Strategies to Address Traffic Congestion in the Boston Area

A comprehensive review of transportation policies is instrumental in formulating a multi-pronged approach to solving an area's traffic problems.

EDWARD L. SILVA

Two fundamental facts should be regarded before the problem of traffic congestion in the Boston metropolitan area can be put into proper perspective. Traffic congestion is generally regarded as one of the major social concerns of those who live and work in the area. In addition, the greater Boston area is always cited as one of the most severely congested metropolitan areas in the United States.

While there is some evidence that state and local officials are beginning to take some of the necessary steps to deal with the problem, much remains to be done. If implemented in a comprehensive manner, a set of practical recommendations presented herein can attempt to address the problem in a meaningful way and possibly reverse the negative trends of the last decade. A very simple and straightforward approach was used to arrive at these recommendations. This approach is outlined, step-by-step, below:

1. Document the scope of the problem in the Boston Area.
2. Develop a *model program* for addressing traffic congestion.
3. Utilizing this model program as a "yardstick," compare the efforts planned or underway in the Boston area to the model program.
4. Based on the comparison produced in the previous step, identify the strategies that need to be emphasized in the Boston metropolitan area.
5. Develop a set of recommendations that can be considered by state and local elected officials.

Traffic Congestion in the Area

The Boston metropolitan area has been experiencing unprecedented economic growth and development during the past decade. Along with this economic "boom" there has also been a resulting phenomenal growth in traffic. On major roadways in the City of Boston traffic grew by 30 to 50 percent in the period between 1977 and 1987.[1] On major roadways in

Table 1
Traffic Growth in the City of Boston Over a Ten-Year Period

	Average Daily Traffic 1977	Average Daily Traffic 1987	Growth (percent)
Southeast Expressway	133,000	182,000	37
I-93 Somerville	88,100	122,000	39
Central Artery	143,300	189,000	32
Tobin Bridge	63,900	96,000	50
Harbor Tunnels	75,400	99,000	31
Mass. Turnpike/Allston	76,900	109,000	42

suburban Boston the traffic growth in that same period of time was even more impressive, with growth ranging in the 50 to 65 percent range.[2] This growth in traffic is illustrated in Tables 1 and 2.

During this period, agencies of the Commonwealth of Massachusetts, working closely with local officials, made substantial expansions to the region's mass transit system, but failed to expand the region's roadway system. As a result, severe congestion is being experienced not only on the radial routes leading into downtown Boston, but also on the Route 128 beltline and on most suburban routes. The level of congestion has taken on extremely serious proportions and, unless state and local officials take the appropriate steps now, the problem will only get worse. Planners forecast that traffic volumes will continue to increase at a rate of two to four percent per year over the next 20 years on most corridors. To compound the problem, Boston is about to embark on a major long-term construction program that involves the Central Artery/Third Harbor Tunnel (see pages 45-60 for "Maintaining Urban Mobility for the Reconstruction of Boston's Central Artery," by M.J. Kohn and Walter Kudlick in this issue) and the cleanup of Boston Harbor. Both of these monumental projects possess the potential for causing massive dis-

Table 2
Traffic Growth in Suburban Boston Over a Ten-Year Period

	Average Daily Traffic 1977	Average Daily Traffic 1987	Growth (percent)
I-93 Andover	49,200	81,100	65
I-95 Georgetown	28,400	45,800	61
Rte. 3 Plymouth	18,600	27,600	48

ruption to traffic.

The costs of traffic congestion are broad and dramatic. Congestion wastes employees' time, hurts morale and productivity, affects the capability to recruit, wastes energy, reduces accessibility and contributes substantially to the degradation both of air quality and of the area's environment in general.[3] Eventually, traffic congestion problems will drive away business since companies in a gridlocked city will quite simply find their costs of doing business prohibitively high. The Conservation Law Foundation estimates that the total annual costs of congestion on Boston's highways will exceed $2 billion (in 1987 dollars) by the year 2005.[4] There is no other better time to deal with this serious problem than now and it must be dealt with in an aggressive and comprehensive manner.

A Model Program for Addressing Traffic Congestion

The *model program* presented here consists of the most promising strategies available to address the traffic congestion problem. This model is based on a study performed by a Federal Highway Administration (FHWA) task force and documented in a report entitled, "Urban Traffic Congestion — A Perspective to Year 2020." The basic premises of that study are as follows:

- There is *no* single presently available strategy that can solve the congestion problem.
- It will take the *best integration* of the most promising strategies available to manage the problem.

In dealing with metropolitan Boston's transportation problems, it is especially appropriate to stress these basic points since a strong argument can be made that Boston has taken a very unbalanced approach to its transportation problems. Since the early 1970s, transportation officials in the area have made a very impressive commitment to mass transit and have built a first-rate transit system, perhaps one of the nation's best. Unfortunately, the same cannot be said for the area's street and highway systems which, over the same period of time, have seen little in the way of improvements of substance.

The proposed model program suggests making a change in direction, since it calls for a balanced approach to transportation. The program itself consists of strategies taken from the following three broad categories:

- Transportation Systems Management (TSM)
- Transportation Demand Management (TDM)
- Capacity Addition.

Transportation systems management involves those strategies that are intended to effectively manage *vehicle flow*. Transportation demand management consists of strategies that can provide a means for *reducing demand* on the transportation system. And the capacity addition category consists of those strategies that involve *major capital improvements* to increase system capacity.[5]

Each of these categories will be examined individually in order to identify those specific strategies that hold the greatest promise for the area's transportation community based on actual successes observed in various parts of the country. Where possible, benefits and costs associated with a particular strategy are identified.

Transportation Systems Management

When considering transportation systems management (TSM), there are certain strategies that are appropriate for dealing with arterial system congestion and there is another completely different set of strategies that is appropriate for dealing with freeway system congestion.

TSM for Arterial Roadways. The TSM measures for addressing traffic congestion on arterial roads that are included in the model program are:

- Signal retiming and coordination
- Centralized computer signal systems
- Enforcement of parking rules and regulations

Signal Retiming and Coordination: More often than not, traffic signals are installed and forgotten about. As traffic increases and patterns change, the signals' timing plans become obsolete and the signals themselves become counterproductive traffic management tools. The FHWA estimates that of the approximately 204,000 urban signalized intersections in the United States, about 148,000 need upgrading of physical equipment and signal timing optimization, and another 30,000 are in need of retiming only.[6] Given that traffic signal improvements, including retiming and signal coordination, generally produce the greatest payoff for reducing congestion on arterial streets, transportation planners and traffic engineers are allowing one of the most effective traffic management tools available to them to go to waste.

Fairly simple microcomputer software is readily available for optimizing signal timing at isolated intersections, while more sophisticated microcomputer software exists for coordinating the timing of a series of closely-spaced signalized intersections that would achieve optimum traffic flow progression through these intersections. Not only is the software readily available, but most transportation planning agencies in major urban areas possess the required advanced microcomputer capabilities to operate this software. Therefore, the means exist for performing the necessary analyses that would produce up-to-date timing plans. These plans need to be put into effect, however, and that necessitates action on the part of the agencies that have responsibility for installing and maintaining the traffic signals. Typically, these would be either the state highway agencies or the traffic engineering departments of the various cities and towns.

Several states — including California, Florida, North Carolina, Pennsylvania, and Michigan — fully recognized the importance of this strategy and have already undertaken statewide traffic signal retiming programs. Their experiences have confirmed that signal retiming is an extremely cost effective strategy. On average, benefit-to-cost ratios of 20 to 1 were attained in these states. In California, the signal retiming program resulted in a three-year benefit-to-cost ratio of 58 to 1. In terms of travel time savings, up to 25 percent reductions in travel time were achieved.[5]

An important point that must be emphasized is that these signal retiming programs cannot be performed on a one-time basis. There needs to be a continuing commitment to this type of program, otherwise the signal timing plans will once again be out-of-date. The rate at which the cycle needs to be repeated will vary with the rate of traffic growth in a particular area. For example, it is recommended that high growth areas should be on at least a three-year cycle.

Centralized Computer Signal Systems: The FHWA estimates that more than 50 cities in the United States have centrally controlled computerized signal systems. Of these cities, Los Angeles and San Diego have two of the most advanced and successful systems.

Computerized signal systems that are centrally controlled offer traffic engineers the ability to monitor and control all signals within an urban area on a real-time basis and in a fully integrated manner. With these systems, the status of citywide traffic flow conditions can be monitored constantly from one central location where the signal timing and control strategies can be easily and quickly changed to meet existing conditions. This type of system offers the traffic engineer tremendous flexibility not only in dealing with everyday changes in traffic, but also in dealing with unexpected incidents as well as with the traffic problems incurred by major cultural and sporting events. Another major advantage offered by this type of system is that it also provides for the fast and accurate detection of equipment malfunctions. These systems, therefore, allow for the optimum management of signalized intersections on an area-wide basis.

Studies have shown that centrally-controlled computer signal systems can reduce travel time by as much as 40 percent.[5] These systems are clearly very sophisticated in nature and, to be successful, they require highly trained and competent traffic engineers to operate and maintain them. Cities interested in such systems should, therefore, recognize that they would have to be prepared to make major investments in order to obtain and maintain the staffing resources and expertise to properly utilize these systems. Typically, only the very largest cities in the country can afford to think in terms of such investments.

Enforcement of Parking Rules and Regulations: The loss of arterial capacity due to illegal parking is a major problem in many of the larger urbanized areas. This problem arises when the available supply of parking spaces falls substantially short of the demand. Under these circumstances, there is intense competition for every space and drivers will go to almost any limits to find a parking space, including parking illegally. This problem is no more evident than in downtown Boston. It is not uncommon to find workers parking there illegally all day long; nor is it uncommon to find drivers double parking, usually on a short-term basis, along some of the city's most important arterial streets during the rush hours. Both of these situations result in a substantial loss of precious arterial capacity that would otherwise be available.

In terms of capacity loss, double parking during the rush hours is especially devastating since it leads to the loss of a lane and can mean the loss of as much as 50 percent of the capacity of the arterial street, just when it is most needed. Such a loss of capacity is a situation that cities on the verge of gridlock cannot allow to happen.

One way to deal with this problem is, of course, through strict enforcement of parking rules and regulations, not only by ticketing but also by employing an aggressive vehicle towing program. Boston has initiated some pilot programs in both of these areas. San Francisco has also done some work in this area. In San Francisco's case, the city has used time-lapse photography to document before and after conditions, and the results are quite dramatic. Certain arterials that had previously been severely congested were transformed into arterials that are now operating at acceptable levels of service — a radical transformation that was achieved quickly and through the simple means of enforcement. There is, perhaps, no more readily available means of reducing arterial congestion than through the application of this particular strategy.

As is the case with all other strategies in the model, to achieve significant area-wide improvements in traffic flow, a comprehensive approach must be taken and there must be a continuing commitment to the program. The old saying that streets are much too valuable to be used as parking lots was never more applicable than it is today.

TSM for Freeways. To properly address the problem of freeway congestion, two types of congestion that affect freeways must be considered:

- Recurring congestion; and
- Non-recurring congestion.

Recurring congestion is very predictable in that, essentially, it takes place every day at the same hours and at the same locations. It takes place during rush hours when a freeway is overloaded and at locations where the capacity is constrained. Examples of such locations are points where ramp traffic accesses the mainline, short weaving sections and narrow freeway cross-sections. Non-recurring congestion, on the other hand, is very unpredictable and is caused by such incidents as traffic accidents, disabled vehicles, spilled loads and adverse weather conditions.

The TSM strategies for dealing with freeway congestion that are included in the model address both of these types of congestion. Those strategies are:

- Ramp metering
- Incident management programs
- Mitigation of construction-related impacts

Ramp Metering: According to the FHWA, short of adding lanes to a freeway or building another freeway, ramp metering is the most effective TSM measure available today for dealing with recurring congestion on a freeway. The points where ramps merge with the mainline are usually the source of much chaos in freeways that carry high volumes of traffic. Ramp metering serves as a means of turning that chaos into some semblance of efficiency. A ramp metering system regulates traffic at entrance ramps by releasing vehicles one or two at a time so that they gain access to the freeway in an orderly fashion. The ramp metering system is usually controlled by a computer

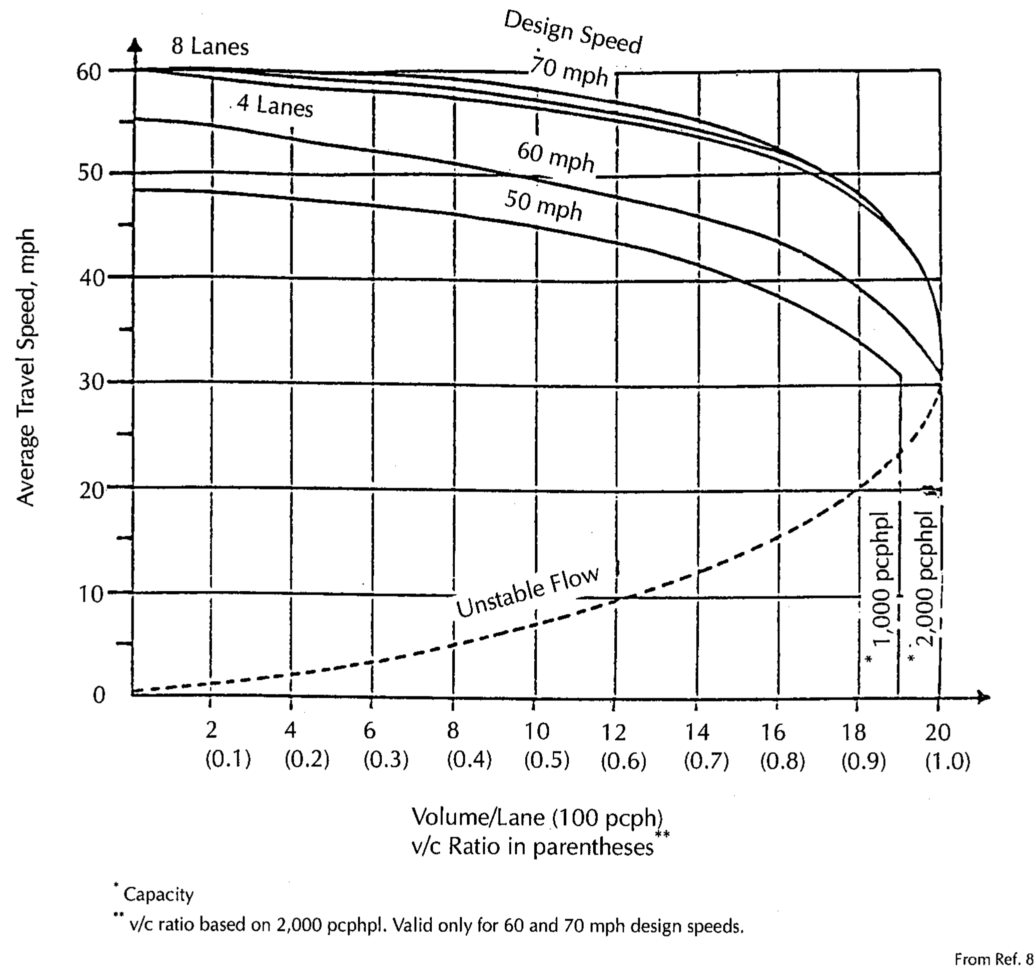

FIGURE 1. The relationship between freeway speed, volume and capacity.

that monitors freeway and ramp traffic volumes and utilizes this information to adjust the rate at which vehicles are allowed onto the mainline.[7]

To properly understand the concept of ramp metering requires some understanding of the classical relationship that exists between freeway travel speeds and volumes per lane. That relationship is presented in Figure 1. The curve shows that speed reduces gradually as the volume per lane increases. This relationship is maintained until the volume per lane reaches 2,000 vehicles per hour, the capacity of a freeway lane. Beyond this critical point, the curve doubles-up onto itself, and enters the range of unstable flow. In this range, the traffic becomes extremely volatile and breaks down at the slightest disturbance. With the breakdown of the normal traffic on the freeway, a dramatic reduction in speeds results, with an accompanying loss of capacity since a lane in the range of unstable flow carries substantially less volume per hour than the maximum capacity of 2,000 vehicles per hour.[8]

The primary objective of ramp metering is to keep the traffic volumes on the mainline at or below the critical volume of 2,000 vehicles per lane per hour and thereby prevent the mainline from going into unstable flow. In this way, the full capacity of the mainline is preserved and the freeway is able to operate efficiently and safely.

Ramp metering can be used to address problems at specific freeway locations or to address system-wide problems. Regardless of the application, the experiences with ramp metering across the country show substantial improvements in traffic flow. According to the FHWA, average speed increases of 30 percent commonly result, while freeway congestion is reduced by 60 percent. In addition, experience has revealed that ramp metering reduces accidents by 20 to 50 percent due to improved merging conditions.[5] The experience with ramp metering is also quite extensive as can be seen in Table 3.[9]

Table 3
Listing of Cities That Use Ramp Metering

Los Angeles, CA
Sacramento, CA
San Diego, CA
San Francisco,CA
San Jose, CA
Denver,CO
Chicago, IL
Detroit, MI
Minneapolis, MN
Dallas, TX
San Antonio, TX
Fort Worth, TX
Houston, TX
Milwaukee, WI
Toronto, Canada

There have been some impressive experiences with ramp metering systems. In Los Angeles, a recent ramp metering installation resulted in a 104 percent increase in average speed (from 25 to 52 mph), and a 20 percent reduction in ramp wait times. In Detroit where ramp metering was installed to address a problem at a specific location on a freeway, results showed a 114 percent increase in travel speeds (from 27.6 to 59.9 mph). In Minneapolis, there was a 32 percent increase in speeds and a reduction of 38 percent in accidents over the 17-mile section of Route I-35 West. Lastly, in Chicago, a 10-mile section of their 90-mile system experienced a 45 percent increase in speeds. It should also be mentioned that in every case where ramp metering has been used in California there has been a reduction in ramp-related as well as in overall accidents.[5] The installation costs run at approximately $30,000 per ramp and the cost to operate is usually in the vicinity of $6,000 to $9,000 per ramp per year. These costs are a reasonable burden to bear for the benefits that can be gained from implementing ramp metering.

Ramp metering will work best when there are adequate alternate routes for ramp traffic and adequate storage at the ramps themselves. In those instances where either of these conditions do not exist, excessive wait times at ramps, as well as unreasonably long queues, can be prevented through the use of meter overrides that can accelerate metering rates when certain prescribed limits are exceeded. The use of these overrides is a common practice in Denver where alternate routes are scarce and in Chicago where ramp storage is often exceeded. Even under these adverse circumstances both cities report that, overall, ramp metering is a most beneficial strategy for controlling freeway congestion.

Incident Management Programs: According to the FHWA's research, it is estimated that 60 percent of all freeway congestion is of a non-recurring nature and can be attributed to incidents. As already defined, an incident can be one of many occurrences ranging from a major traffic accident to a simple flat tire. The gawking that is associated with these incidents can also contribute significantly to the problem of freeway congestion. Because incidents contribute so heavily to freeway congestion, it is important to have in place programs for dealing with them. Such programs are known as incident management programs and consist of the means for detecting incidents, responding to the incidents and clearing the incidents as quickly as possible. The element of time that it takes to accomplish each of these three phases is absolutely critical since it is estimated that each additional minute that it takes to clear an incident results in six additional minutes of upstream delay. To compound the problem, this additional delay invites opportunities for secondary incidents.[5]

An incident management program typically consists of automatic surveillance systems and service patrols that serve as the means of detecting incidents, tow trucks of varying sizes to clear incidents of varying scope, and real-time motorist information systems (such as changeable message signs and highway advisory radio) to inform motorists of the appropriate actions that they should take to avoid the incident.

A well thought-out incident management program requires advanced planning and cooperation between the many agencies that have jurisdiction over the different types of incidents that might occur in the area. This interagency coordination is essential so that the proper agencies can be dispatched to respond to a given incident in a quick and orderly fashion.

The FHWA has compiled a listing of all known incident management programs in the country.[10] Based on this listing, the most comprehensive programs currently in place are found in the following cities:

- Chicago: 110 miles of freeway
- Los Angeles: 450 miles of freeway
- New Jersey Turnpike: 50 miles of highway
- San Diego: 50 miles of freeway
- Minneapolis/St. Paul: 35 miles of freeway
- Seattle: 20 miles of freeway

The best documented information available today on benefits and costs associated with these programs comes from the Los Angeles program where, based on ten years of experience, they have observed benefit-to-cost ratios of 6 to 1. On certain segments of their freeway system, they have achieved reductions in delays in the order of 50 to 65 percent which are attributed directly to their incident management program.[5]

In Chicago where the program consists primarily of 35 vehicles patrolling 110 miles of freeways around the clock, it is estimated that the program costs $25.00 per incident and that it has handled over 100,000 incidents per year. The savings in freeway travel time, although not known, must be astronomical.

Mitigation of Construction Related Impacts: Currently, many urban freeways are in need of reconstruction, and many more will require rehabilitation throughout the next decade. The reconstruction of a major urban freeway can, of course, cause significant disruption to traffic and contribute greatly to congestion woes. Therefore, the challenge to the transportation engineer is to ensure that these freeways are reconstructed with a minimum of disruption to traffic.

Knowledge gained over the past three to five years on such rehabilitation indicates that a successful reconstruction project requires a strong traffic management plan consisting of a series of measures designed to mitigate the impacts of the reconstruction. The types of measures that have proven most effective in minimizing construction-related impacts include project site measures, alternate route measures, alternate mode measures and public information measures.

Project site measures to mitigate construction impacts include such activities as:

- The use of reversible lanes, where appropriate, to maintain the capacity of the freeway in the peak direction of travel.
- The use of tow trucks, as part of an incident management plan, to clear the roadway of accidents and breakdowns as quickly as possible.
- The use of nighttime and weekend periods, whenever possible, for performing construction work.
- The construction of temporary detours.
- Extensive use of construction signing and lighting.

Alternate route measures consist of the following:

- Designating the appropriate alternate routes.
- Providing adequate signing along these routes to facilitate their use by unfamiliar users.
- Improving operations along these routes by making the necessary intersection and traffic signal alterations.
- Providing sufficient police supervision

along alternate routes to further facilitate traffic flow.

Alternative mode measures include the following:

- Expand transit service.
- Increase promotion and marketing of ridesharing programs.
- Expand the park-and-ride network.

Public information measures are important in providing the community with accurate and timely information on the status of the reconstruction project and require establishing a comprehensive community relations/media campaign.

All of the above measures were employed during the reconstruction of the Southeast Expressway in Boston, a project that many had feared would create total chaos but which, in fact, was accomplished with only minimal disruption. The experience with the Southeast Expressway and with several other similar projects throughout the country clearly demonstrates that an effective traffic management plan is the key to a successful freeway reconstruction project.

Transportation Demand Management

The transportation demand management (TDM) measures included in the model program are:

- Public transportation
- Ridesharing
- Variable work hour programs
- Truck delivery rescheduling
- Growth management

While the strategies included in the TSM category were chosen on the basis of proven successful use, most of the strategies in the TDM category are included on the basis of their *potential* for addressing the problem of traffic congestion. With the exception of variable work hour programs, and of public transportation which has a proven track record in certain situations, the other measures included in the TDM category have a very limited record, either in terms of successful use or in terms of the extent to which they have been tried. These programs are, nevertheless, included here because they hold a good deal of promise for the transportation community.

Public Transportation. Many urban planners have long subscribed to the belief that public transportation is the ultimate solution to the problem of traffic congestion. Extensive experience nationally, however, does not support this general belief. First and foremost, what we know from experience is that mass transit *alone* is not the answer to the traffic congestion problem under any circumstances. Secondly, mass transit can be a major part of the solution to the problem *only* under certain circumstances. The facts regarding mass transit seem to indicate the following:

- That public transportation plays a critical and indispensable role in serving the central cities of the older and larger metropolitan areas. This service includes the commute from the suburbs to the central city.
- That it plays only a very minor role in the ever-growing suburb-to-suburb commute, even in the older and larger urban areas.
- That it plays a virtually insignificant transportation role in the smaller metropolitan areas.

Support for each of the above points can be found in a 1988 Urban Mass Transportation Administration report to Congress entitled "The Status of the Nation's Local Mass Transportation: Performance and Conditions."[11] Some of the more pertinent statistics from that report indicate that the older metropolitan areas with over one million population experience over ten times more mass transit use per capita than areas with populations under 200,000. The report also shows that areas in the Northeast experience over four times higher mass transit use per capita than areas in the West. The report goes on to state that only two percent of the suburb-to-suburb work trips are made using public transportation and that mass transit's share of urbanized area work trips is only nine percent when the smaller metropolitan areas are included.

Strong support for the point that mass transit plays a vital role in serving the central cities of the older and larger metropolitan areas can be found in the 1980 Census Journey To Work information that, in the case of Boston, reveals that 61 percent of the work trips to the central business district are made using public transportation. Similarly, strong transit statistics can be found for Manhattan and downtown Chicago.

The case for mass transit, therefore, needs to be made on a very selective basis since it will vary dramatically with the characteristics of a particular metropolitan area. For large, established cities such as Boston, however, there is no question that the utmost use of mass transit must be made and that it will undoubtedly be a critical component to the solution of the traffic congestion problem.

Ridesharing. The 1980 Census indicated that approximately one out of every six work trips in the larger metropolitan areas was by carpooling. That Census further indicated that there was a slight decline in carpooling between 1970 and 1980. At least two conclusions can be drawn from these statistics. First, it can be concluded that ridesharing is by no means an insignificant mode of transportation in the larger metropolitan areas. Second, a conclusion can be drawn that the many programs established since 1974 to market ridesharing have not been especially productive. The latter conclusion is further supported by a 1985 Urban Mass Transportation Administration evaluation of 17 of the nation's most comprehensive ridesharing programs.[12] That evaluation concluded that:

- Ridesharing programs were found to have a small direct impact on the rideshare mode split.
- Only 0.4 to 1.2 percent of all employees surveyed had found the ridesharing program of direct help to them in getting started with ridesharing.
- When the question was limited to ridesharing employees, it was found that only two to five percent of the existing carpoolers were helped to join, form or maintain their carpools by the ridesharing programs.
- An overwhelming majority of ridesharing arrangements resulted from informal contacts at work or from household members deciding to commute together.

Ridesharing theoretically has great possibilities for reducing congestion; however, this potential has not been attained. The challenge to the transportation community is, therefore, to find a better means to tap this unrealized potential. Perhaps more resources must be devoted to programs that serve as incentives to ridesharing. Such programs include preferential parking programs at the workplace, park and ride programs at fringe sites, and a network of high occupancy vehicle (HOV) facilities. Much more work could be done in each of these incentive areas that might just provide needed breakthroughs.

Variable Work Hour Programs. The purpose of variable work hour programs is to reduce highway and transit congestion by spreading peak periods of travel over a longer span of time. These programs can include staggered work hours and flextime, both of which allow employees varying degrees of flexibility in arrival and departure times, as well as shortened work weeks.

According to the FHWA, a variable work hour program has served as the leading strategy for reducing traffic congestion in several cities. Further, these programs have the potential for reducing travel times by 15 percent.[5] To have a meaningful impact, however, these programs must be implemented and coordinated on an area-wide basis.

Truck Delivery Rescheduling. The objective of rescheduling truck deliveries to off-peak hours is to reduce truck traffic during the peak periods on both the freeway system and the arterial streets and thereby reduce traffic congestion.

Having trucks on commuter routes during the congested peak period is a less than desirable situation since trucks take up as much space as 2 to 2.5 automobiles and they have limited maneuverability — factors that can greatly limit the capacity of the roadway. Furthermore, when trucks are involved in an accident, the results can be devastating.

Major incidents involving trucks during the commuting hours are a nightmare to the transportation engineer, and to incident management personnel as well, since these incidents usually lead to lane closures and, at times, lead to the closure of the entire freeway in the peak direction of travel for several hours. The impacts of such incidents on traffic congestion are enormous, sometimes quadrupling the length of time it takes to complete the commute trip.

The best experience to date with the rescheduling of truck deliveries was during the 1988 Los Angeles Olympics.[13] In preparation for the Olympics, the City of Los Angeles and the California Highway Patrol, working in conjunction with the California Trucking Association, successfully negotiated an arrangement with one of the major trucking unions that allowed some truckers to shift their delivery hours to the off-peak periods during the five weeks of the Olympics. The following benefits resulted:

- Peak period truck traffic was down six percent overall, and more than 15 percent on some freeways.
- Truck related freeway accidents were down 42 percent.
- Truck related accidents decreased 58 percent region-wide.

This experience has shown that rescheduling truck traffic can lead to very substantial reductions in truck-related accidents that, in turn, translates into improved commuting safety and a lessening of congestion.

The rescheduling of truck traffic can be accomplished either through the imposition of truck bans or through negotiated agreements. The imposition of truck bans is not an easy issue to be dealt with, either politically or administratively. Therefore, cities that are experiencing problems with traffic congestion should, as a first step, pursue voluntary arrangements with trucking associations and unions as a means of rescheduling truck traffic. As a last resort, the possibility of imposing truck bans on severely congested routes should be fully explored.

Growth Management. Growth management involves a series of innovative techniques whereby the burden of traffic mitigation is placed on developers and businesses. Because these techniques have only been in use for a short period of time, very little quantifiable data is available for determining their effectiveness in reducing traffic congestion. Nevertheless, the early signs are promising and there appears to be great potential for this up-and-coming field.

Two of the techniques that fall in the category of growth management are:

- Mitigation ordinances from local agencies or authorities that require developers to minimize the traffic impacts caused by their developments.
- Negotiated development agreements between public and private entities reached through case-by-case negotiations whereby the private sector shares in the costs of financing infrastructure improvements.[9]

According to the FHWA, one of the most successful examples of an ordinance instituted to mitigate traffic impacts involves the City of Pleasanton, California. Under this ordinance, businesses and developers were required to take steps to reduce single-occupant vehicle trips during peak traffic hours by 45 percent and to maintain a level of service "C" on city streets. (The level of service is a qualitative measure that describes the operational conditions within a traffic stream. The level of service ranges from A to F, with an A level representing the highest rating and F representing the lowest.) A period of four years was established for meeting these objectives. The ordinance also called for monetary penalties to be imposed on businesses that fail to demonstrate adequate progress toward meeting the program's objectives. To date, after three years, this ordinance is on target towards meeting its objectives.[5]

An experience in San Diego, California, can also be cited as a successful example of a negotiated development agreement. A developer in that city spent some $58 million on new roadways and traffic signal upgrades in order to mitigate the impacts for a particular project.[9]

Based on the early successes in this field, more and more cities are turning to growth management techniques as one means of dealing with traffic congestion.

Capacity Additions

Measures to institute capacity additions constitute the last category of the model program and includes the following strategies:

- Widening existing highways
- Adding high occupancy vehicle (HOV) lanes to the network
- Intersection widening

Widening of Existing Highways. In the central cities of large metropolitan areas few opportunities remain for widening existing highways because of the limited availability of rights-of-way, the severity of environmental and social impacts, and the extraordinarily high costs of construction. Where the opportunities still exist, however, as is the case with Boston's Central Artery, widening should be given full consideration because it can add substantially to the capacity of the highway, reduce congestion significantly, and help maintain the economic vitality of the area.

In the suburbs, the opportunities for widening highways are greater because the constraints mentioned above are usually not as severe. Furthermore, there is an added incentive to pursue highway widening in the suburbs. That incentive is public transportation's apparent inability to serve the suburb-to-suburb commute.

The FHWA estimates that, nationally, highway widening is still feasible in about 10 to 15 percent of the urbanized area freeway mileage and that, where feasible, highway widening can lead to benefit-to-cost ratios of 4 to 1.[6]

Adding High Occupancy Vehicle (HOV) Lanes to the Network. HOV lanes are freeway and arterial street lanes that are dedicated exclusively for use by carpools, vanpools and buses. HOV lanes vary in form, but usually consist of:

- Physically separated lanes that are concurrent with the peak direction of flow and that are located adjacent to the center line of the roadway.
- Physically separated lanes on the shoulder of the freeway.
- Physically separated contra-flow lanes.
- Physically separated single or twin reversible lanes.
- Concurrent flow lanes, either in the median or in the shoulder, that are not physically separated.

HOV lanes offer the transportation engineer a very powerful tool for dealing with traffic congestion because they can carry three times the number of persons that one conventional lane can carry. For example, one HOV lane on the Shirley Highway in Washington, D.C., typically carries 8,600 persons per hour during peak traffic hours, whereas a conventional lane on that same highway carries around 2,400 persons per hour. Similar results have been documented on Route I-10 in San Bernardino, California. With that kind of capability, it is easy to see how the person-carrying capacity of a roadway can be dramatically increased by the addition of an HOV lane. HOV lanes offer another major benefit to commuters in that the travel time advantage on an HOV lane can be twice that of a conventional lane.[5]

The problem to date is that the HOV concept has been highly underutilized. Fortunately, all indications are that this situation is changing and that HOV lanes will play a primary role in addressing traffic congestion in the next decade.

In 1985 there were only about 123 miles of HOV lanes in operation nationally, whereas by the end of 1989 the FHWA estimates that there will be some 260 miles open to traffic. In addition, the FHWA estimates that there are presently $5 billion worth of HOV facilities under design.

Areas that recognize the tremendous potential of HOV lanes, and that are planning extensive systems, include Santa Clara County, California, which has a proposed 140-mile HOV network; Seattle, Washington, with 110 miles proposed; Houston, Texas, with 70 miles proposed; and Miami, Florida, with 30 miles proposed.[5] The vision shown by these areas can

Table 4
TSM/City of Boston

	Strategy Implemented	Prototype Effort Underway	Strategy Planned	Strategy Inactive
TSM\Arterials				
Signal Retiming			X	
Centralized Computer Signal System			X	
Enforcement of Parking Laws		X		
TSM\Freeways				
Ramp Metering				X
Incident Management Programs		X		
Mitigation of Construction Impacts	X			

serve as models for other localities, and it is only a matter of time before every major metropolitan area in the United States develops a comprehensive HOV network.

HOV facilities can be costly to build, but given their person-carrying capacity, they are very cost-effective transportation improvements.

Intersection Widening. The capacity of arterial streets is essentially governed by the capacity of the intersections along those arterials. Thus, if the intersections along arterial streets operate at, or above, capacity levels, traffic along the entire length of these arterials is likely to flow at unacceptable levels of service. In those instances where intersections are operating at or above capacity (and there are many such instances in major metropolitan areas), the most direct way to improve the capacity of the intersections is to provide an additional lane at the approaches to the intersections.

Additional lanes at approaches can be provided either by the traditional method of physically widening the intersection or by the more expedient method of removing parking at the curb and thereby creating an additional lane at the approach. In highly developed urban areas, the option to physically widen the intersection is not likely to be available very often. However, the option to eliminate parking at the curb is, probably, readily available in most cases. Like many of the other straightforward strategies discussed in this model, though, this option is not taken advantage of often enough since it can mean eliminating parking spaces in neighborhood communities that already suffer from a shortage of parking spaces.

Large metropolitan areas with traffic congestion problems should take a comprehensive look at all intersections along major arterials and, where needed, widen those intersections by one of the two means discussed above, if at all possible.

Comparison of Current Efforts in the Boston Area Against the Model Program

The model program serves as a "yardstick" to assess the extent to which efforts to combat traffic congestion are being pursued in the Boston metropolitan area. That assessment will be carried out at two geographic levels. Utilizing the model program, first the extent of the efforts being pursued in the City of Boston are assessed, and then the extent of those being pursued in suburban Boston, an area extending to the I-495 beltline, are assessed.

The City of Boston. Boston has several efforts either planned or underway to combat congestion. A comparison of those efforts against the model program is shown in Tables 4, 5 and 6. Table 4 deals with the TSM component of the model; Table 5 with the TDM component; and Table 6 with the capacity addition component. Each table lists the model program strategies, then indicates whether the strategy is being pursued by the city and to what extent. The extent to which a strategy is being pursued is defined in one of four ways. If a strategy has been implemented area-wide, and on a comprehensive basis, it is considered to be fully implemented. If, on the other hand, a strategy has only been implemented on an experimental basis, or in an isolated fashion, it is defined as a "prototype effort." Strategies that have not yet been implemented, but that are either being planned or under design are defined as "strategies planned." Lastly, strategies that have not been pursued to any significant extent are shown in the column labeled "strategy inactive."

Assessment of TSM Activities in the City of Boston: Table 4 shows that some progress is being made towards implementing the various strategies in the TSM category. While the level of activity depicted is encouraging, it also can be seen that much remains to be done to reach the desired goal — *i.e.*, full implementation of all of the strategies. Some specific observations about the extent of progress towards implementation of each strategy follow:

• Centralized Computer Signal Systems. The city and the state are now installing a state-of-the-art centralized computer signal system that will extend to some 200 signalized intersections in the downtown area. When it becomes available sometime in late 1990, it will provide the city with an excellent tool for optimizing traffic flow on arterial streets. The success of this sophisticated system will hinge on the city's ability to obtain the necessary expertise to operate and maintain it.

• Enforcement of Parking Laws. The city has established its pilot Traffic Relief Program that provides for strict enforcement and aggressive vehicle towing efforts on certain designated arterials. This pilot program has been very successful to date, but it needs to be expanded to incorporate more of the city's major arterials. Unfortunately, given the tight fiscal environment that is developing within the state, it seems more likely that there will be a relaxation in maintaining this program rather than providing for its needed expansion.

• Ramp Metering. Neither the city nor the state have shown any appreciable interest in this strategy. Given the numerous and very substantial successes that have been documented throughout the country, it is indeed very disappointing that state and city governments have chosen to ignore this option. If the city and the state are serious in their efforts to combat traffic congestion, they should fully explore all opportunities for establishing ramp metering systems on Boston's freeways. They should start by looking at the Depressed Central Artery megaproject currently under design. It would appear that ramp metering would have tremendous applicability for relieving the congestion that is anticipated to take place along this stretch of highway, even after the project is built.

• Incident Management Programs. A rudimentary incident management program has been initiated on the Southeast Expressway and the Central Artery by the Metropolitan District Commission. Under this program, four large tow trucks and several police vehicles equipped with push bumpers patrol these highways during peak traffic periods. This effort is coordinated

Table 5
TDM/City of Boston

TDM	Strategy Implemented	Prototype Effort Underway	Strategy Planned	Strategy Inactive
Public Transportation	X			
Ridesharing	X			
Variable Work Hour Programs	X			
Truck Delivery Rescheduling				X
Growth Management		X		

with various radio station helicopter patrols. Some of the key ingredients missing from this program include electronic surveillance to supplement the roving patrols, effective interagency coordination that usually results in the development of incident management teams and well-conceived contingency plans, and a progressive motorist information system to alert drivers to seek alternate routes. The other very critical limitation with this program is that it does not cover the entire freeway system in Boston. What is needed is a state-of-the-art incident management program that is area-wide in scope.

• Mitigation of Construction-Related Impacts. These efforts represent an area in which the state highway agency appears to excel. During the reconstruction of the Southeast Expressway in Boston, a project which had the potential for causing massive traffic disruption, the state implemented an impressive traffic management plan that resulted in the project being accomplished with only minimal disruption. Currently, another large reconstruction project is underway in Boston, the Central Artery North Area Project, which appears to be following the path of success of the Southeast Expressway Project.

Assessment of TDM Activities in the City of Boston: As can be seen in Table 5, significant progress is being made towards achieving full implementation of the TDM strategies. In the area of public transportation, the state and the city are doing an outstanding job and the benefits derived have been immense. Likewise, variable work hour programs have been implemented successfully in downtown Boston, most notably by the insurance companies in the Copley Square area and by the state and federal governments. The state's ridesharing program has also been given a good deal of attention but, like most other ridesharing programs, the results have been less than impressive and the program appears to be stagnating. It is perhaps time to reevaluate the program and to find new and more productive directions to follow. With regard to growth management, Boston, like many other cities throughout the country, is getting very involved in this emerging area. The city has its "Access Plan Zoning Regulations" that went into effect recently. These

Table 6
Capacity Additions /City of Boston

	Strategy Implemented	Prototype Effort Underway	Strategy Planned	Strategy Inactive
Capacity Additions				
Widening of Existing Highways			X	
Adding HOV Lanes to the Network				X
Intersection Widening				X

regulations give the city certain powers such as:

- the ability to control the number of parking spaces in a private development;
- the ability to require developers to provide detailed traffic studies of the area affected by their development;
- the ability to require developers to make the necessary street improvements to mitigate the impact of their development;
- the ability to require developers to provide mass transit subsidies; and,
- the ability to require developers to achieve certain levels of transit use by the occupants of their development.

These regulations, in effect, give the city the power to manage growth. It remains to be seen, however, whether Boston will take full advantage of these powers, since the regulations have only been in effect for a short period of time. In any event, a major step forward has been taken with the enactment of the regulations.

The one strategy in Table 5 that needs considerably more attention is truck delivery rescheduling. Both the city and the state need to take a more aggressive posture in this area. Currently, there does not appear to exist a comprehensive program that would deal with the trucking issue on both freeways and arterial streets. As a first step, better communications need to be established with trucking associations and unions to broach the voluntary rescheduling of truck traffic on certain congested routes.

Assessment of Capacity Addition Activities in the City of Boston: This assessment is shown in Table 6. It would appear that the Central Artery/Third Harbor Tunnel represents the last opportunity for a freeway widening in the City of Boston. This project is currently under design and the state, in particular, appears totally committed to seeing that the project is constructed.

With regard to the use of HOV lanes, the city and the state have a long way to go to catch up with those cities that have taken a progressive stance on this issue. At this time Boston does not even have an area-wide HOV plan, nor does it have any significant operational HOV facilities. There is an HOV lane on the Route I-93 bridge in Boston over the Charles River and an HOV "system" is planned for the Central Artery/Third Harbor Tunnel project. The I-93 lane is a meager 0.5 mile in length and

Table 7
TSM/Suburban Boston

	Strategy Implemented	Prototype Effort Underway	Strategy Planned	Strategy Inactive
TSM/Arterials				
Signal Retiming				X
Centralized Computer Signal System				X
Enforcement of Parking Laws				X
TSM/Freeways				
Ramp Metering				X
Incident Management				X
Mitigation of Construction Impacts	X			

the "system" for the Central Artery/Third Harbor Tunnel is highly localized and extremely limited in scope. It would extend along Route I-93 from the Massachusetts Avenue interchange to South Station and along Route I-90 from South Station to the portal of the Third Harbor Tunnel, a grand total length of approximately two miles. In comparison, and to put these efforts in perspective, the cities of San Francisco, Los Angeles and San Diego already have a combined 90 miles of HOV lanes in operation, much of Houston's 70-mile system is already operational, and Miami's 30-mile system is well underway towards being implemented.

Even though Boston's freeway system cannot easily accommodate HOV lanes because of the limited availability of right-of-way, HOV lanes can be, and have been, placed in shoulders and contra-flow HOV arrangements are a possibility. As a minimum, there should be an HOV lane along the entire length of the Southeast Expressway that extends beyond the City of Boston; there should be an HOV lane carried through the Third Harbor Tunnel; there should be an HOV lane on Route I-93 North from Route 128 to downtown Boston, a large portion of which would lie in suburban Boston; and on the Massachusetts Turnpike there should be toll booths dedicated exclusively to HOVs.

Both the city and the state are missing out on a great opportunity to add substantially to the person-carrying capacity of their freeway system by not recognizing the tremendous potential of HOV lanes. As a first step, they should develop a comprehensive area-wide HOV plan.

Much remains to be done also in the area of intersection widening. While it is recognized that in Boston the opportunities for intersection widening through the acquisition of additional rights-of-way are very limited, much could still be done to provide additional lanes at intersec-

Table 8
TDM/Suburban Boston

	Strategy Implemented	Prototype Effort Underway	Strategy Planned	Strategy Inactive
TDM				
Public Transportation			X	
Ridesharing	X			
Variable Work Hour Programs		X		
Truck Delivery Rescheduling				X
Growth Management		X		

tion approaches by the simple and expedient method of eliminating parking at the curb for a short distance. Given the city's extremely limited arterial street capacity, there is a need to develop a comprehensive program that would optimize its implementation.

Suburban Boston to I-495. Concerted efforts to remediate traffic congestion problems in the suburban Boston area have been either planned or are currently underway. A comparison of those efforts against the model program is shown in Tables 7, 8 and 9. Table 7 presents the TSM component of the model; Table 8 deals with the TDM component; and Table 9 summarizes the capacity addition component. Each table lists the model program strategies, then indicates whether the strategy is being pursued and to what extent. The format and organization of this information is identical to that used in the previous section on the efforts made by the City of Boston.

Assessment of TSM Activities in Suburban Boston: Table 7 shows that little progress is being made towards implementing the various strategies in the TSM category. The need for signal retiming is every bit as great on suburban arterials as it is on city arterials. Unfortunately, efforts by the state to update signals under their jurisdiction have stagnated, and there does not appear to be a comprehensive program in place by the suburban communities to update the hundreds of signals that fall under their jurisdiction. Without an aggressive and well-coordinated plan of attack, suburban arterials will needlessly continue to function at lower levels of service than they should. Enforcement of parking laws on suburban arterials also appears to be lacking.

On suburban freeways, state-of-the-art incident management programs and ramp metering efforts are non-existent. Highly congested suburban freeways such as Route 128, Route 3 North, Route 3 South, Route 24 and Route I-93 North would appear to be prime candidates for state-of-the-art incident management programs. In addition, some of these routes may also be good candidates for ramp metering. Although not freeways, Route 1 North and Route 9 West could also benefit from incident management programs.

The feasibility of establishing a centralized state-of-the-art incident management program to cover all of the above facilities should be fully explored. Ramp metering should also be inves-

Table 9
Capacity Additions for Suburban Boston

Capacity Addition	Strategy Implemented	Prototype Effort Underway	Strategy Planned	Strategy Inactive
Widening Existing Freeways			X	
Adding HOV Lanes				X
Intersection Widening				X

tigated on each of the above freeways, starting with Route 128 where the levels of congestion have become intolerable.

Assessment of TDM Activities in Suburban Boston: This assessment is shown in Table 8. Public transportation's role in the suburbs, particularly in dealing with the suburb-to-suburb commute, has been virtually non-existent and is expected to continue to be very limited because of the nature of these trips. The suburb-to-suburb work trip involves scattered origins and scattered destinations that comprise patterns that mass transit cannot effectively handle. Massachusetts is, nevertheless, contemplating some innovative concepts in the hopes of enhancing mass transit's ability to serve these trips. The state is looking at the feasibility of establishing "transportation centers" at strategic locations along the congested suburban corridors. These centers would intercept the automobile trips that originate in the suburbs and provide mass transit service from those points to the various suburban employment centers. While these efforts are encouraging, there is no reason to believe mass transit will ever play a substantial role in serving the suburb-to-suburb commute.

As is the case in the City of Boston, the state has a well-funded ridesharing program that extends into the suburban area. This program has included extensive marketing efforts aimed at the suburb-to-suburb commuter, but despite these efforts ridesharing's potential in this area remains largely unrealized. As with public transportation, the challenge for ridesharing programs is made extremely difficult by the scattered nature of the trips.

Variable work hour programs in suburban Boston are usually the result of isolated efforts by individual companies. A comprehensive variable work hour program aimed at Route 128, Route 9 West, and Route 3 North employers would appear to be especially appropriate since these routes are extraordinarily saturated with employment centers. These same routes also should be targeted for truck delivery rescheduling.

The extent to which growth management is practiced in suburban Boston varies from community to community. Some towns, like Lexington, have excellent programs underway, others make virtually no attempt at controlling growth. This fragmented approach is not likely to have any significant impact on traffic congestion. From a traffic perspective, the key to successful growth management is to practice it on a broad regional basis.

Assessment of Capacity Addition Activities in Suburban Boston: As shown in Table 9, much remains to be done in this area. Any program to combat congestion in suburban areas that does not include a substantial effort to widen existing freeways would not appear to be a realistic program. Typically, major suburban freeways are facilities that are radially directed to the central city but which must serve two forms of commuting: the traditional commute from the suburb to the central city, and the suburb-to-suburb commute. It is the latter commute that is growing at an enormous rate and that is placing an extraordinary burden on these suburban radial routes. As already mentioned, the burgeoning suburb-to-suburb commute is a burden that public transportation cannot realistically handle. Therefore, freeway widening must serve as the most direct method of attacking this particular problem.

In suburban Boston there are two such radial routes in dire need of widening: Route 3 North and Route 3 South. In addition, the Route 128 beltline that is also plagued by the suburb-to-suburb commuting problem is in need of widening along certain segments. The state appears to be pursuing these widening projects. However, given the slow pace at which these projects are evolving, particularly the pace of the Route 3 projects, there is much to question about the state's commitment to them. An aggressive program to expedite these projects is needed, otherwise the opportunities that currently exist for widening these freeways will be lost.

Serious consideration also needs to be given to adding HOV lanes to the suburban Boston freeway system. The most obvious opportunities appear to exist on the suburban portions of the Southeast Expressway and on Route I-93 North from Route 128 to downtown Boston. Both routes serve primarily the suburb to the central city commute and both are badly congested — the two primary requirements for a successful HOV facility. On the Southeast Expressway, because of severe right-of-way limitations, a contra-flow HOV arrangement might be the appropriate solution. On Route I-93 North, on the other hand, there would appear to be sufficient space to add HOV lanes in the median. Other less obvious possibilities for HOV lanes might include Route 3 South, Route 24 South, and Route 128 in Braintree. There are presently no HOV facilities in suburban Boston, a fact that does not speak well for the state's program to combat traffic congestion.

There is presently no comprehensive program to widen intersections along congested suburban arterial streets. The state should first undertake a study to identify the most critical intersections in need of widening, and then establish a program to widen those intersections.

Strategies for the Boston Metropolitan Area

From the comparison drawn in the previous section of efforts underway in the Boston metropolitan area against the model program, several strategies that need to be further emphasized were identified. For the City of Boston these strategies that require strengthening involve:

- Comprehensive program to enforce parking laws
- State-of-the-art incident management program
- Ramp metering
- Truck delivery rescheduling
- Adding HOV lanes to the network
- Intersection widening

For suburban Boston these strategies consist of:

- Signal coordination and retiming
- State-of-the-art incident management programs
- Ramp metering
- Comprehensive variable work hour programs
- Truck delivery rescheduling
- Region-wide growth management program
- Aggressive program to widen the freeways
- Adding HOV lanes to the network
- Comprehensive intersection widening program

The basic framework for establishing a balanced and progressive program for combatting traffic congestion has been identified. It is now up to state and local elected officials to take the necessary steps to see that such a program is carried out.

Recommendations

It has been 15 years since the last comprehensive review of the Boston metropolitan area's transportation policies. That review was the Boston Transportation Plan Review (BTPR) that furnished the area's transportation officials with a set of transit-oriented policies that have guided them through the last decade and a half. While those policies may have been good for their time, they were one-dimensional in nature. In addition, based on what has been learned since that time, those policies have been shown to be ill-equipped to deal with the explosion in automotive traffic that occurred during the 1980s, and, more importantly, those policies are woefully inadequate for the coming decade. The Boston metropolitan area is thus left with severe traffic congestion problems that will only worsen unless these policies are updated and a more balanced approach for combatting traffic congestion is developed and implemented.

Other large metropolitan areas whose policies have, for the most part, been freeway-oriented are experiencing similar problems because they too failed to recognize that there is no single answer to the problem of traffic congestion. If the transportation community has learned anything in the last decade on how to combat traffic congestion, it is that it requires a multi-faceted approach wherein all of the components are in balance with each other to tackle the problem.

It is thus time for another comprehensive review of the Boston area's transportation policies. To be fair and objective, that review should be undertaken by an *independent* commission appointed by the Governor. Furthermore, the process for carrying out that review should allow for direct policy input by elected officials and should be totally open to the public.

The technical aspects of establishing a program for addressing traffic congestion have been addressed herein, and as such, it is intended to be only a starting point for further study and work. There are critical institutional issues of, at least, equal importance that also will need to be fully explored. Those issues should be addressed in the recommended policy review.

NOTE — *The contents of this article reflect the views of the author and do not necessarily reflect the official policy of the Federal Highway Administration.*

EDWARD L. SILVA *is a Transportation Planner for the Federal Highway Administration in Massachusetts. He holds a B.S. in Civil Engineering from Brown University and is a graduate of the Federal Highway Administration's two-year Highway Engineering and Administration Training Program. His transportation planning experience spans sixteen years with assignments with the FHWA Regional Office in Atlanta, Georgia, the FHWA North Carolina Division Office and the FHWA Massachusetts Division Office. He is an associate member of Sigma Xi and of the Institute of Transportation Engineering.*

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