reseau Rapide Regional), but its name was later changed to Hyssop (after an aromatic plant which relieves congestion of the lungs). Its initial network would be 27 miles of double-decked tunnel (two lanes in each direction) forming an X beneath central Paris, with additional branches to be added later. Like LASER, it would be limited to cars and vans, and its cost would also be about $3 billion. Hyssop's operating concept stressed reduction of congestion and pollution more than LASER's. For example, although vehicles would be allowed to enter the tunnels from within central Paris, they would not be able to exit onto surface streets. Those driving into Paris via Hyssop would only be able to park in underground parking structures, located at major commercial centers and transportation nodes such as railway and subway stations. To keep traffic moving at design speeds, Hyssop planned to use congestion pricing. Traffic studies carried out by SETEC estimated that Hyssop could lead to 25 percent less traffic on major Paris boulevards, especially during rush hours.

Both LASER and Hyssop were proposed as fully privately funded projects, supported by toll revenues, and to be franchised by the Paris city government on a BOT basis. A city study of the two proposals concluded that vehicle emissions would be 14 percent less for tunnel traffic than for traffic on congested surface streets (due to the difference of average speeds expected: 9 MPH on surface streets vs. 37 MPH in the tunnels). It also concluded that the tunnels would be safer (as measured by the number of accident victims), in part due to the absence of pedestrians and bicycles in the tunnels.

The city report made a number of recommendations, including higher tunnel ceilings than proposed, better lighting, and more safety exits. And it stressed that any tunnel project approved by the city must be: 1) for light vehicles only (i.e., no trucks or buses); 2) primarily for long-distance, cross-town travel; 3) self-financing through tolls, with no use of tax funds; 4) based on using congestion pricing to keep traffic flowing at design speed (and hence, free of regulation of toll rates); 5) built and operated via private concession (i.e., BOT); 6) built in stages, with each stage functional as built; and 7) in compliance with normal city and state traffic regulations.

After extensive press coverage and public discussion, the Paris city government in May 1990 decided to reject the specific LASER and Hyssop proposals. Rather than tunnels across central Paris, the initial use of congestion-relief tunnels should be to relieve congestion on the inner ring-road (the Peripherique). The reasons given were: 1) concern over the validity of the forecast reduction of traffic on city streets; and 2) concern over disruption of city life during the construction period.

Requests for proposals for a Peripherique tunnel system were issued, and a consortium of Cofiroute, GTM-Entrepose, and SAE was selected in November 1990. Traffic studies and negotiations on terms of the concession continued through the end of 1992 without a concession agreement being signed.

Meanwhile, in the spring of 1991, the Hauts-de-Seine Department (county)—directly to the west of Paris and encompassing 36 municipalities and 1.4 million people—issued a request for qualifications for international consortia to design, finance, develop, and operate a congestion-relief tunnel network for that region. Dubbed MUSE (Maille Urbaine Souterraine Express), the concept outlined in the tender documents was quite similar to LASER and Hyssop: a private concession (BOT), congestion pricing, no tax funds involved, and designed for light vehicles only. The justifications given were increased mobility and improved environmental quality:

> Because it will be underground, MUSE will preserve the urban fabric, avoid new divisions of property, and enable surface space to be recovered. Thus maintaining its land potential, the Department will be able to use this space for housing, parks, gardens, and arts and sports facilities, while benefiting from a large-scale road system. The reduction of traffic on the surface system resulting from MUSE, as well as the reduction in noise and air pollution and visual nuisances, will increase the comfort and quality of life of all those who have chosen to live or work in the Hauts de Seine.[7]

Seven consortia were selected as qualified, six French and one Italian, and were asked to prepare and submit detailed proposals by January 1992. All seven submitted proposals, which were reviewed by a "jury" of mayors from Hauts-de-Seine municipalities. In July 1992, the consortium headed by SGE and Bouygues was selected to lead the project, but it was decided that, at $5.4 billion, the project was so large that each of the other consortia would receive a share in the concession company to develop and operate the system.

The design concept calls for 30.5 miles of tunnel, consisting of two roadway levels with four lanes each plus a light rail line on a third level. Design speeds will be between 31 and 50 mph. Financing is expected to be 20 percent equity (provided by the consortium), 55 percent commercial borrowings, and 25 percent as subordinated debt provided by the Department. (The government portion is to pay for the rail line.) The project was officially approved by the Hauts-de-Seine government in April 1993, and the first phase is expected to be open for use by 1999.

III. KEYS TO SUCCESS OF OVERSEAS TUNNEL PROJECTSIII. KEYS TO SUCCESS OF OVERSEAS TUNNEL PROJECTS

In the overseas tunnel experience discussed in Section II, several features characterize most of these projects. Nearly all of these projects are being developed largely or entirely with private capital, under long-term franchise agreements of the build-operate-transfer (BOT) type. Nearly all make use of electronic toll collection (ETC), which permits nonstop, at-speed payment and dramatically lower operating costs than conventional toll booths. Many also employ congestion pricing, charging higher tolls at peak periods, in order to limit access so as to keep traffic moving at design speeds. And many also are designed to handle only cars and other small vehicles, to minimize tunnel dimensions. These four features serve to change the economics of urban tunnels, making them more viable candidates for congestion-relief than American planners have believed.

A. Build-Operate-TransferA. Build-Operate-Transfer

Long-term franchises or concessions for infrastructure have been used in Europe for more than 40 years. Much of the motorway mileage in France, Italy, and Spain has been financed, built, and operated by this method, with tolls as the principal revenue source. By the early 1990s, the BOT concept for highways had spread to much of the rest of Europe, with projects under way in Britain, Bulgaria, the Czech Republic, Greece, Hungary, Ireland, the Netherlands, Portugal, Romania, Russia, and Yugoslavia.[8]

BOT highway, bridge, and tunnel projects have also become an important phenomenon in Australasia and Latin America. In 1992 Australia opened the Sydney Harbor Tunnel and two Sydney-area toll roads, the first BOT highway projects in that country. Other projects are under way or in operation in China, Hong Kong, Malaysia, and Thailand. The largest of these is the triple-deck $3.1-billion Bangkok Elevated Transport System, which combines retail shops (ground level), rail transit (second level), and tollway (top level). In Latin America, Mexico has set the pace with an ambitious program of producing some 5,000 km of tollways, most of it on a BOT basis. Argentina, Brazil, Chile, and Venezuela are also planning projects of this kind.

The United States has begun to utilize this kind of private finance for tollways, as well. As of mid-1993, seven states (Arizona, California, Florida, Minnesota, Texas, Virginia, and Washington) and Puerto Rico had enacted highway privatization statutes. The first project—the San Jose Lagoon Bridge in San Juan, Puerto Rico—was financed and put under construction in 1992, and the first authorized tollway projects in California and Virginia were in their final stages of financing in the first half of 1993.

Congress included public-private partnership provisions in the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991, under which federal highway funds can be used, for the first time, as seed money for private toll projects. These can include both new projects (except on the Interstate system) and the rebuilding and modernization of existing tolled and untolled facilities.

The basic principle that makes BOT projects work is that of a "bankable franchise." In other words, if a facility has the potential to generate sufficient revenues to cover both its capital and operating costs plus a competitive rate of return to investors, *and* if the private team proposing the project can negotiate an acceptable long-term franchise agreement, then private capital in the form of (taxable) debt and equity can be raised to build the project.

While U.S. financial institutions are still in the process of learning the ins and outs of BOT projects, European and Australasian investors have become accustomed to this type of financing. An international survey by the newsletter *Public Works Financing* in October 1992 identified over 70 projects valued at $30 billion in 14 countries (including the huge Channel Tunnel between Britain and France) that have been financed since the mid-1980s.[9] At least another 100 projects in 33 countries, worth $160 billion, were identified as being in some stage of planning or development. U.S. institutions have a decade of experience financing one specific type of facility, the independent power project (IPP). Based on that successful experience, two major financial institutions, GE Capital and Prudential Power Funding, announced early in 1993 the formation of new business units to invest more widely in BOT projects in the United States. Toll facilities were high on both companies' lists of candidate projects.

B. Electronic Toll CollectionB. Electronic Toll Collection

To the average person, a toll road (or bridge or tunnel) calls to mind images of massive toll plazas, behind which hundreds of cars line up, delaying their journeys, polluting the air, and causing safety hazards from rear-end collisions. Fortunately, the telecommunications revolution has made this image virtually obsolete.

The basic technology for ETC consists of three parts. A small *tag* is mounted on the vehicle; this tag is capable of being "read" by a radio-frequency *transponder* mounted above, below, or alongside the traffic lane as the vehicle moves past. The third component is a *computer system* which keeps track of the relevant information, such as the applicable toll rate, the time and date of the transaction, the status of the user's account, etc.

In principle, ETC systems can operate on either a credit or a debit basis. In a credit-type mode, the user's transaction would create a record (much like a long-distance call), to be billed at periodic intervals (just like a phone or electric bill). In a debit mode, the user maintains an account balance with the toll agency; each time the system is used, the account balance is debited for the applicable charge. Users receive a warning signal when their balance drops to a threshold level, or (in some systems) they can opt to have their balance replenished automatically by drawing on a major credit card.

First-generation ETC systems use a passive tag, on which a readable account number is permanently stored. Second-generation systems are being developed, in which the tag has the ability to receive information from the toll system (rather than simply sending out its I.D. number when interrogated). Some versions employ a "smart card," similar to a transit system farecard, which the user can "charge up" with a certain dollar value and insert into the vehicle's on-board tag. Each time the vehicle passes a toll-collection point, the charge is deducted from the card's balance and the remaining balance is displayed on the tag's display. Because no account number is needed in this type of system, a smart-card system has inherent privacy advantages.

First-generation ETC is rapidly being retrofitted onto existing toll facilities in the United States and Europe. In retrofit applications, existing toll lanes are equipped with transponders, and users are offered the opportunity to rent or purchase tags for their vehicles, in order to reduce the time needed to go through the toll lanes (typically at no more than 15-20 MPH, because of the narrow width of the toll lane). The Dallas North Toll Road, the Crescent City Connection bridge across the Mississippi in New Orleans, and the Oklahoma Turnpike System have all retrofitted first-generation systems during the past several years, to speed up toll collection and reduce operating costs.

For new tollways, further improvements are possible. If most users can be persuaded to opt for ETC (either by convenience alone or via a discount off the manual toll), then mainline toll plazas can be dispensed with, to be replaced simply by transponders at those points where tolls are to be collected. ETC users do not slow down, since the systems work reliably at speeds in excess of 100 MPH. They simply notice a sign overhead informing them that they are passing a toll collection point and are incurring the stated amount of toll. Users not equipped for ETC are directed to exit the main highway lanes to an off-line toll booth. This takes care of out-of-area users and those who prefer not to use ETC. This type of configuration is in use on Oklahoma's newest toll road and is planned for several new tollways under development in Orange County, California.

For certain types of facilities, toll booths can be dispensed with altogether. Where a congestion-relief facility is added to an existing tollway or freeway, it can be offered *only* to those users willing (a) to pay a premium price, and (b) to make use of ETC. As an optional service, it need not accommodate all comers. Precisely this type of facility is being developed as California's first private tollway. A consortium headed by Kiewit is adding four express lanes to the median of the Riverside Freeway (SR 91) in Orange County, California. It will accommodate both authorized high-occupancy vehicles (HOVs) carrying three or more people at no charge, and regular users paying peak- and off-peak toll rates (congestion pricing). Both types of users will be required to make use of on-vehicle tags, to identify the qualifying HOVs and to permit payment by the paying users. The SR 91 express lanes will be the world's first tollway with no toll booths whatsoever.

C. Congestion PricingC. Congestion Pricing

For a congestion-relief tunnel to fulfill its purpose, it must keep its traffic moving. To do so in a high-demand area, it is necessary to limit access to the maximum number of vehicles per hour consistent with smoothly flowing traffic. The most feasible way to do this is to vary the level of toll in accordance with the varying demand at different types of day. This form of road pricing has come to be known as congestion pricing.

Transportation economists have been advocating the use of congestion pricing for nearly 30 years, dating back to the Smeed Report in London in 1964.[10] Among the most recent works is a 1989 study by the Brookings Institution, which advocated shifting the funding of the U.S. highway system from gasoline taxes to a combination of truck axle-weight fees and congestion pricing.[11]

Actual implementation of congestion pricing has lagged far behind theoretical discussions of its efficacy. Singapore implemented a crude version of such pricing in 1975, requiring the purchase of a daily, weekly, or monthly windshield sticker to enter the central business district during business hours. It reduced vehicular traffic in the CBD by some 40 percent. Norway's three largest cities installed “toll rings” around their CBDs during the 1980s, partially to reduce CBD traffic but primarily to raise revenue to finance highway improvements. By the early 1990s, both Norway and Singapore were planning to upgrade their systems to ETC and to institute peak and off-peak price differentials. Both Sweden and the Netherlands have done detailed studies of ETC-based congestion pricing, but as of the end of 1992, implementation decisions had been held back by political constraints.[12] In Britain the U.K. Department of Transport in 1991 commissioned a $5-million, three-year study of congestion pricing for London, and Cambridge and Edinburgh are pursuing independent studies of the issue.

In the United States, the Urban Mass Transportation Administration funded considerable research on road pricing in the 1970s and attempted to launch demonstration projects, but in the end, no cities were willing to make the political decisions necessary to implement the projects, most of which were focused on CBDs. U.S. interest revived in the late 1980s, sparked by growing concerns over both urban air quality and traffic congestion levels; this time the emphasis was primarily on freeway pricing. Further research by the Federal Highway Administration and UMTA's successor, the Federal Transit Administration, led to the inclusion in 1991s ISTEA legislation of provisions for up to five federally assisted pilot projects to introduce congestion pricing in urban areas. The FHWA developed guidelines and sought proposals from urban areas at the end of 1992, receiving 16 proposals in February 1993.

Thus, public-sector transportation agencies have become supportive of congestion pricing in the 1990s. This will serve to reinforce the legitimacy of proposals by the private sector to make use of congestion pricing on congestion-relief projects. As noted previously, the private sector has incorporated congestion pricing in project plans in both Paris and Orange County, California.

Congestion pricing may also assist with tunnel ventilation. A continuous flow of vehicles moving in the same direction can serve as a plunger, pushing fresh air through the tunnel, thereby minimizing the energy which must be expended to mechanically ventilate the tunnel. Uniform vehicle sizes (see below) could also improve this natural ventilation.[13]

D. Small-Vehicle DimensionsD. Small-Vehicle Dimensions

The cost of a tunnel depends considerably on the volume of material that must be excavated to create it, as well as on the surface area of its walls and the volume of air that must be moved in ventilating it. Hence, the size of a tunnel is a critical factor in its overall economics.

Engineer Gary Alstot of T. Y. Lin International has graphically illustrated the difference in dimensions required to serve heavy trucks as opposed to automobiles. As shown in Figure 1, a standard lane capable of accommodating trucks is 12 feet wide and 16.5 feet high, an area of 198 sq. ft. By contrast, a car requires only a 9-foot lane and 7 feet of vertical clearance, an area of 63 sq. ft. In other words, the cross-sectional area of a single tunnel lane for trucks must be more than three times the cross-sectional area of a cars-only lane. Since the volume of material to be removed is equal to the cross-section times the length, the volume of a cars-only tunnel lane is also only one-third that of an all-purpose tunnel lane.

Figure 1

Auto-Size Vehicle Lanes

This dramatic difference in volume explains the decisions of French authorities and private consortia to opt for congestion-relief tunnel systems built to accommodate only cars, vans, and other small vehicles. Limiting congestion-relief tunnels only to small vehicles involves trade-offs, of course. Trucking interests (and probably public bus operators) will likely oppose such a policy, on grounds that their vehicles, too, deserve the opportunity to bypass congestion. But if the costs of all-purpose tunnels are so high that they cannot be built, then no users will benefit from the congestion relief they can offer. The policy trade-off may come down to that of obtaining relief for the majority of vehicles rather than no relief for any of them.

In this context, it should be noted that trucks constitute only 10 to 20 percent of the traffic on existing freeways. Buses constitute a much smaller fraction. Hence, a small-vehicles-only tunnel would be able to accommodate 80 to 90 percent of all current freeway traffic. All vehicles diverted from existing facilities by the congestion-relief tunnel would free up space on those facilities for those users unable to make use of the tunnel. Moreover, transit services can be provided economically by 8- to 12-passenger vans, which would be eligible to use most small-vehicle-only tunnels.

IV. COSTS AND CHARGESIV. COSTS AND CHARGES

The common perception in the United States is that tunnels are extremely expensive and hence can only be justified in very unusual circumstances. For example, in the ongoing controversy over the California Department of Transportation's (Caltrans's) proposal to extend the I-710 freeway through South Pasadena, a tunnel alternative was considered but rejected. Caltrans estimated the cost of the eight-lane, 1.75-mile tunnel through South Pasadena to be $980 million, compared with an estimated total cost of $426 million for the entire 6.2-mile surface route. (Left out of the comparison, of course, was the opportunity cost of 30 years of delay in constructing this missing link in the Los Angeles freeway system.)

In a system funded by gasoline taxes, and for which more projects are desired than can be funded, it is hardly surprising that transportation agencies such as Caltrans choose the alternative that involves the least outlay of funds. But the present system neglects to consider that some projects may be so valuable to their potential users that those users would be willing to pay sufficiently high tolls to fund more-expensive alternatives such as tunnels. And by avoiding many of a freeway's negative effects on urban communities, congestion-relief tunnels might actually get built, rather than being tied up in decades of litigation.

A. Tunnel Investment CostsA. Tunnel Investment Costs

A number of urban tunnel projects have been proposed or carried out in the past five years, both in the United States and overseas. Not all of them are congestion-relief toll tunnels, but all provide an opportunity to assess the possible range of costs for such projects.

Table 2 presents summary data for 11 actual and proposed urban tunnel projects. All but one of the overseas projects have been described previously in Section II. The exception is the Limehouse Link, a non-toll tunnel which opened in 1993 in the London Docklands. As can be seen, these tunnels range in size from the 1.5-mile Marseilles converted rail tunnel to the proposed 30.5 and 31-mile LASER and MUSE tunnel systems in Paris. The range of investment costs per lane-mile is from $22 million to $76 million.

Table 2

TUNNEL INVESTMENT COSTS							
Project	Construction Method	Length mi.	No. of Lanes	Lane-miles	Capital Cost $M	$M/Lane-miles	Finance Method
Overseas							
Oslo Tunnel	Cut & cover, immersed tube	2.25	6	13.5	376	28	Gov't
Marseilles Tunnel	Excavation	1.50	4	6	221	37	BOT
Lyons Tunnels	n/a	3.8	4	15.2	423	28	BOT
Limehouse Link	Cut & cover	1.1	6	6.6	500	76	Gov't
LASER	Bored	31.0	6	186	5,000	27	BOT
Hyssop (3R)	Bored	27.0	4	108	3,000	28	BOT
MUSE	Bored	30.5	8	244	5,400	22	BOT
Domestic							
Seattle Bus Terminal	Bored	0.95	2	1.9	45	24	Gov't
Boston Central Artery I-93	Cut & cover	----	----	95.8	3861	40	Gov't
Boston-new Harbor Tunnel I-90	Immersed tube	----	----	62.4	1918	31	Gov't
U.S. 710-Caltrans	Bored	1.75	8	14	980	70	Gov't
U.S. 2-Caltrans	Cut & cover	2.25	6	13.5	310	23	Gov't

Of the four U.S. projects, two are never-built Caltrans proposals and the other two are the Seattle Bus Tunnel (which opened in 1990) and the giant Boston Central Artery/Tunnel project which is currently under construction. From this limited sample, one can observe that investment costs are slightly higher (per lane-mile) for the domestic projects. While overseas tunnels average $35 per lane-mile, the domestic tunnels' average cost is $38 per lane-mile.

With a sample size as small as this one, it is difficult to form definitive conclusions. A number of factors might account for the differences. One is the construction method. According to Caltrans, the large difference between its Rt. 710 and Rt. 2 tunnel costs is that the former assumes use of a tunnel boring machine while the latter is based on the cut-and-cover method. However, examination of the other cases in Table 2 reveals no clear relationship between construction type and cost. In particular, the large French projects (LASER, Hyssop, and MUSE) all are planned as bored tunnels, 100 feet below ground (so as to pass beneath subway lines). Yet their investment costs, at $22–30 per lane-mile, are among the lowest in the table. Clearly, much of this difference is due to their smaller dimensions, as small-vehicles-only tunnels.

This difference appears to stem from institutional factors. The high-cost tunnels in Table 2 are virtually all being developed as public-sector projects. Most of those with low investment costs are projects being proposed or developed by private consortia under long-term BOT arrangements. The private sector's need to make a profit provides a powerful incentive to search for ways of reducing the project's investment costs. Eliminating toll plazas and opting for small-vehicles-only are two obvious contributors to lowering costs.

Another factor is the shorter expected time required for developing a private-sector project, thanks to streamlined development techniques routinely used by the private sector but often precluded by public-sector procurement regulations. For example, the “design-build” method involves coordinated and overlapping work between the project's designers and its prime construction contractor. Time is saved directly by overlapping the design and construction phases, and further savings occur because the involvement of the contractor in the design process produces a more buildable design, with less need for costly and time-consuming change-orders during the construction process. The design-build technique is usually precluded in the public sector, because procurement regulations require separate competitions first for the engineering/design firm and later, after the design is finalized, for the construction prime contractor and subcontractors.

Overall, the government-run projects average $42 per lane-mile in investment costs, while the privately developed projects average only $28 per lane-mile.

B. Tunnel Toll Rates B. Tunnel Toll Rates

Will users pay high enough rates to make congestion-relief tunnels economically feasible? Table 3 presents data on those toll projects from Section II for which pricing data were available. As can be seen, the rates for these projects range from 55 to 142 cents per mile. These rates are dramatically higher than the 5-10 cents/mi. typical of current U.S. toll roads.

Table 3

TOLL RATES: NEW URBAN TUNNELS

Tunnel	Length (mi.)	Charge	¢ / mi.
Oslo Tunnel	2.25	$1.50	67
LASER	31.0	variable	55
Hyssop	27.0	variable	142
MUSE	30.5	variable	86

However, from the user's perspective, a tunnel is analogous to a bridge, not a highway. It is a way to get across or around an obstacle, be it a body of water or a congested downtown. In this regard, the relevant comparison is with existing tunnels that cross obstacles such as harbors and rivers. As Table 4 reveals, on a per-mile basis, existing tunnels in New York, Detroit, and Baltimore charge from 53 to 150 cents/mi., the same range of charges proposed for the new congestion-relief urban tunnels.

Table 4

TOLL RATES: EXISTING URBAN TUNNELS

Tunnel	Length (mi.)	Charge	¢ / mi.
Holland Tunnel, N.Y.	1.8	$2.00	111
Detroit-Windsor Tunnel, Mich.	1.0	$1.50	150
Lincoln Tunnel, N.Y.	2.5	$2.00	80
Brooklyn Battery Tunnel, N.Y.	2.1	$3.00	143
Midtown Tunnel, N.Y.	2.6	$3.00	115
Baltimore Harbor Tunnel, Md.	1.9	$1.00	53

Thus, if marketed to users not as highways but as bypasses of obstacles, urban congestion-relief tunnels should be able to justify charges in the range of $0.75–1.50 per mile.

V. CALIFORNIA TOLL TUNNEL POSSIBILITIES V. CALIFORNIA TOLL TUNNEL POSSIBILITIES

According to the previously cited study by the Texas Transportation Institute, the Los Angeles and San Francisco areas rank number one and three, respectively, on TTI's Roadway Congestion Index. Among the most severely congested regions of these two metro areas are the freeways in the traditional downtown (CBD) areas. As noted in Section I, changes in urban form have resulted in substantial portions of the traffic on CBD freeways being through traffic. For these users, the CBD is neither their origin nor their destination. It is simply an obstacle on their journey to begotten past, like a river, a harbor, or a mountain. It is, in other words, something that might be bypassed via a congestion-relief toll tunnel.

This section identifies several possible congestion-relief tunnels that would let through traffic bypass downtown Los Angeles and San Francisco, respectively. They are presented not as detailed proposals for implementation, but rather as case studies to test the feasibility of the concept in an American context.

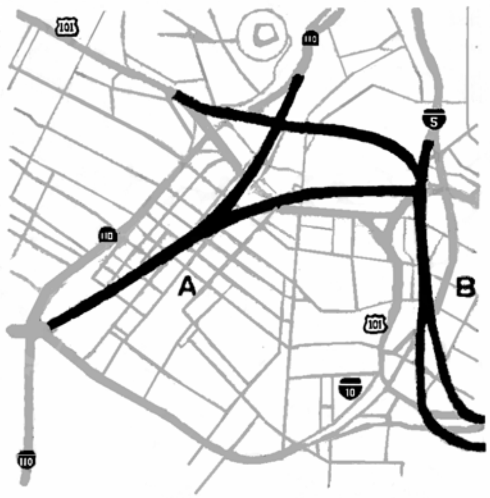
A. Downtown Los Angeles BypassesA. Downtown Los Angeles Bypasses

Downtown Los Angeles is ringed by freeways: the Santa Monica Freeway (I-10) runs east-west across the southern boundary of the CBD; the Harbor/Pasadena Freeway (I-110) forms the western boundary, running from the southwest to the northeast; the Hollywood Freeway (SR 101) forms the northern boundary; and the extension of 101 and the parallel I-5 form the eastern boundary of the CBD vicinity. These freeways are among the most heavily traveled in the world. But much of this traffic is not heading to or from the CBD. An ad-hoc committee including Caltrans, the Los Angeles Transportation and Planning Departments, the Central City Association, and others found that approximately half of all traffic on these freeways has neither its origin nor its destination in the CBD.

A number of possible bypass routes can be imagined to permit various portions of the traffic on these routes to bypass the most congested portions surrounding the CBD. Figure 2 presents one such configuration, which actually consists of two bypass routes. Route A is basically an I-10 bypass of downtown, with additional connections to provide for an I-110 bypass, as well (to attract additional toll-paying traffic). Route B is essentially an I-5 north-south bypass of downtown, with additional connections to the 101 and 60 freeways to generate additional traffic.

Figure 2

Downtown Los Angeles Bypasses



Both are assumed to be built as eight-lane tunnels, with four upper lanes in one direction and four lower lanes in the other direction. To hold down investment costs, dimensions are based on auto-size-vehicles only, thereby making it feasible to use European BOT-level investment cost figures. It is also assumed that there would be no toll booths or toll plazas. All toll collection would be done electronically, at normal highway speed, via second-generation electronic toll collection systems. For purposes of analysis, it was also assumed that 75 percent of the non-through traffic (i.e., 37.5 percent of the total traffic) would opt for one of the toll-tunnel bypasses, rather than remaining on the congested freeways surrounding downtown.

B. San Francisco Bypass TunnelB. San Francisco Bypass Tunnel

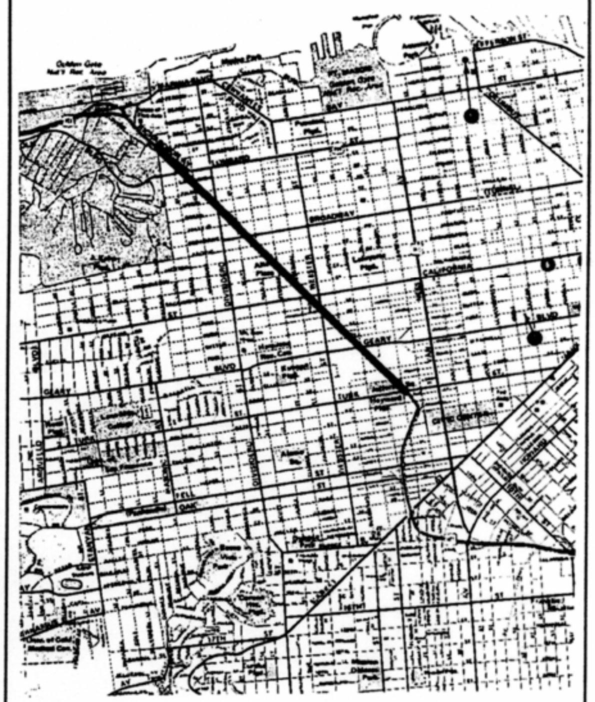
Downtown San Francisco is seriously impacted by through traffic on SR 101. Between Golden Gate Avenue and the Presidio, 101 is no longer a limited-access freeway but becomes simply a designation for the surface streets Van Ness Avenue, Lombard Street, and Richardson Avenue. Approximately 70,000 through vehicles per day must crowd onto these congested surface streets due to this missing link in the 101 freeway.

Completing SR 101 as an elevated freeway through San Francisco would be politically impossible. However, the prospect of removing up to 70,000 vehicles from the city's surface streets each day, at no cost to the taxpayers, might make a bypass tunnel politically feasible. A hypothetical route for such a bypass is depicted in Figure 3. From the south, it begins at or near Golden Gate Avenue where the current 101 freeway terminates, already in a double-deck configuration. The proposed tunnel consists of two lanes northbound (lower level) and two lanes southbound (upper level), making a straight-line path to the northwest, to link up with the resumption of the 101 freeway at the eastern border of the Presidio. This routing would not only complete SR 101 through the city on a limited-access basis, but it would also provide a limited-access route for traffic from the Bay Bridge (I-80) to reach the Golden Gate Bridge without impacting the city's surface streets.

It is assumed that following the opening of this bypass route, Caltrans and the city would designate the bypass as SR 101, with the present surface-street route becoming Alternate-101, for those vehicles either unwilling to pay the toll on the bypass or too large for the tunnel dimensions (e.g., trucks). Since there would be no freeway alternative through the city (unlike the case of the proposed Los Angeles bypasses, discussed above), it is assumed that the bypass would attract 90 percent of the auto-size through traffic. Assuming that outsize vehicles are 10 percent of the total, the bypass is therefore assumed to attract 81 percent of the 70,000 daily through vehicles. As with the Los Angeles bypasses, congestion pricing and electronic toll collection are assumed to be used, eliminating the need for toll booths.

Figure 3

Downtown San Francisco Bypass



C. Financial FeasibilityC. Financial Feasibility

Several other assumptions are needed in order to produce a financial model of these hypothetical bypass tunnels. Besides construction costs and traffic levels, annual operating costs were assumed to be 35 percent of each year's gross revenue. Operating costs include the costs of the toll collection system, preventive and corrective maintenance, ventilation system operation, and policing and accident response.[14] Toll revenues were assumed to grow at a rate of 6 percent per year (composed of 2 percent annual traffic increase plus 4 percent inflation).

A construction period of four years was assumed, and a franchise life (after construction) of 40 years was also assumed. The project was assumed to be financed 20 percent by equity and 80 percent by taxable debt, at an average interest rate of 11 percent. In addition, no cost was assumed for right of way, on the assumption that whatever subsurface rights were necessary would be purchased by

Caltrans, as part of its participation in these public-private partnerships. All other costs, however, would be covered by the private consortia developing and operating the tunnels. Depreciation was calculated on a straight-line basis.

A financial model was created using these assumptions and the specific investment cost and first-year traffic figures summarized in Table 5. The model computes annual cash flows for each project over its four-year construction period and 40-year franchise life. These annual figures are then used to compute the net present value (NPV) of each project's (pre-tax) cash flow, using a discount rate of 11 percent. This is a standard technique in investment analysis; projects having a positive NPV produce an economic return on investment; projects with a negative NPV consume more resources than they produce, after taking into account the time value of money.

Table 5

PROJECT PARAMETERS

	Downtown Los Angeles		San Francisco
	Bypass A	Bypass B	101 Bypass
Lanes	8	8	4
Length (mi.)	5.1	5.3	1.85
Lane (mi.)	40.8	42.4	7.4
Investment Cost ($M) (@ $30 M / lane-mi.)	$1,224	$1,272	$222
First-Year Average Daily Traffic	185,600	162,400	56,700
Toll Charge (average level)*	$3.25	$3.75	$2.00
Toll Rate (¢ / mi.)	64¢	71¢	108¢
Net Present Value ($M)	$341.9	$321.8	$69.4
Internal Rate of Return (after-tax)	16.15%	15.68%	16.74%

* Toll will vary by time of day to control congestion; rate shown is average rate paid by all users.

The variable in this financial modeling is the assumed average per-vehicle toll charge. The calculations carried out for these three proposed bypass tunnels found that toll rates needed to produce a positive NPV, as well as a positive cash flow from the first year of operation, were $3.25, $3.75, and $2.00, respectively. These equate to between $0.64 and $1.08 per mile, clearly within the range of toll rates per mile for the proposed and actual tunnels shown previously in Tables 3 and 4. Hence, it appears that these three projects would be financially feasible.

D. Other Possible ApplicationsD. Other Possible Applications

The three cases examined above were selected to illustrate the magnitude of the numbers involved in congestion-relief projects in two of America's most heavily congested cities. We intentionally selected downtown bypasses, in order to produce cases with: 1) high traffic volumes; and 2) alternate routes for outsize vehicles that could not be accommodated in auto-size-vehicle tunnels (i.e., the existing freeway or surface-street routes).

Another possible application of the toll-tunnel concept is situations where a freeway project faces major opposition on environmental grounds. Putting all or a portion of that project underground will significantly reduce its adverse impacts (neighborhood disruption, noise, dust and dirt, and ground-level emissions), potentially enabling it to be built years sooner (or to be built at all), compared with the at-grade freeway version. The following paragraphs explore several examples of this type.

1. California Examples

Long Beach Freeway Extension/South Pasadena. The extension of the Long Beach Freeway (I-710) through South Pasadena has been on the drawing boards for some 30 years. In 1973 a federal judge granted an injunction to halt this controversial project, pending completion of adequate environmental impact studies, and it has been fought over ever since. Opponents point to the displacement of 3,000 residents and the destruction of historic homes and buildings.

In 1990, one member of the California Transportation Commission proposed that the project be built as a (non-toll) tunnel through South Pasadena. However, Caltrans's estimate of $980 million just for the 1.75-mile tunnel portion (versus $426 million for the entire 6.2-mile at-grade freeway) prevented this alternative from receiving very serious consideration. But Caltrans did not consider any of the key features that make European toll-tunnel projects (and the three downtown bypass projects discussed above) financially feasible: small-vehicle dimensions, congestion pricing, electronic toll collection, and private development and operation.

Whether the completion of this missing link as a cars-only facility would be legally and politically acceptable (given that it would be an Interstate connecting to another Interstate, I-210) is an open question. If full-size lane dimensions were mandatory, another possibility would be a public private partnership, in which private capital would be matched with public capital, as permitted by ISTEA (see Section VI, below).

Cypress (I-880) Freeway, Oakland. Considerable controversy has dogged Caltrans's preferred solution to replacing the double-decked section of I-880 that collapsed in the Loma Prieta earthquake. The approach selected involves building a longer route along Southern Pacific railroad tracks to the west of the original location. The new route will displace 25 homes but will remove what had been considered to be the "concrete colossus which divided this community," in the words of one county supervisor. A conventional tunnel alternative had been considered by Caltrans but, as with the Long Beach freeway case, was dismissed on grounds of much higher cost. Again, none of the success factors noted previously was considered in the design.

Embarcadero Freeway (SR 480) Replacement, San Francisco. The demolition of the elevated Embarcadero Freeway structure near the waterfront in San Francisco, following its damage in the Loma Prieta quake, removed what many citizens of that city considered an eyesore and a nuisance. But it left a gap in the city's transportation system. A tunnel was one of the alternatives considered in the city's scoping report. Despite its environmental advantages, the tunnel approach has been dropped from the environmental review (which is ongoing at the time of this writing), largely on financial grounds. Once again, none of the success factors discussed in this report was included in the tunnel concept that was considered.

2. Boston's Central Artery/Tunnel Project

This country's one attempt to develop a congestion-relief urban tunnel project is far from the model set forth in this paper. The nation's largest single highway project, this $5.8-billion project will replace the antiquated elevated I-93 Central Artery expressway through Boston's CBD with an eight-lane tunnel. In addition, it is adding a third harbor tunnel to link the CBD with Logan Airport, and a new bridge taking I-93 across the Charles River. Federal law at the time the project was designed was very hostile to tolls, and despite the project's huge cost, only the harbor tunnel portion will charge tolls.

The project has been subject to fierce opposition from environmental organizations, on grounds that by adding lane-miles and modernizing the Central Artery, it will attract additional traffic and therefore worsen air quality. Even if project proponents sought to apply the success factors noted in this report, the fact that I-93 is an existing untolled Interstate would generally preclude the addition of tolls. Ironically, congestion pricing via electronic toll collection would provide a means of addressing the chief objection of environmental groups. Not only would congestion pricing limit demand (vehicle miles traveled); it would also reduce per-vehicle emissions by keeping traffic moving at steady speeds, rather than in stop-and-go conditions.

More-enlightened federal policy would permit this project to be developed as a public private partnership. As a major north-south Interstate route, it would have to be built to standard dimensions accommodating heavy trucks, so its capital costs would be higher than for auto-size-vehicle tunnels. But with ETC and congestion pricing, the project would be able to attract significant private capital while (as noted above) addressing the very real environmental concerns that have been raised.

One possible approach under existing federal law would be for Boston to take advantage of provisions in Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) that permit up to five congestion-pricing pilot projects. As many as three of these projects can be on Interstate facilities where tolls would otherwise be prohibited. As of mid-1993, the Federal Highway Administration's first round of solicitations for pilot projects had led to only one acceptable project (out of 16 submissions); consequently, bidding has been re-opened for additional proposals.

VI. IMPLEMENTATIONVI. IMPLEMENTATION

Based on the foregoing analysis, congestion-relief toll tunnels appear to be economically and technically feasible in selected urban areas. The remaining questions to be addressed are the legal and political feasibility of this concept. To what extent do mechanisms already exist to permit such projects to go forward, and to what extent is new legislation needed? And how realistic is it to expect sufficient political support for actual projects?

A. Legal FrameworkA. Legal Framework

Much of the legal basis for toll-tunnel projects as private or public-private ventures has been established by Section 1012 of ISTEA. This section permits states, at their option, to use a portion of their federal highway funds either as grants or as loans for toll projects, with certain exceptions. In the case of tunnels, new toll tunnels that are not part of the Interstate system are eligible for an up-to-80 percent federal share of the capital costs. In addition, reconstruction or replacement of toll-free bridges or tunnels on or off the Interstate system are also eligible for the same 80 percent share. To make use of these provisions, states must create and enact enabling legislation.[15]

Of course, projects which can be self-supporting from toll revenues, as some congestion-relief toll tunnels may be, do not necessarily need federal funding. As of this writing, six states and Puerto Rico already have state legislation in place to permit private tollway projects to be franchised on a BOT or BTO basis, and specific projects are moving forward in Arizona, California, Florida, Puerto Rico, and Virginia. A number of other states (including Georgia, Illinois, and North Carolina) have similar legislation under consideration. The newer measures generally incorporate the ISTEA provisions.

In the specific case of California, the focus of the case studies discussed previously, the 1989 legislation (AB 680) authorized only four pilot projects. Four franchises have been granted, via a competitive process, and unless any of the franchised developers withdraws there is no current legal mechanism for Caltrans to authorize additional projects. Legislation was drafted by Caltrans in autumn 1992 to authorize 10 additional projects and to implement the ISTEA Sec. 1012 provisions (including the creation of a revolving loan fund), but it failed to win the governor's approval to be introduced, and therefore did not find a legislative sponsor in the 1993 session.

In addition to state legislative authority, any major highway project in an urban area must be incorporated into the official transportation improvement program (TIP) adopted by the metropolitan planning organization (MPO) in that region. In the case of Los Angeles, the MPO is the Southern California Association of Governments (SCAG); in San Francisco, it is the Metropolitan Transportation Commission (MTC). ISTEA directs the MPOs to explore the potential benefits of private investment in transportation projects and to recommend "innovative financing techniques," including tolls and congestion pricing.

Assuming the needed state legislation were in place, would the specific projects suggested in Section V qualify under ISTEA? The two Los Angeles downtown bypass projects would appear to be no problem, since they would not themselves be part of the Interstate system (though they would connect to certain Interstate segments). As new construction of non-Interstate tunnels, they would be eligible for up to 80 percent federal loans or grants, should the project developer wish to pursue this source of funding. Likewise, the 101 bypass in San Francisco would be eligible as a state highway. The availability of grants or of subordinated loans at the state pooled investment-fund earnings rate might make feasible a higher-cost project, such as the provision of full-size (rather than auto-size) tunnel lanes.

The I-710 and I-880 projects in California and the I-93 projects in Boston are somewhat problematical. The first would involve the initial construction of a new tunnel facility on the Interstate system, which is explicitly excluded as a toll project by ISTEA. The other two would involve the replacement of free highways or bridges with toll tunnels, which is less clear-cut. If the pre-existing I-880 and I-93 facilities are defined as highways, ISTEA excludes them. But since both were constructed as elevated highways, they might be legally definable as bridges, in which case ISTEA does permit the replacement of a free bridge with a toll tunnel on the Interstate system. Alternatively, as noted previously, these projects could be proposed as congestion pricing pilot projects, under those provisions of ISTEA.

B. Political FeasibilityB. Political Feasibility

The idea of public-private partnerships for infrastructure has been increasingly accepted by elected officials, as city and state budgets have been increasingly squeezed during the early 1990s.[16] The first half of 1993 saw a new round of state enabling legislation for the public-private partnership provisions of ISTEA. Thus, there would appear to be inherent appeal to elected officials in the idea of relieving urban freeway congestion without having to commit significant public funds. In addition, traditional public-works constituencies (engineering firms, contractors, construction-trades unions) have supported recent state legislation along these lines and can be expected to support specific project proposals.

However, several other interest groups can be expected to play key roles either for or against congestion-relief toll tunnels. These include highway users, transit advocates, and environmental groups. Each of these must be considered in an assessment of political feasibility.

Automobile user groups, such as the American Automobile Association (AAA) and the Highway Users Federation (HUF) are likely to be supportive of the concept. Although they have historically opposed tolls, they appear to have come to terms with the idea of adding new capacity via toll-based public-private partnerships, especially for congestion relief. And both AAA and HUF have been fully engaged with other transportation planners in the evolving debate over the merits of congestion pricing in the early 1990s. Neither group flatly opposes congestion pricing any longer.

Trucking interests are somewhat more problematical. The American Trucking Associations and its member groups are likely to oppose any proposed toll tunnels that do not permit access by trucks. Since these tunnels would be net additions of capacity, however, which might reduce the extent of congestion on the existing routes used by trucks, their opposition might be able to be overcome. It should also be noted that the resistance of trucking organizations to congestion pricing has been softening, as such pricing begins to be seen as an alternative to command-and-control congestion-relief measures such as rush-hour bans on trucks.

Transit advocates may oppose any additions to existing highway capacity as the wrong type of transportation investment. Some transit advocacy groups (e.g., the California Transit League) have written positively about privately funded tollways and congestion pricing, as a long-overdue shift to requiring highway users to fully (or more nearly fully) pay their own way. But this distinction may in the end prove to be too subtle to prevent opposition from this quarter.

Finally, environmental groups might be expected to view congestion-relief toll tunnels in a similar manner to transit groups. However, this conclusion may be premature. For one thing, an increasing number of environmental organizations is endorsing congestion pricing, an integral element of these projects. These groups include the Environmental Defense Fund, the Oregon Environmental Council, the Union of Concerned Scientists, the Sierra Club, and the World Resources Institute. To be sure, even these groups tend to oppose most new-highway projects. But the proposed toll tunnels are so different from conventional highways that the environmental community may well adopt a more nuanced perspective toward them.

As noted in Section II, a major reason for the development of such projects in Europe is to remove significant amounts of vehicle traffic from surface streets, thereby improving the environment in downtown areas. Removing tens of thousands of cars each day from the streets of San Francisco, for example, would reduce the noise, vibrations, dust, dirt, and street-level emissions (and would somewhat reduce total emissions, since congestion pricing of the tunnel traffic would reduce or eliminate stop-and-go driving for those users).

This assessment is consistent with the findings of the final environmental impact report for Boston's Central Artery/Tunnel project. Although this project does not plan to use congestion pricing, the EIR found that it would result in net reductions in the levels of CO, NO_2, and HC compared with the no-build alternative. Emissions from the project's six ventilation buildings were found to be below the applicable state and federal guidelines.[17] Although the Conservation Law Foundation and the Sierra Club's New England chapter have fought this project in the courts, their principal argument has been that it will induce new traffic (and thereby increase emissions by increasing vehicle miles traveled). Without congestion pricing, that argument has some degree of plausibility. It is not clear that these groups would have opposed the project had it featured congestion pricing expressly designed to limit traffic volume and maintain smoothly flowing traffic.

Thus, it is possible that some environmental organizations will perceive congestion-relief toll tunnels as producing net benefits to the environment of our cities. They may become critical supporters of these projects as further steps toward more widespread implementation of serious congestion pricing.

VII. CONCLUSIONVII. CONCLUSION

While it has become a cliche to say that "we cannot build our way out of congestion," the fact remains that urban mobility is significantly constrained by bottlenecks and gaps in the current freeway systems, most of which were designed for a different urban land-use pattern than exists today. Selective additions to these congested systems can provide significant relief for hard-pressed motorists.Unlike conventional freeway additions, however, congestion-priced toll tunnels will: 1) be self-financing via user charges; 2) operate in a low-emission, constant-speed mode (rather than in a stop-and-go manner); and 3) divert significant traffic off existing urban freeways and streets, reducing noise and street-level emissions.

These advantages suggest an important role for congestion-relief toll tunnels, not merely in Europe where the idea originated, but in the United States, as well.

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toll-collection expenses, thanks to electronic toll collection, but would have the added operating expense of a ventilation system. Hence, 35 percent was selected as a reasonable modification of the Japanese rule of thumb.

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