NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM
SYNTHESIS OF HIGHWAY PRACTICE 177

FREEWAY CORRIDOR MANAGEMENT

TRANSPORTATION RESEARCH BOARD
National Research Council

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TRANSPORTATION RESEARCH BOARD
NATIONAL RESEARCH COUNCIL
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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Systematic, well-designed research provides the most effective approach to the solution of many problems facing highway administrators and engineers. Often, highway problems are of local interest and can best be studied by highway departments individually or in cooperation with their state universities and others. However, the accelerating growth of highway transportation develops increasingly complex problems of wide interest to highway authorities. These problems are best studied through a coordinated program of cooperative research.

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PREFACE

A vast storehouse of information exists on nearly every subject of concern to highway administrators and engineers. Much of this information has resulted from both research and the successful application of solutions to the problems faced by practitioners in their daily work. Because previously there has been no systematic means for compiling such useful information and making it available to the entire highway community, the American Association of State Highway and Transportation Officials has, through the mechanism of the National Cooperative Highway Research Program, authorized the Transportation Research Board to undertake a continuing project to search out and synthesize useful knowledge from all available sources and to prepare documented reports on current practices in the subject areas of concern.

This synthesis series reports on various practices, making specific recommendations where appropriate but without the detailed directions usually found in handbooks or design manuals. Nonetheless, these documents can serve similar purposes, for each is a compendium of the best knowledge available on those measures found to be the most successful in resolving specific problems. The extent to which these reports are useful will be tempered by the user's knowledge and experience in the particular problem area.

FOREWORD

By Staff
Transportation Research Board

This synthesis will be of interest to state and local traffic engineers, transportation planners, transit operators, law enforcement officials, public information agencies, and others responsible for the transportation elements of freeway corridors. Information is provided on the policies and procedures for freeway corridor management, and descriptions of a number of techniques and practices are presented.

Administrators, engineers, and researchers are continually faced with highway problems on which much information exists, either in the form of reports or in terms of undocumented experience and practice. Unfortunately, this information often is scattered and unevaluated, and, as a consequence, in seeking solutions, full information on what has been learned about a problem frequently is not assembled. Costly research findings may go unused, valuable experience may be overlooked, and full consideration may not be given to available practices for solving or alleviating the problem. In an effort to correct this situation, a continuing NCHRP project, carried out by the Transportation Research Board as the research agency, has the objective of reporting on common highway problems and synthesizing available information. The synthesis reports from this endeavor constitute an NCHRP publication series in which various forms of relevant information are assembled into single, concise documents pertaining to specific highway problems or sets of closely related problems.

Traffic growth and increasing congestion on urban freeways require a comprehensive approach toward managing the complex elements of freeway operations. This report of the Transportation Research Board provides information on freeway corridor management strategies, the components of management, examples of effective applications of the strategies, and benefits of freeway corridor management. The management techniques that are discussed include freeway surveillance and control; corridor street surveillance and control; high-occupancy vehicle facilities and incentives; police enforcement and traffic control, hazardous material and other truck traffic restrictions; alternative route planning; motorist assistance patrols; motorist information techniques; and traffic management for recurrent congestion, for incidents, for special events, and for work zones.

To develop this synthesis in a comprehensive manner and to ensure inclusion of significant knowledge, the Board analyzed available information assembled from numerous sources, including a large number of state highway and transportation departments. A topic panel of experts in the subject area was established to guide the researcher in organizing and evaluating the collected data, and to review the final synthesis report.

This synthesis is an immediately useful document that records practices that were acceptable within the limitations of the knowledge available at the time of its preparation. As the processes of advancement continue, new knowledge can be expected to be added to that now at hand.

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FREEWAY CORRIDOR MANAGEMENT

SUMMARY

Increasing traffic volume and congestion have made it essential to optimize use of existing facilities within urban freeway corridors. Business and service vehicles, as well as people traveling to and from work require around the clock mobility. Managing urban freeway corridors can provide mobility and optimize traffic operations. To do this, a comprehensive strategy is required, consisting of selective roadway construction, transportation demand management actions, and intensive management and control of the roadways in the freeway corridor (including freeways, arterial streets, and high-occupancy vehicle (HOV) facilities). This synthesis addresses the management and control of the entire freeway corridor.

The components of a freeway corridor management system include:

- Freeway surveillance and control,
- Corridor street surveillance and control,
- High-occupancy vehicle (HOV) facilities and incentives,
- Enforcement and police traffic control activities,
- Hazardous material and other truck restrictions,
- Alternative route plans and real-time motorist information displays to encourage diversion,
- Motorist assistance patrols, and
- Public information efforts (disseminating advance and real-time information).

The applications of freeway corridor management (with emphasis on active traffic management) include:

- Traffic management of recurrent congestion,
- Traffic management of incidents (non-recurrent congestion),
- Traffic management of special events, and
- Traffic management through and around work zones.

A complex interrelationship exists among the various components in the freeway corridor. A change in one part or one component of the corridor often affects traffic conditions in another. Since no one agency is responsible for all transportation-related facets of a freeway corridor, a coordinated and cooperative approach is required by all agencies as well as for different departments within the same agency to effectively manage traffic conditions throughout the corridor and to maximize the efficiency with which the corridor serves the traveling public.

SUMMARY OF BENEFITS TO BE GAINED THROUGH FREEWAY CORRIDOR MANAGEMENT

Several different groups benefit from freeway corridor management. Obviously, the motorist is the ultimate winner. Improved coordination, cooperation, and newly initiated system components in the corridor can result in:

- Decreased delay, fuel consumption, and vehicle emissions;
- Improved safety through reduced congestion, more timely response to accidents, and reduced exposure of stranded motorists to moving traffic;
- Improved public opinion of the agencies trying to provide the safest and most efficient transportation system possible; and
- Reduced driver stress and anxiety levels.

In some instances, freeway corridor management also provides benefits to the various agencies themselves. Sharing information among agencies helps to reduce duplicated effort in terms of data collection and analysis, and the management and operation of a particular component in the system can be tailored more precisely to the requirements of the corridor. Freeway corridor management can also benefit the overall economic stability and desirability of an area, helping to maximize traffic flow in the corridor, and making the area more attractive to businesses.

ORGANIZATIONAL STRUCTURES, POLICIES, AND PROCEDURES FOR EFFECTIVE FREEWAY CORRIDOR MANAGEMENT

The development of freeway corridor management differs significantly from that of other highway projects. First, the emphasis of freeway corridor management is on the integration of new or existing transportation components in the corridor, focusing on the cooperative operation and control of these components by various agencies. This is in contrast to highway projects where emphasis is on construction or expansion of traffic control and management hardware (although construction/expansion may be a part of a given freeway corridor management plan). Secondly, freeway corridor management plans are dynamic and highly flexible, unlike typical highway project plans which are relatively rigid once designed. Freeway corridor systems can vary in size from a single component (such as the operation of peak-period courtesy patrols or the introduction of HOV facilities into the area) to a complex multi-agency effort involving most or all of the transportation components in the corridor.

KEY ISSUES IN FREEWAY CORRIDOR MANAGEMENT PLAN DEVELOPMENT

Before efforts toward developing freeway corridor management can begin, three basic issues must be addressed:

- Who is going to develop the freeway corridor management plan and participate in the freeway corridor system?
- Who is going to fund the system and what sources of funds exist?
- Who is going to operate the system?

Who takes the lead in the development of freeway corridor management depends on the nature of the corridor problems being addressed. Regardless of who initiates the idea and system formation, it is imperative that all transportation-related agencies in the corridor be involved in the developmental process. Each agency contributes a different perspective to the overall view of the problem, and consideration of the various viewpoints present in the corridor can help avoid pitfalls throughout the development process. Although involvement of all agencies may not be required from the very onset of conceptual planning efforts, participation of all agencies must begin early enough to influence the planning process.

It should also be stressed that a given agency may have more than one department involved. For example, the planning, design, traffic, and/or maintenance departments of a state highway agency may also offer different perspectives. In many cases, it may be beneficial to an agency to establish its own internal corridor management team or other internal organizational structure to provide a multi-disciplinary approach to the problems being addressed through freeway corridor management.

One of the primary benefits of freeway corridor management is that it involves several agencies and entities. Furthermore, each of these agencies typically has responsibility for implementing or modifying certain components in each corridor that are to be integrated and managed as a system. With such distributed financial and operational responsibility, a functional system can be developed without excessive burdens placed upon any one agency.

Generally, it takes an effort by *all* agencies originally involved in the corridor management effort to continue to operate the system once it has been established. In order to facilitate ongoing cooperation and coordination of activities in a freeway corridor, many locations currently have traffic management teams already established. These teams, consisting of key decision-making personnel from the various agencies in the corridor, meet regularly to discuss transportation problems in the corridor and look for ways to address the problems through a coordinated interagency approach. They have been found to be especially useful for incident, work zone, and special event management planning. This team can serve as a good starting point when developing freeway corridor management. Once operational, the team can also serve as the mechanism for the continued operation of the system.

LESSONS LEARNED FROM PREVIOUS FREEWAY CORRIDOR MANAGEMENT EFFORTS

Past experiences with the development and implementation of freeway corridor management by several highway agencies have provided valuable lessons. Some of the major points that were raised during data collection for this synthesis are:

- A definable need must exist for freeway corridor management;
- Top administrative officials within the various agencies must support corridor management efforts;
- The support of one or more local politicians assists in the implementation and funding efforts of freeway corridor management;
- It is important to be able to demonstrate the actual or expected benefits (operations, safety, economic) of freeway corridor management;
- Continuity of key personnel involved in freeway corridor management development is important to its long-term success; and
- Sources of funding for the continued operation and maintenance of components of freeway corridor management must be considered and identified prior to its implementation.

In addition to an overview of freeway corridor management concepts and development, the synthesis presents discussions of the various components that constitute a freeway corridor system. Administrative overviews of the components are presented; the concepts and objectives of the components are explained; historical perspectives are given; applications in the United States are summarized; benefits are highlighted; and specific case examples of successful systems and reported benefits are presented. The integration of freeway corridor management components into a cohesive system is also discussed. The different types of applications in which freeway corridor management can be beneficial are summarized and benefits are illustrated.

CHAPTER ONE

INTRODUCTION

STATEMENT OF THE PROBLEM

Nationwide, traffic congestion continues to be one of the most pressing domestic problems, particularly along many freeway corridors in major urban areas. In 1985, it was estimated that congestion caused motorists more than 1.2 billion hours of delay, 1.3 billion gallons of wasted fuel, and more than $9 billion in excess road user costs nationwide (*1*). At the present rate of growth, these numbers are expected to grow five-fold by the year 2005 (*1*). Using a slightly different analysis methodology, another estimate of the congestion impacts in 1987 exceeded a total of $41 billion for 39 selected cities nationwide (*2*). Regardless of the analysis methodology used, it is generally accepted that the urban congestion problem is staggering and cannot be solved simply by additional roadway construction. An extensive effort is underway nationwide to develop and implement Intelligent Vehicle/Highway Systems (IVHS) (*3*), which are expected to drastically improve urban mobility in the United States. Unfortunately, the IVHS program is just in its infancy, and it is expected that a significant time lag will occur before the nation begins to reap the benefits of this technology (most likely after the turn of the century)(*4*).

In the short-term, urban areas must continue to deal with increasing levels of traffic congestion. To do this, a comprehensive strategy is required, consisting of selective roadway construction, transportation demand management actions, and intensive management and control of the roadways in the freeway corridor (including freeways, arterial streets, and high-occupancy vehicle (HOV) facilities). Management and control of the entire freeway corridor are addressed in this synthesis.

No one agency is responsible for all transportation-related facets of a freeway corridor. Most typically, the freeway system will be under the jurisdiction of the state transportation agency, and the surrounding arterial streets will be the responsibility of the local transportation agency or agencies. If HOV facilities are present, the local transit agency may have responsibility for these. Added to this are state and local enforcement agencies, who each have traffic regulation, control, and patrol responsibilities for portions of the corridor. Other influential sources in the operation and management of the corridor include the media (providing advance and real-time traffic information), and state and local governmental bodies (who create the traffic regulations and impose any roadway and operational restrictions). Regional metropolitan planning organizations (MPO) and air quality management agencies also have a vested interest in and impact on the transportation-related concerns of the corridor. Finally, public service-minded private corporations may possibly be involved, as they donate part of their resources to improving transportation mobility of their employees or of the general public.

A complex interrelationship exists among the various components in the freeway corridor. A change in one part or one component of the corridor often affects traffic conditions in another. Hence, a coordinated and cooperative approach is required by all agencies, as well as for different departments within the same agency to effectively manage traffic conditions throughout the corridor and to maximize the efficiency with which the corridor serves the traveling public. At the present time, however, little guidance is available as to how to accomplish this type of coordination and cooperation. Of course, the proper personnel and administrators of the various agencies involved must first support such an approach, and must be able to see the potential benefits of a unified strategy to managing a freeway corridor. This report has been prepared to help address these issues, providing an overview of why, how, when, and where freeway corridor management has already been established nationwide as well as suggesting how it can be initiated and maintained at locations not currently practicing that philosophy.

MANAGEMENT STRATEGIES

The terms "recurrent" and "non-recurrent" are commonly used to categorize traffic congestion in urban freeway corridors. Recurrent congestion occurs routinely at specific locations and at specific times of the day, and as such is fairly predictable. Non-recurrent congestion, on the other hand, is the result of a temporary reduction in roadway capacity (due to an incident, roadway maintenance, or construction activity) or a temporary increase in traffic demand (as commonly occurs immediately before, during, and after special events). Analyses (*1*) indicate that non-recurrent congestion is and will continue to be the bigger problem facing urban areas. As illustrated in Figure 1, non-recurrent congestion accounted for more than 61 percent of all urban congestion in 1984, and is expected to cause more than 70 percent of the total congestion by the year 2005.

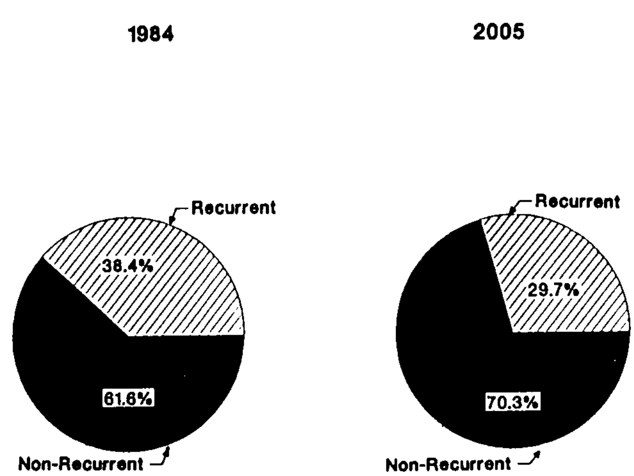


FIGURE 1 Causes of congestion: 1984 versus 2005.

Management of Recurrent Congestion

Recurrent traffic congestion occurs when normal traffic demands overload a roadway segment. This overloading can occur at entrances and exits to major employment centers, at freeway entrance ramps, at signalized intersections, or at geometric bottleneck locations such as lane drops or complex weaving sections (*5*). From a freeway corridor perspective, a number of strategies are available for mitigating the effects of recurrent congestion. These can be subdivided into *vehicle demand management strategies* (to reduce the number or type of vehicles attempting to use specific roadway sections over specified time periods), and *travel demand management strategies* (to reduce the total demand for travel, to shift the demand to other times of the day, or to shift the demand to other travel modes) (*5*). Many of these strategies are low-cost, transportation systems management (TSM) activities (*6,7*). Efforts to increase roadway capacity through geometric bottlenecks are another method of alleviating recurrent traffic congestion.

Management strategies for recurrent congestion can be grouped into the following categories:

- Freeway surveillance and control;
- Corridor street surveillance and control;
- Peak-period truck restrictions;
- Peak-period enforcement activities; and
- High-occupancy vehicle facilities and priority treatments.

In addition, promotional efforts to encourage variable work hours, shared rides, and use of transit systems are also important in reducing total travel demand during peak periods. Chapter Twelve contains more detailed information concerning management of recurrent congestion.

Management of Non-Recurrent Congestion

Non-recurrent congestion is somewhat more difficult to manage than recurrent congestion. In the case of freeway incidents, neither the location, the time, nor the severity of the cause of the congestion is known beforehand. For work zone operations and special events, these variables may be known, but their expected effect on traffic is difficult to predict with any degree of certainty.

Traffic surveillance is essential if non-recurring congestion is to be effectively managed. Traditionally, the importance of surveillance has been stressed from the standpoint of detecting non-recurring congestion (*1*). However, as integrated freeway and arterial control systems and extensive motorist information systems are being installed in many major urban freeway corridors, surveillance has become essential in obtaining real-time data for use in making adjustments elsewhere in the corridor (to arterial traffic signal timings, freeway entrance ramp metering, motorist information displays, etc.).

Other strategies for managing non-recurrent congestion include:

- Incident detection and response measures (e.g., motorist assistance patrols, tow truck services, accident investigation sites, alternative route planning),
- Truck restrictions to reduce the occurrence and severity of truck incidents during peak periods,
- Police presence to supplement the effectiveness of existing traffic control devices or to provide control where traffic control devices do not exist,
- Provision of real-time information to motorists, and
- Real-time traffic management at work zones.

More detailed information concerning management of recurrent congestion is provided in Chapters Thirteen, Fourteen, and Fifteen.

COMPONENTS OF FREEWAY CORRIDOR MANAGEMENT

Freeway corridor management consists of two parts. The first is the *freeway corridor system*, made up of the different transportation-related components in the corridor that are coordinated to act in harmony and synchronization. The second is the *freeway corridor management plan*, which describes how the freeway corridor system is to be established and operated in a coordinated, cooperative fashion.

A freeway corridor system includes some or all of the following components:

- Freeway surveillance and control,
- Corridor street surveillance and control,
- HOV facilities and incentives,
- Enforcement and police traffic control activities,
- Hazardous material and other truck restrictions,
- Alternative route plans and real-time motorist information displays to encourage diversion,
- Motorist assistance patrols, and
- Public information efforts (disseminating advance and real-time information).

A freeway corridor management plan specifies how the different transportation-related components available in the corridor are to be synthesized so that they operate together at the corridor level. In general, they all possess the common theme of "active traffic management." However, vast differences exist from one location to the next in terms of the technical, administrative, and political elements in a corridor. Likewise, the needs and objectives of freeway corridor management differ dramatically, depending on location and type of problem being addressed. Consequently, a generic freeway corridor management "plan" does not exist. Rather, individual plans are developed to address specific concerns or issues in the corridor. Four common concerns or issues exist in a freeway corridor,

- Traffic management of recurrent congestion,
- Traffic management of incidents,
- Traffic management of special events, and
- Traffic management through and around work zones.

In general, freeway corridor management probably offers the greatest potential operational and safety benefits for those dynamic, less predictable situations that characterize non-recurrent congestion (incidents, special events, work zones). However, freeway corridor management efforts are also important in helping to alleviate recurrent congestion. Here, it may be that management and coordination efforts in the corridor are less intense, such as merely trading count data back and forth or notifying the other agencies when a control or operational change in a particular corridor component has taken place. Efforts as simple as these can provide a building block of coordination and cooperation upon which more sophisticated systems and management plans can be developed.

SUMMARY OF BENEFITS TO BE GAINED THROUGH FREEWAY CORRIDOR MANAGEMENT

Several different groups benefit from freeway corridor management. Obviously, the motorist is the ultimate winner. Improved coordination, cooperation, and newly initiated system components in the corridor can result in:

- Decreased delay, fuel consumption, and vehicle emissions;
- Improved safety through reduced congestion, more timely response to accidents, and reduced exposure of stranded motorists to moving traffic;
- Improved public opinion of the agencies for their efforts to provide the safest and most efficient transportation system possible; and
- Reduced driver stress and anxiety levels.

In some instances, freeway corridor management also provides benefits to the various agencies themselves. Sharing information among agencies helps to reduce duplicated effort in data collection and analysis, and the management and operation of a particular component in the system can be tailored more precisely to the requirements of the corridor, reducing inefficiencies. Freeway corridor management can also benefit the overall economic stability and desirability of an area, by helping to maximize traffic flow in the corridor, making the area more attractive to businesses.

LESSONS LEARNED FROM PREVIOUS FREEWAY CORRIDOR MANAGEMENT EFFORTS

Past experiences with the development and implementation of freeway corridor management by several highway agencies have provided valuable lessons. Some of the major points that were raised during data collection for this synthesis are enumerated below.

1. *A definable need must exist for freeway corridor management.* Experience indicates that it is hard to establish freeway corridor management if the need is not readily apparent or cannot be demonstrated. Past efforts to establish freeway corridor systems to avoid future problems have met with little success. Conversely, locations where a critical need for freeway corridor management was evident or could be shown received valuable financial and administrative support.
2. *Top administrative officials within the various agencies must support corridor management efforts.* Freeway corridor management planning and system component installation efforts compete with other "traditional" agency activities and expenditures. Support of freeway corridor management efforts by top management is essential if agency resources are to be allocated to its implementation and operation. If the problem is large enough, upper-level support may already exist and propagate through the agency in a "top-down" fashion. If this support is not present, it must be developed from the bottom up, implementing components of the plan one at a time so that the benefits can be quickly and easily demonstrated.
3. *The support of one or more local politicians assists in the implementation and funding efforts of freeway corridor management.* It is desirable to have the support of local or even state politicians to assist in carrying the fight for money to establish freeway corridor management. Often, this support will be automatic if conditions have already severely deteriorated in the corridor or if the potential for major traffic problems looms on the near-term horizon.
4. *It is important to be able to demonstrate the actual or expected benefits (operations, safety, economic) of freeway corridor management.* This ability is important in obtaining and maintaining support for freeway corridor management from local politicians, citizens, and upper agency management.
5. *Continuity of key personnel involved in freeway corridor management development is important to its long-term success.* A common thread among past successful traffic control systems has been that key personnel committed to freeway corridor management have remained with the agencies throughout the planning, implementation, and ongoing operation of the systems.
6. *Funding sources for the continued operation and maintenance of components of freeway corridor management must be considered and identified prior to its implementation.* Certain aspects of freeway corridor management require ongoing funding for operations and maintenance. If treated as a normal agency operating expense, freeway corridor management must periodically compete with other demands upon the agency at budgeting time. The lack of a guaranteed funding source suggests that ongoing monitoring and evaluation of the benefits of freeway corridor management are necessary to continue to justify its existence and expense.

SCOPE AND ORGANIZATION OF THE SYNTHESIS

This synthesis is a summary of freeway corridor management, what it is, and how it is accomplished. It has been prepared to provide administrative officials in transportation-related agencies with an overview of the process needed to develop a systems approach to freeway corridor management, of the components that make up a freeway corridor system, and of the planning process required for a freeway corridor system to address recurrent and non-recurrent congestion in the corridor.

The synthesis has been constructed in three parts. The first, comprising Chapters Two and Three, provides an overview of freeway corridor management concepts and of the process involved in its development and implementation.

The second part, Chapters Four through Eleven, is devoted to short administrative overviews of the various components that constitute a freeway corridor system.

Integrating these components into a cohesive system is discussed in the third part, Chapters Twelve through Sixteen. Here, the different types of situations in which freeway corridor management can be beneficial are summarized and the benefits are illustrated.

CHAPTER TWO

EXAMPLES OF ORGANIZATIONAL STRUCTURES, POLICIES, AND PROCEDURES FOR EFFECTIVE FREEWAY CORRIDOR MANAGEMENT

The development of freeway corridor management differs significantly from that of typical highway projects. The emphasis of freeway corridor management is on integrating new or existing transportation components in the corridor, focusing on the cooperative operation and control of these components by the various agencies involved. This is in contrast to highway projects where emphasis is on construction or expansion of traffic control and management hardware (although construction/expansion may be a part of a given freeway corridor management plan). Freeway corridor management plans are dynamic and highly flexible, unlike other highway project plans which are relatively rigid once designed. Freeway corridor systems can vary in size from a single component (such as the operation of peak-period courtesy patrols or the introduction of HOV facilities into the area) to a complex multi-agency effort involving most or all of the transportation components in the corridor.

KEY ISSUES IN FREEWAY CORRIDOR MANAGEMENT PLAN DEVELOPMENT

Before efforts toward developing freeway corridor management can begin, three basic issues must be addressed. These issues include:

- Who is going to participate in the freeway corridor system and develop the freeway corridor management plan?
- Who is going to fund the system and what sources of funds exist?
- Who is going to operate the system?

Each of these issues is discussed in greater detail in the following sections.

Who Is Going to Develop the Plan?

Who takes the lead in developing freeway corridor management depends on the nature of the corridor problems being addressed. In many cases, the state highway agency will be this entity. If the problem(s) involves predominantly arterial streets, the local transportation agency may initiate the activities. On the other hand, freeway corridor management efforts to combat recurrent congestion through vehicle and travel demand reduction techniques may be initiated through a regional transit agency, an MPO, or a council of governments. Finally, two or more agencies may unite in task-force fashion to lead the developmental efforts.

Regardless of who initiates the idea and system formation, it is imperative that all transportation-related agencies in the corridor be involved in developing the plan. Each agency contributes a different perspective to the overall view of the problem, and consideration of the various viewpoints present in the corridor can help avoid pitfalls throughout the development process. Although involvement of all agencies may not be required from the very onset of conceptual planning efforts, participation of all agencies must begin early enough to influence the planning process. Nationwide, the experiences from a number of HOV facilities that were designed without input from local enforcement agencies illustrate the need for multi-agency participation in freeway corridor management. After implementation, it was found that the facilities could not be enforced. Violation rates soared, and the facilities failed to provide the intended HOV incentives (*8*). Examples of successful traffic control systems (*9*) also indicate the need for all affected agencies to be involved in system planning, design, and implementation phases.

It should also be stressed that a given agency may have more than one department involved. For example, the planning, design, traffic, and/or maintenance departments of a state highway agency may offer different perspectives. In many cases, it may be beneficial to an agency to establish its own internal corridor management team or other internal organizational structure to provide a multi-disciplinary approach to the problems being addressed through freeway corridor management.

Who Is Going to Fund the System (and How)?

One of the primary benefits of freeway corridor management is that it involves several agencies and entities. Furthermore, each of these agencies typically would already have responsibility for implementing or modifying certain components in each corridor that are to be integrated and managed as a system. For example, freeway surveillance and control would likely fall under the financial and operational jurisdiction of the state highway agency, while similar hardware on the arterial streets in the corridor would be the responsibility of the local transportation agency. With such distributed financial and operational responsibility, a functional system can be developed without excessive burdens placed upon any one agency.

This is not to say that financial problems do not exist in freeway corridor management. An all-too-common dilemma revolves around how to pay to operate and maintain the various components in a freeway corridor system once they have been purchased and installed. While purchasing and installation costs are often paid for through capital improvements funds of the specific agencies, operation and maintenance costs typically must be covered through the agency's normal operating budget. Given the uncertainties involved in the budget process, continued financial support for operations and maintenance is never guaranteed. It is desirable, however, to have designated maintenance and operations funds for the system. In some cases, an agency may have to reduce other activities (such as litter pick-up or minor roadway maintenance activities) in order to provide the monies for operating and maintaining a component of the system (personal communication with S.E. Rowe, City of Los Angeles Department of Transportation, January 1988).

The agencies involved in freeway corridor management need to be aware of financial opportunities that are available for special situations. For example, the federal government allows interstate construction money to be used to fund traffic operations improvements off-site to help mitigate the potential impacts of diverted traffic from the freeway during reconstruction (*10*). Private corporations are another potential funding source. In a number of cities corporations sponsor motorist assistance patrols to aid with incident management efforts in the corridor. Private support has also been obtained for traffic management efforts during special events. During the annual rodeo in Houston, for example, a local corporation helped fund the operation of a shuttle bus service that was provided by the county transit agency (*11*).

Who Is Going to Operate the System?

The final issue to be resolved is that of who will operate the system once it has been established. This issue refers not to the day-to-day operation of specific components of the corridor system (as these will likely continue to be handled by the agencies with initial responsibility for them), but rather who will continue to foster agency cooperation and integration of the various components in the system.

In actuality, the continued operation of the system does not usually come down to a single agency, rather, it takes an effort by all agencies originally involved in the corridor management project. In order to facilitate ongoing cooperation and coordination of activities in a freeway corridor, many locations currently have traffic management teams already established. These teams, consisting of key decision-making personnel from the various agencies in the corridor, meet regularly to discuss transportation problems in the corridor and to look for ways to address the problems through a coordinated interagency approach (*12*). They have been found to be especially useful for incident, work zone, and special event management planning. As will be discussed in Chapter Three, this team can serve as a good starting point when developing freeway corridor management. Once operational, the team can also serve as the mechanism for the continued operation of the system.

Case Examples

Three case studies are presented below to illustrate how the policies and organizational structures of agencies in the corridor as well as the procedures followed affect the development and implementation of freeway corridor management plans and systems. The examples describe freeway corridor management efforts to deal with recurrent and incident congestion problems in Seattle, with the reconstruction of the Southeast Expressway in Boston, and during preparations for the 1984 Olympic Games in Los Angeles.

Case Example 1: Seattle's Freeway and Arterial Management Effort

In October 1987, the Washington State Department of Transportation (WSDOT) embarked upon a new transportation initiative to address the mobility problems facing the urban areas in the state. The initiative, termed FAME (for Freeway and Arterial Management Effort), consists of a comprehensive approach to freeway corridor management consisting of the following nine components (*13*):

- Freeway management
- Arterial management
- Freeway and arterial control system integration
- Incident management
- Construction traffic management
- HOV treatments
- Motorist information systems
- Advanced technology
- Demand management

WSDOT has been combating the urban congestion problem for several years, with ridesharing and TSM measures in place since the early 1970s. The new FAME program also provides continued support and expansion of these measures. A key emphasis in the FAME program is the coordination of all affected agencies in the Seattle area. A Technical Advisory Committee, consisting of 27 representatives of various agencies throughout the greater Seattle metropolitan area, has been established to oversee the direction and progress of the FAME program (*14*).

The state of Washington is just now beginning to see results of FAME. Improved predictive algorithms for real-time ramp metering control have been developed (*15*), and HOV treatments for arterial streets in the Seattle area have been identified (*16*).

Case Example 2: Reconstruction of I-93, Southeast Expressway, Boston

In the summers of 1984 and 1985, an 8.5-mile section of I-93, the Southeast Expressway, in Boston underwent construction to widen bridges, lengthen merge areas at ramps, resurface the travel lanes, improve drainage, and improve lighting and signing. The six-lane expressway, the major route between Boston and southeastern Massachusetts, carried approximately 160,000 vehicles per day (vpd) prior to the start of construction. Because of the large traffic demands and the importance of the roadway to the regional transportation system, there was great concern about how the reconstruction project would impact on traffic throughout the corridor. This concern escalated through local and state government all the way to the state legislature, which eventually passed a resolution requiring the Massachusetts Department of Public Works (MDPW) to submit for review a traffic management plan for the project. This concern did facilitate funding efforts, as the legislature provided \$2.0 million to implement the traffic management plan. In total, over \$10 million was eventually spent on traffic management for the project (*17*).

The reconstruction project was initiated by the MDPW, who also served as the lead agency in the development of the freeway corridor management plan to mitigate the effects of construction. Planning for traffic management during construction began about one year prior to the start of construction. A task force was established to foster intra- and interagency coordination, and to facilitate traffic mitigation activities by various agencies throughout the corridor. This task force met on a monthly basis to report activities by the various members and to set targets for the next month. Initially, the task force consisted of members from planning, construction, operations, and public relations divisions within the MDPW. After a few months of preliminary planning, other outside agencies were added, including:

- Massachusetts Bay Transit Authority,
- Massachusetts Port Authority,
- Massachusetts State Police, and
- local community officials.

Local citizen and government officials were not totally convinced of the need for the project, and had significant concerns about the potential traffic diversions to their areas and resulting congestion and increased accident potential. A public information/relations consultant was hired to help educate the community about the benefits of the project and to generate support for it. Numerous public meetings were held and brochures were developed to inform citizens about the project.

Because of the sensitive nature of the project, several policy decisions were made early in the traffic management planning process. A partial list of these decisions is provided below.

- The most significant decision was to maintain as much roadway capacity within the reconstruction as possible (*17*). An innovative construction schedule was developed that allowed two reversible peak-direction express lanes to be maintained in addition to two regular purpose lanes in each direction throughout construction.
- Because of a limited (one year) planning time frame and a lack of available data regarding the impacts of major freeway reconstruction, a decision was made not to attempt to predict possible motorist responses to the project. Instead, efforts focused on providing as many travel options to motorists in the corridor as possible. The options would be monitored once construction began, and those that were not needed would be discontinued.
- It was also recognized that the task force could not identify beforehand all of the possible transportation-related needs throughout the corridor. Consequently, a fund was established that local governments could access to help them address problems resulting from the reconstruction project.

A supply-side analysis of transportation capacity throughout the corridor was undertaken to identify areas of improvement. Emphasis was given to high-occupancy vehicle and mass transit usage. Other criteria used for selecting improvement actions included the feasibility of implementation within the necessary time span, the contribution of each action to more permanent transportation improvements after reconstruction was completed, and the flexibility of removing an action not found to be effective. The traffic management plan for the corridor consisted of the following items (*17,18*):

- Providing increased commuter rail, boat, and bus service,
- Increasing the number of park-and-ride lot spaces,
- Supporting an employer-based ridesharing program,
- Encouraging large employers to implement flextime programs,
- Making traffic signal and pavement marking improvements on alternative routes,
- Placing police officers at certain intersections for traffic control, and
- Funding proposals from 15 local communities to mitigate local traffic control problems resulting from the reconstruction project.

Overall, the freeway corridor management efforts were successful. Only a small amount of diversion from the expressway (5,000 to 9,000 vpd) was detected. The majority of diversion occurred to alternative routes in the corridor; only modest increases in transit or ridesharing activity were detected. The lack of more significant travel disruptions was likely due to the innovative traffic control plan implemented in the reconstruction zone. Measured travel conditions within the reconstruction zone were actually better than before reconstruction began. Apparently, the separation of through drivers in the express lanes from the local traffic improved driving conditions.

A critique of the traffic management planning process indicated that the approach taken was reasonable and worked very well. The flexibility to delete unnecessary actions was particularly beneficial. In addition to providing motorists with many options early in the project, this philosophy allowed marginal actions to be field tested and evaluated objectively, rather than having to rely on suspect predictions and extensive analysis. It was noted, however, that planning efforts could have been initiated sooner. Certain aspects of traffic management planning, particularly the preparation and implementation of necessary interagency contracts, required fairly lengthy periods of time.

Case Example 3: 1984 Summer Olympic Games, Los Angeles

The 1984 Summer Olympic Games in Los Angeles provided one of the best examples of freeway corridor management for a special event. Although massive transportation problems were predicted, such problems never materialized. Instead, traffic conditions reportedly were even better than normal (*19-21*).

Transportation planning for the Olympics was a cooperative, multi-agency effort, involving:

- the City of Los Angeles Department of Transportation,
- the California Department of Transportation (Caltrans),
- the Southern California Rapid Transit District,
- the Los Angeles Police Department, and
- the California Highway Patrol.

In addition, the Los Angeles Olympic Organizing Committee assisted with the coordination of venue planning. Furthermore, no one agency was placed "in charge"; instead, the different agencies worked together to address any transportation issues.

The political importance of a successful transportation plan for the Olympics was obvious from the beginning of the planning process. The project drew enough attention to attract key decision makers from each agency to the task force; this streamlined the planning process considerably. In addition, there was consensus among agency officials as to the magnitude of the potential problems and of the feasible solutions. Overall, a sense of urgency existed to successfully manage traffic for the duration of the games.

Interestingly, the City of Los Angeles Department of Transportation used the Olympics to facilitate implementation of its Automatic Traffic Surveillance and Control (ATSAC) system, a computerized traffic signal control system. Attention was already focused on transportation issues for the Olympics, and this provided an opportunity for city transportation officials to showcase the computerized traffic signal control technology. In this way, the immediate benefits of the system could be demonstrated to the public, and future expansion of the system would be greatly facilitated. The spirit of cooperation extended beyond the agencies to the general public. Everyone wanted the Olympics to be successful, and was willing to endure some temporary inconveniences to attain that goal. As a result, public responses to traditionally unpopular travel alternatives, such as ridesharing or trip deferment, enjoyed much more success during the Olympics. Also, agency officials were able to obtain cooperation from trucking entities to refrain from peak-period travel and deliveries in the Los Angeles area.

The overall approach adopted for developing the traffic management plan was to separate the traffic demand to the event into the various transportation modes (automobiles, existing transit services, special Olympic transit services) and to assign the modes to different routes and apply different traffic control treatments to each (*20*). The following additional transportation actions were employed:

- Implementing an operations response team to respond to traffic congestion problems in real-time;
- Using computerized, aerial, and ground-based manual real-time surveillance of traffic conditions;
- Providing park-and-ride lots and shuttle bus service;
- Rescheduling start and end times of the event to avoid peak-period traffic times;
- Encouraging non-spectator traffic to choose transit, ridesharing, and/or alternative work hours during the Olympics; and
- Establishing an extensive public information program to encourage spectators to use alternative routes or transit and to travel early.

The overall traffic management plan was deemed quite successful. Traffic volumes collected showed that the peak period commuting travel pattern was broadened and flattened, such that congestion in the area was reduced 60 percent. Commuter ridesharing remained essentially unchanged, although vehicle occupancy was much higher than normal for spectator traffic inbound.

CHAPTER THREE

OVERALL FREEWAY CORRIDOR MANAGEMENT DEVELOPMENT

Freeway corridor management does not just happen. Rather, it is the result of a methodical process that includes the thorough assessment of existing deficiencies in the corridor; the needs, capabilities, and limitations of affected agencies; and the expected costs and benefits of freeway corridor management development. Although this chapter discusses development and implementation of a plan for one freeway corridor, the procedure applies to a system consisting of several freeway corridors as well. The successful experiences of others who have already developed freeway corridor systems provide valuable guidance to those contemplating a system in the future.

Figure 2 illustrates an overall approach to developing freeway corridor management. The approach consists of three major phases:

1. Freeway Corridor Management Plan Development
2. Preparations for Freeway Corridor Management Plan Implementation
3. Freeway Corridor Management Plan Implementation and System Evaluation

In turn, each phase consists of a number of tasks. The phases and tasks follow sequentially from initial system conceptualization to final implementation and evaluation. The sections that follow discuss these phases and tasks in greater detail.

FREEWAY CORRIDOR MANAGEMENT PLAN DEVELOPMENT

The first tasks in freeway corridor management focus on the development of a plan for achieving a freeway corridor system. This phase consists of five tasks:

- Establish a freeway corridor management team,
- Identify corridor problems,
- Establish support for freeway corridor management,
- Develop the freeway corridor management plan, and
- Solicit support for the plan.

Establish a Freeway Corridor Management Team

The first step in the development of a freeway corridor management plan is to establish a freeway corridor management team (also known as traffic management teams in some areas). This team, made up of officials of the various transportation-related entities in the freeway corridor, then meets to identify the problems and needs of the corridor, and to coordinate development of the freeway corridor management plan (Figure 3). Attempts should be made to include all affected agencies and jurisdictions in the corridor, but particularly state and city traffic engineering offices, city and state law enforcement agencies, and local transit authorities (*22*).

Identify Corridor Problems

The next task in developing a freeway corridor management plan is to identify and quantify the problems in the corridor that the plan and system are trying to address. This task involves three steps. First, the corridor limits must be identified. Not only does this involve determining the boundary of the roadway network, it also includes identification of the various entities who are potential participants in the corridor management effort. Second, the characteristics of the corridor

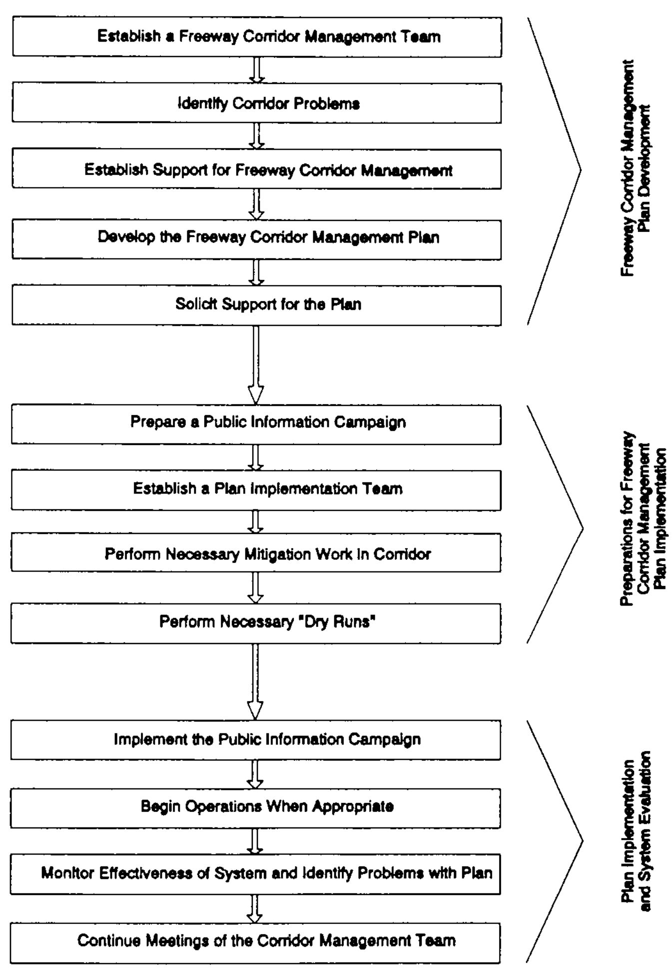


FIGURE 2 Freeway Corridor Management Planning Process.

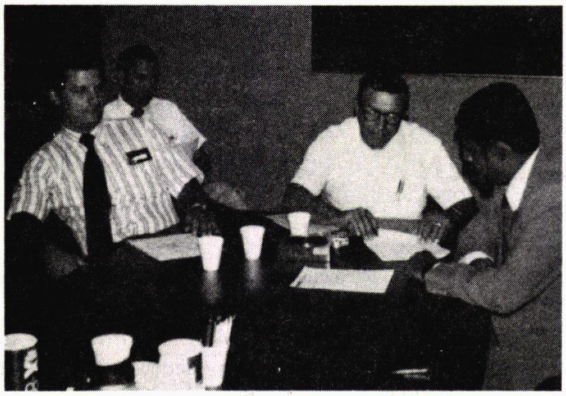


FIGURE 3 Establishing a freeway corridor management team is the first step in developing and implementing freeway corridor management.

must be inventoried, assessing traffic demands, roadway capacities, traffic control capabilities, and transit utilization. The degree of existing coordination among and between agencies in the corridor (i.e., a multi-agency incident response team, for example) should also be determined. Less tangible facets of the corridor should also be assessed. These could include such things as the overall political climate of the area, the degree of trust or distrust among the various transportation agencies in the corridor, and so on. Finally, the traffic-related problems that exist in the corridor are defined in the third step of this task. Likewise, political and administrative obstacles to the initiation of freeway corridor management are identified.

Establish Support for Freeway Corridor Management

After assessing the specific needs that exist for freeway corridor management, the next task is to secure the support for establishing a freeway corridor system. In order to successfully develop and implement a system of this type, it is necessary to have the backing of the key opinion and decision makers in the corridor. These individuals must be identified and their support for the system developed early in the process. Key individuals include officials within the agencies who are high enough in the hierarchy to have significant funding autonomy and who can make major decisions regarding personnel and expenditures. This group may also include local or even state political officials or officials of major corporations in the corridor.

In some cases, the magnitude of the problems or potential problems will be great enough that support for freeway corridor management activities will already exist at the upper levels of management, and will proceed down through the administrative structure of the agency. Although this "top-down" support structure may facilitate funding, there does tend to be heavy pressure to produce results as quickly as possible. In other cases where the problem is not readily apparent or where upper-level support does not already exist, it will be necessary to actively campaign for this support. Past experiences in implementing freeway corridor systems suggest that it is important to be able to physically demonstrate to key decision makers both the need for the project (such as by site visits to observe the actual problems in the corridor) and the specific benefits that will result from freeway corridor management (through tours of existing successful systems) (personal communication with L. Lipp, Colorado Department of Transportation, March 1987). In this regard, a stepwise approach to corridor management has proven effective at several locations, implementing parts of the system with high-visibility benefits and good chances of success (personal communications with D. Roper, R. Murphy, and J. Bork, California Department of Transportation, February 1988; personal communications with F. DeLuca, Florida Department of Transportation, March 1988). After demonstrating these initial successes, it has been easier to proceed with the implementation of the rest of the system.

Develop a Freeway Corridor Management Plan

The freeway corridor management plan spells out the process by which freeway corridor management is to be accomplished, both in terms of the start-up activities and in the ongoing management efforts. In essence, this plan describes how the freeway corridor system elements, consisting of the various transportation-related components in the corridor, are to be brought together to act in harmony and synchronization. The plan can address how an ongoing management subsystem is to be integrated and operated (i.e., the establishment of a multi-agency incident management system), how to cope with a temporary fluctuation in the characteristics of the roadway corridor (as occurs when major freeway reconstruction projects require long-term lane closures), or how to adjust the system when traffic demand patterns vary dramatically from the norm (as occurs before and during major special events).

First, the goals and the anticipated constraints of a freeway corridor management plan are specified. For example, past experiences nationwide indicate that incentives to increase HOV use during major urban freeway reconstruction projects have generally resulted in only small diversions of drive-alone commuters to HOV modes. Hence, a freeway corridor management plan for an upcoming reconstruction project should be constrained against heavy reliance on HOV market share increases to accommodate displaced drive-alone commuters.

Combining the goals and constraints with the problems identified in the earlier tasks, possible mitigation measures for addressing the problems are formulated. Options for this step of the process would include roadway TSM improvements (turning prohibitions, intersection widening, etc.), computer control hardware purchases, interagency agreements, and integrated control systems, among others. In general, any improvement that increases corridor capacity or reduces corridor demand would be an appropriate candidate freeway corridor management measure. In order to select from the available options, an analytical framework must be adopted and applied. This framework includes:

- Choice of appropriate analysis tools or models,
- Collection of data, preferably operational data, to use in the models,
- Application of the models to estimate the benefits or effectiveness of the potential measures,
- Estimation of the costs of the measures, and
- Comparison of the expected benefits or effectiveness of the measures to their expected costs.

For more detailed discussions of plan development for specific situations (e.g., freeway surveillance and control, incidents, major reconstruction), other reports are available in the literature (*23-25*).

Solicit Support for the Plan

Following the analysis and selection of appropriate measures to be included in the freeway corridor management plan, the final task in this phase is to solicit funding and operational support. This task is closely related to the previous one, as the funding source(s) available for plan implementation depends directly on the system components and mitigation measures to be included. For example, HOV priority treatment construction might be funded and operated by a single highway agency, or jointly operated and funded by city and state highway and transit agencies. As another example, a motorist assistance service patrol program in Houston is being jointly funded by the state highway agency, the county sheriff's department, the county transit authority, and two private corporations that have supplied vehicles and cellular telephone communications. Many urban freeway reconstruction projects have included provisions that required the contractor to provide extra tow trucks or other equipment to assist in incident management during freeway reconstruction. Another example is the corporate sponsorship of transit or other services during special events. Developers fees are being used to help fund the computerized traffic signal control system (ATSAC) in Los Angeles (personal communication with S.E. Rowe, City of Los Angeles Department of Transportation, January 1988).

PREPARATIONS FOR FREEWAY CORRIDOR MANAGEMENT PLAN IMPLEMENTATION

Once a freeway corridor management plan has been formulated, the next phase of development is to make the necessary preparations for its implementation. Within this phase, four tasks have been identified:

- Prepare a public information campaign,
- Establish a plan implementation team (if needed),
- Perform necessary mitigation work, and
- Perform necessary "dry runs."

Prepare a Public Information Campaign

Effective communication with the public is essential to the initial implementation of a freeway corridor management plan and to the continued operation of the system. Providing motorists and other citizens with information about the management plan and the operation of the system is important from several aspects;

- It increases driver awareness during unusual conditions, reducing driver confusion and frustration, and may improve safety,
- It can help influence temporary adjustments in travel patterns, also by increasing driver awareness of potential problem times and locations,
- It facilitates general acceptance by the public of any adverse traffic or other conditions created by unusual circumstances such as work zones, special events, and incidents, and
- It can help obtain public feedback about the perceived effectiveness of the freeway corridor management plan.

Depending on their objectives, components of public information campaigns vary widely. However, the basic concepts used in campaign development remain fairly consistent. It is necessary to identify the different population groups who will need information, determine what information they will need, and how that information should be disseminated to them.

Establish the Plan Implementation Team

In some instances, the individuals who developed the freeway corridor management plan will not be those responsible for implementing the plan and participating in the freeway corridor system. If this is the case, the implementation team must be established beforehand and efforts made to foster cooperation and coordination among the individuals and organizations as was intended during the development of the plan.

Perform Necessary Mitigation Work

The freeway corridor management plan may include certain physical improvements to be made at one or more locations in the corridor. For example, minor roadway and intersection widening, signing and lighting improvements, and traffic control system upgrades have been implemented as part of the freeway corridor management plan for several major reconstruction projects and special events nationwide. Implementing these measures prior to the initiation of the rest of the freeway corridor management plan allows the system to operate more efficiently and increases its flexibility.

Perform Necessary Dry Runs

Many times, the driving need for freeway corridor management is for one-time or very unusual circumstances (such as the Olympic Games in Los Angeles or hazardous material incidents). Past experience at a given location is typically not available from which to base decisions in planning and implementing freeway corridor management for these situations. In these cases, it may be beneficial to conduct a dress rehearsal of the plan prior to the event so that deficiencies in the plan (and system) can be identified and remedied, improving the potential for success of the plan when it actually is implemented.

PLAN IMPLEMENTATION AND SYSTEM EVALUATION

Once planning and implementation preparations have been made, all that remains is to implement the freeway corridor management plan and evaluate the effectiveness of the freeway corridor system. Four tasks make up this final phase:

- Implement the public information campaign,
- Initiate the plan/system operation,
- Monitor effectiveness of plan/identify problems with system, and
- Continue meetings of freeway corridor management team.

Often, the public information campaign is launched with a high-profile event of some type. The freeway corridor management plan is then initiated, and operation of the system begins when appropriate. Ongoing monitoring of the successes and failures of the plan, and the assessment of actual effectiveness of the freeway corridor system are important parts of this final phase. These activities provide a database that is useful in making adjustments to the system and the current plan, as well as in future planning efforts. It is equally important that meetings of the freeway corridor management team be held on a regular basis. In these meetings, the results of the ongoing monitoring and evaluation effort and other issues relating to the freeway corridor system can be raised and discussed. Depending on the results of the meetings, certain aspects of the plan or the system operation may be changed.

CHAPTER FOUR

FREEWAY SURVEILLANCE AND CONTROL

OBJECTIVES AND GENERAL DESCRIPTION

The objective of freeway surveillance and control (S&C) systems is to provide relief from both recurrent and non-recurrent congestion. Freeway S&C systems help to protect peak-period level-of-service and to detect and respond to incidents (*26*). S&C systems can be used either to divert freeway demands (modally, temporally, or spatially) or to accommodate the existing demands but delay the onset of congestion (*27*). Freeway S&C systems, such as the one shown in Figure 4, are designed and operated to monitor traffic conditions, detect the occurrence of incidents, monitor and report on the status of traffic control hardware, provide information for traffic controls, and operate those controls (*28*). Systems may include one or more of the following components:

- Electronic surveillance,
- Closed circuit television surveillance,
- Ramp controls,
- Motorist information displays,
- Traffic signal control,
- Preferential HOV treatments, and
- Incident management systems.

Another component sometimes associated with freeway S&C systems is mainline metering. However, this is a very specialized type of control, applicable primarily at spot locations such as tunnels and bridges (*29*).

Freeway S&C systems differ dramatically from jurisdiction to jurisdiction, depending on the needs and resources of each. The following descriptions illustrate the range of systems that are possible:

- *Spot systems* - are generally limited to tunnels, bridges, or fairly short segments of freeway. Such systems may operate one or two ramp meters, for example.

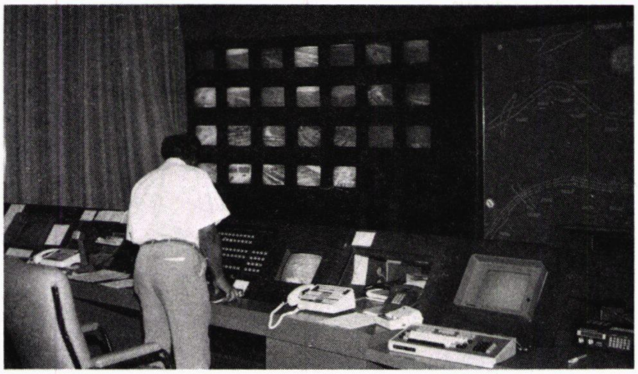


FIGURE 4 Freeway S&C systems help to protect peak-period level of service and respond to incidents along the freeway.

- *Linear systems* - are implemented on single highway facilities, generally limited to freeway mainlanes and their ramps.
- *Mini-Corridor systems* - include the freeway mainlanes, ramps, and service or frontage roads.
- *Corridor systems* - include the freeway mainlanes, ramps, service or frontage roads, any nearby parallel freeways or limited-access facilities, and a network of traverse roadways.
- *Areawide systems* - encompass all freeways surrounding the city center.

HISTORICAL PERSPECTIVE

The idea of implementing traffic controls based on prevailing conditions and control system status is not new. The first freeway S&C project, the John C. Lodge Expressway Project in Detroit, Michigan, was initiated in 1962 (*30*). The Eisenhower Expressway project in Chicago soon followed (1963). Chicago has continued to be a leader in freeway S&C, currently operating one of the largest areawide systems in the country. Nationally, interest in freeway S&C has grown steadily in the past few years, as traffic congestion has spread from large cites down to even moderate-sized urban centers. A 1991 inventory report listed 64 freeway S&C systems in operation nationwide, with 11 more listed as being under construction or in planning and design stages (*31*).

SURVEILLANCE APPROACHES

Freeway surveillance can be either automatic (electronic) or manual. Electronic surveillance has traditionally relied on inductive loop detectors embedded in the freeway lanes at set intervals (1/4 to 1/2 mile). Vehicles passing over the loops activate the detector, sending a signal back to the computer. In this manner, various traffic parameters (volumes, speeds, lane occupancies) can be determined, and the operation of the system monitored in real-time. Electronic surveillance also allows for the automatic control of other components of the S&C system (such as ramp metering rates) and for incident detection.

New electronic surveillance methods are currently under development. One such method that shows considerable promise is that of video image processing. Computer technology is used to accomplish vehicle detection as well as extraction of various traffic parameters in real-time from images generated by video cameras overlooking a traffic scene (*32*). Development and evaluation are ongoing at this time; initial assessments suggest that this technology is reaching the necessary level of accuracy and cost-effectiveness to become a feasible detection method (*33*).

In contrast, manual surveillance methods are used primarily for incident detection and validation purposes. Manual methods include:

- Closed circuit television,
- Police patrols,
- Motorist Assistance patrols,
- Motorist call-boxes,
- Aerial surveillance,
- CB radio,
- Cellular telephone call-in systems, and
- Human observers (i.e., for special events or temporary construction zone situations).
- Image processing techniques

Procedures for estimating the benefits and costs of each method have been developed (*24*) as have planning, design, implementation, and operation guidelines (*34*).

LEVELS OF RAMP CONTROL

Presently, ramp controls that regulate traffic demands entering freeway sections are the most commonly used S&C system component, and specific procedures for selecting and implementing ramp control systems have been developed (*35*). Ramp controls can be either temporary ramp closures where no traffic is allowed to enter, or ramp metering where traffic is allowed to use the ramp but at a metered rate. HOV priority treatments (bypass ramp lanes, exclusive ramps) are another type of ramp control, and are discussed in greater detail in Chapter Six.

Ramp metering can operate in three different ways, depending on the needs and capabilities of the particular S&C system. The alternative methods are:

- Fixed-time operation,
- Traffic-responsive operation, and
- System or integrated control.

Fixed-time ramp metering rates are based on average traffic conditions at a given ramp at a given time of the day (*27*). In essence, the ramp meter operates in the same manner as a fixed-time traffic signal at an intersection. Rates are based on the amount of traffic that can be reasonably expected on the freeway and at the ramp. Since no real-time information from the freeway mainlanes is considered, this type of operation cannot respond to fluctuations in entrance ramp demands or freeway traffic conditions.

Traffic-responsive ramp metering, in comparison, is based on freeway traffic conditions monitored in the immediate vicinity of the entrance ramp. Relying on real-time traffic information received from the system detectors, metering rates are computed and updated periodically based on demand and capacity conditions. This type of system can help reduce demands on the freeway during incident situations. Metering rates can be simultaneously reduced at ramps upstream of the incident and increased at downstream ramps, encouraging diversion to the downstream ramps (*27*).

The third type of ramp metering approach is system or integrated control. In this case, ramp metering rates are developed and updated based on freeway conditions throughout the system. A central control unit and communications link, which can be operating under fixed-time or traffic-responsive control, handles several ramps at one time.

TRAFFIC DIVERSION

A major issue with respect to freeway S&C systems in corridor traffic management is that of traffic diversion. Motorist information systems (MIS, e.g., changeable-message signs, highway advisory radio), a component of many S&C projects, are used to reduce traffic demands on the freeway, and have been successfully used for encouraging diversion from the freeway during incidents, special events, and work zone operations (*36-38*). Guidelines for their effective use have also been developed (*39,40*). The other major S&C control component, ramp metering, also has the potential for encouraging traffic diversion from entrance ramps to downstream ramps or to other roadways in the corridor.

Although such diversion improves traffic flow conditions on the freeway, concern is often expressed about the impacts of diverted traffic on nearby streets which are typically under local agency jurisdiction. Interestingly, although a few cases of diversion in connection with ramp metering have been documented (*23*), significant diversions have not occurred at the majority of ramp metering project evaluations (*35*). Nevertheless, state and local agencies may maintain formal and informal agreements regarding the operation of ramp metering and possible impacts upon adjacent streets. For example, the introduction of ramp metering in Portland, Oregon included an agreement between the state and local highway agencies that would require the ramp metering system to be adjusted or abandoned if adjacent street volumes increased by 25 percent or more (*35*). No problems resulted from the implementation of the ramp metering system, however (personal communication with Mr. Matt Bauer, City of Portland, Oregon, April 1991). Since that time, several more ramp meters have been installed in the Portland area, and the city has not pursued agreements for those installations.

In comparison, concerns regarding motorist information system usage for diversion appear to be less intense. One possible explanation for this is that these systems are most commonly used to encourage diversion when special or emergency situations exist. The temporary nature of these situations may reduce interagency conflict and move the various agencies toward a more cooperative sentiment.

APPLICATIONS IN THE U.S.

Table 1 presents a list of the various freeway S&C systems in operation, construction, design or planning. The table is based on a recent report by the Freeway Operations Committee of the Transportation Research Board (*31*). The systems are categorized according to the definitions provided earlier (areawide, corridor, mini-corridor, linear, spot).

BENEFITS

The benefits of freeway S&C include:

- Reduced travel time—delays occur at entrance ramps where they affect fewer motorists (*23,26*),

TABLE 1
U.S. FREEWAY SURVEILLANCE AND CONTROL SYSTEMS

Type of System	System Location
Areawide Systems:	
In Operation	Chicago Metropolitan Area Traffic Systems Center
	Denver Area Ramp Metering Control System
	Detroit SCANDI (Surveillance, Control ANd Driver Information) System
	Los Angeles Metropolitan Area Management System
	Maryland CHART System
	Minneapolis-St. Paul Twin City Traffic Management System
	San Diego Area Management System
	Seattle FLOW System
In Planning or Design	Boston Central Artery/Third Harbor Tunnel
	Columbus Metro Freeway Operations System
	Connecticut Statewide Traffic Management
	Dade County, FL FLAMINGO
	Fort Worth Traffic Management System
	New Jersey MAGIC (Metropolitan Area Guidance, Information, and Control)
	New York City Computerized Area Tracking System
	Orlando TRAVTEK
	Portland Freeway Management
	Phoenix Freeway Management System (Future)
	San Fransisco Bay Area Traffic Operations Management System
Corridor Systems:	
In Operation	Covington, KY I-75 Reconstruction Projects Traffic Management Program
	Dallas North Central Expressway Corridor
	Long Island INFORM (Information for Motorists)
	Virginia I-66/I-395 Traffic Management System
In Design	Philadelphia I-95 Intermodal Mobility Project
	Santa Monica Freeway SMART Corridor Demonstration
Mini-Corridor Systems:	
In Operation	Delaware Wireless Emergency Phone System
	New Jersey Turnpike Automatic Traffic Surveillance and Control System
	New York Van Wyck Expressway Control System
In Planning or Design	Honolulu Trans-Koolau Tunnels System
Linear Systems:	
In Operation	Baltimore Jones Falls Expressway Surveillance and Control Project
	Cincinnati I-75 Traffic Diversion System
	Florida I-10/I-75 Motorist Aid System
	Florida Turnpike Motorist Aid System
	Los Angeles Artesia Freeway High-Occupancy Vehicle Commuter Lane System
	Massachusetts Motorist Aid Call Box Systems
	Orange County Costa Mesa Freeway High-Occupancy Vehicle Commuter Lane System
	Phoenix Black Canyon Freeway Surveillance
	Seattle FLOW System
	Southeast Wyoming I-80 Motorist Information and Diversion System
	Wisconsin Milwaukee Freeway Control Project
Under Construction	Baltimore Area Surveillance and Route Diversion
In Planning or Design	Brooklyn Gowanus Expressway Contraflow Bus Lane Variable Message Sign System
	Newark Airport Interchange Surveillance and Control System
	Portland U.S. 26 Surveillance System
	Salt Lake City I-15 Corridor System

- Improved travel time reliability—the effect of congestion on travel times is reduced,
- Reduced fuel consumption and vehicle emissions—smoother freeway operations result (*41*),
- Reduced accidents—the ramp to freeway merging operation is controlled (*23,26,35*),
- Increased driver satisfaction—motorists encounter less congestion and improved conditions (*23,26*),
- Increased capacity—more vehicles use the freeway without causing additional delay, and
- Better maintenance—traffic management hardware problems are automatically detected.

In quantitative terms, ramp metering alone has been shown to reduce travel time 13 to 60 percent, and to reduce accidents 24 to 50 percent (*35*).

Examples and Benefits of Selected Operating Systems

Detroit

Detroit, Michigan served as the birthplace of freeway S&C with the Lodge Expressway Project in the early 1960s (*30*). Detroit is currently moving into a new generation of freeway S&C with its implementation of the SCANDI (Surveillance Control ANd Driver Information) system. Initiated in 1982, the project consists of five major components:

- Electronic surveillance at all ramps and at 1/3-mile spacing on the freeway,
- Closed circuit television surveillance at high-accident locations,

TABLE 1 *CONTINUED*

Type of System	System Location
Spot Systems:	
In Operation	Austin I-35 System
	Albuquerque Variable Speed Limit System
	Baltimore Fort McHenry Tunnel Surveillance System
	Beaumont Freeway Ramp Closure Gate
	Columbus Ramp Control Systems
	Dewey Square Tunnel Highway Advisory Radio
	Eisenhower Memorial/Johnson Memorial Tunnels
	Escambia Bay Bridge I-10 Surveillance and Control System
	Franconia Notch, NH I-93 Highway Advisory Radio
	Hampton Roads Bridge-Tunnel Surveillance System
	Idaho I-90 Motorist Warning System
	MA I-93, I-95, I-91 Motorist Aid Call Box System
	Manhattan Tunnel Traffic Control System
	Mobile, AL Tunnel Surveillance and Control System
	Norfolk/Portsmouth Elizabeth River Tunnel Traffic Surveillance and Control System
	Pennsylvania Lehigh Tunnel Traffic Control and Surveillance System
	Pittsburgh I-376 Squirrel Hill Tunnel System
	Pittsburgh Liberty Tunnels System
	Philadelphia I-95 Intermodal Mobility Project
	Philadelphia I-297 Fort Pitt Tunnel
	Portland I-5 and I-84 Ramp Metering Systems
	Sacramento Area Ramp Control Systems
	Saltese Motorist Aid Warning System, Speed Check, and Speed Monitoring System
	San Antonio I-10 and I-35 Ramp Control
	San Fransisco Bay Area Ramp Control Systems
	San Fransisco-Oakland Bay Bridge
	Tampa Sunshine Skyway Bridge Motorist Warning System
	Tuscon, AZ Ramp Control Systems
Under Construction	Newport News I-664 Bridge/Tunnel Traffic Surveillance and Control System
In Design or Planning	Boise Idaho Ice Warning System
	New York Triborough Bridge Variable Message Warning Sign System

- Changeable-message signs for providing real-time information to motorists,
- Ramp metering at a total of 51 locations on I-94, I-375, and US-10, and
- Motorist-aid telephones placed at 69 locations along I-94 and connected to the Michigan State Police post in downtown Detroit.

It appears that the SCANDI system continues to fight a credibility problem with the public, despite significant improvements in freeway operations where it has been implemented. Cost overruns and political concerns about the preferential treatment given suburban commuters versus Detroit citizens (by means of the ramp metering system) have created a somewhat hostile public environment for the project. A study by Michigan State University indicates the system is providing positive benefits (*42*). Ramp metering alone has been attributed with increasing speeds on I-94 by 8 percent while accommodating 14 percent more traffic (*35*). Accidents were reduced by 50 percent, and it appears that injury accidents were reduced even more (71 percent). To assist in combating the negative opinions of the media and the public, a 5- to 10-minute videotape presentation of the operation of the SCANDI system is being prepared. This videotape will be shown to area city councils, highway groups, civic organizations, and the media to help build public support and confidence in the project.

Chicago

With its beginnings in 1961 (initiating an emergency traffic patrol), the Illinois Department of Transportation (IDOT) Traffic Systems Center (TSC) operates and maintains an extensive freeway S&C system, encompassing a six-county region in the Chicago area. The system encompasses 118 miles of freeway and includes (*43*):

- Electronic surveillance placed at 1/3-mile intervals,
- Ramp controls at 95 locations,
- 12 changeable-message signs,
- Highway advisory radio at seven locations,
- Emergency Traffic Patrol,
- Communication center, and
- Cellular telephone communications.

In 1982, TSC computer expansion allowed IDOT to integrate the TSC, Communications Center, the Emergency Traffic Patrol, and IDOT management and traffic personnel into an intraagency computer terminal network so that traffic information and special notices could be quickly and easily disseminated. The IDOT TSC also continues to provide modem hookups into the computer for radio/TV stations to obtain improved real-time information. Results indicate that the combined surveillance and control system has been responsible for a 60 percent reduction in peak-period traffic congestion and an 18 percent reduction in accidents (*44*).

CHAPTER FIVE

CORRIDOR STREET SURVEILLANCE AND CONTROL

OBJECTIVES AND GENERAL DESCRIPTION

Just as they enhance the operational efficiency and safety of freeways, surveillance and control systems serve a valuable function on arterial streets within a corridor, helping to maximize the traffic-carrying capacity of the surface street roadway network (*9*). Since the major capacity restrictions on most urban arterials are the at-grade intersections, the primary objective of most corridor street S&C systems is the centralized operation and coordination of the traffic signals within an area. Other important objectives of S&C systems include the detection of incidents, operation of other roadway controls (lane control signals), and management of real-time information displays (*45*).

Traffic surveillance in corridor street S&C systems is most often accomplished through loop detectors located on approaches to signalized intersections. These detectors may be supplemented with closed circuit television at critical locations to verify incidents or to assist in signalized intersection control at locations where high pedestrian/vehicle conflicts exist (*46*). Roving motorist assistance patrols are another incident detection and verification mechanism (*47*).

Traffic signal control equipment monitoring is another major task of corridor street S&C. Quick and accurate detection of equipment malfunctions is essential in order to maintain the highest level of safe and efficient operations within the corridor. Synchronized control of signalized intersections in the system results in increased capacity and dramatically improved operations and safety (*47*); hence, the need to ensure that all traffic signals within the system are operating in harmony is of paramount importance in urban areas where all available capacity is needed and where traffic volumes are at critical levels.

HISTORICAL PERSPECTIVE

In the broadest sense, corridor street S&C had its beginnings with the first traffic signal installed in 1914 (*27*). The 1950s and 1960s ushered in the concept of coordinated corridor street system control, and led to the development of arterial and network traffic signal timing software such as PASSER II, TRANSYT-7F, and MAXBAND (*48*). These software programs determine the necessary settings to operate the signals efficiently as a system. Also in that time frame, interest grew in centralized traffic signal computer control. This topic became the focus of an extensive research thrust by the Federal Highway Administration (FHWA) in the mid 1970s and into the 1980s as the Urban Traffic Control System (UTCS) software package was developed (*49*). A few state agencies and private vendors have developed proprietary systems to accomplish similar tasks.

Work is now underway on the next logical step toward improving urban mobility, integrating freeway and corridor street operations and control. Several demonstration projects and research efforts are underway to address the technical and administrative difficulties that system integration presents.

CONTROL SYSTEM OPTIONS

Agencies vary with respect to the goals, constraints, and financial resources available for a corridor street S&C system (*27*). Obviously, an inadequate system is of little use, but a system that is overdesigned for the needs of the agency cannot be fully utilized and is also undesirable. Overall, the most important element of the S&C system selection process is matching equipment capabilities to identified agency requirements (*27*). In general, an agency has its choice of systems with basic, mid-range, or sophisticated capabilities. As the sophistication and complexity of a system increases, so does its cost. The following sections highlight the features and differences among these options.

Basic System Option

The basic system option is a stand-alone system that provides equipment malfunction detection, centralized traffic signal timing plan installation, and a simplified operator interface (*50*). Furthermore, the system is of modular design to facilitate future additions and modifications.

In addition to the above items, a basic system should be capable of the following:

- Controlling local intersections from a central site;
- Selecting and implementing timing plans that are based on historical time-of-day, day-of-week, and week-of-year data;
- Operating 24 hours a day unattended;
- Downloading timing plans while offline, and fine tuning operations at the local controllers while online;
- Handling additional local intersections without requiring large purchases for more central computer equipment; and
- Performing certain self-diagnostic checks.

Other components that are not included in a basic system but should be available as options are (1) traffic-responsive decision logic and data input, (2) collection of various traffic performance data from the detectors, (3) measure-of-effectiveness (MOE) computation and evaluation, and (4) display maps (a large wall map or television map image). Furthermore, the system should be designed with flexibility to accommodate expansion at a future date.

Mid-Range System Option

The mid-range system represents the next level in system sophistication. This system possesses all of the components of the basic system, plus such additional abilities as

- Storage and implementation of different signal timing plans,
- Preemption capability, and
- Traffic-responsive timing and signal plan selection.

Optional features of a mid-range system could include multiple levels of traffic surveillance, online timing plan computation and traffic pattern prediction, and a more sophisticated timing plan evaluation methodology.

Sophisticated System Option

Sophisticated systems are those that provide the most advanced signal control logic and capabilities. Typically, these systems are custom designed for a particular installation (*45*), and often include

- Dynamic wall-map displays or projection-type graphics displays,
- Online pattern-matching traffic-responsive abilities for signal timing plan selection,
- Extensive surveillance capabilities,
- Timing plan development with information provided by system detectors,
- Detailed MOE equipment status reporting facilities, and
- Full-time staffing or monitoring by system personnel.

Also included in this category of systems are those that employ special controls for transit vehicles and for real-time motorist information displays. An example of a sophisticated system is shown in Figure 5.

CONTROL CONCEPTS

In addition to differences in system sophistication, corridor street S&C systems also differ in terms of the type of control provided. Again, three major categories of system control are available: arterial intersection control (open network), closed network control, and areawide control. Selection of an appropriate type of control is likewise a decision an agency must make based on the system requirements it has identified during system planning. The sections below briefly summarize the characteristics of each type of control.

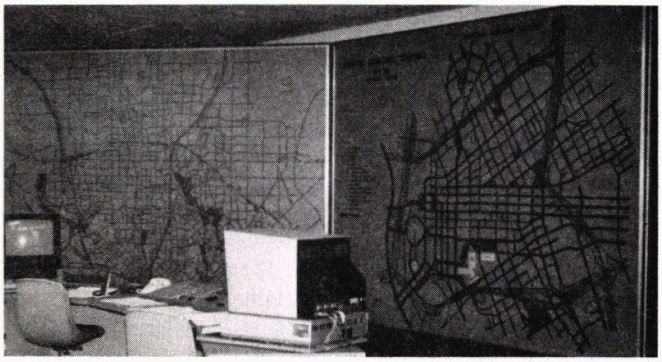


FIGURE 5 A sophisticated control system provides operators with extensive traffic signal monitoring and control capabilities.

Arterial Street (Open Network) Control

This type of control refers to the coordination of a series of signals along an arterial street. The primary emphasis is on the provision of progressive traffic control along the arterial, establishing signal timings so that vehicles beginning at one end of the arterial can travel along without stopping. Emphasis is placed on establishing coordinated traffic signal operation to maximize the number of vehicles that can travel nonstop through the green indications of the signals (i.e., the "bandwidth") at a reasonable speed (the "band" speed).

As this type of control is concerned with progression along a single route, it is the simplest of the system control concepts previously listed. Nevertheless, proper control from a system standpoint is still quite complex, depending on factors such as individual intersection demand volumes, intersection spacing, roadway geometrics, and regional driver characteristics. The coordination task is even more complicated if progression in both directions of travel on the arterial is desired.

Closed Network Control

Closed network control refers to coordinating a group of traffic signals along two or more arterials that intersect. Coordination may occur among all signals in a given closed system, or subnetworks may be designated to allow the operations to be configured specifically to the volumes and intersection geometry of each. This may be possible, for instance, if a lack of coordination between sections can be determined to have a minimal effect upon overall network operations.

Areawide System Control

Development of powerful computers and advanced communication techniques has made the prospect of areawide signal control systems more reasonable in recent years. In areawide control, the surveillance and control of all traffic signals in an urban area are treated as a system under the supervision of a central command control center (*51*).

Several important advantages have been enumerated with regard to areawide control, including:

- Total area surveillance and control capabilities,
- More options with respect to control strategy development and implementation, and
- Standardized equipment throughout the area to promote maintenance efficiency and economy.

Often, several agencies are responsible for traffic signals in an urban area, and attempts toward areawide control must be a multi-jurisdictional effort. The degree of interaction and coordination across jurisdictional boundaries varies depending on each agency's desired level of autonomy, from an overall centralized control system with no interaction or control by involved agencies, to decentralized systems with high agency control and with limited interagency coordination where possible. The development of interjurisdictional traffic signal control committees can provide ongoing managerial and administrative coordination and open up important lines of communication (*52*).

TRAFFIC DIVERSION

Within the context of freeway corridor management, one of the major concerns many local jurisdictions have about freeway diversion systems is the effect that diverted traffic will have on adjacent surface streets in the corridor. Although there have been some instances where jurisdictional conflicts create this apprehension, more often it is a real concern about the ability of surface streets to accommodate additional diverted traffic without increasing congestion to intolerable levels. The more sophisticated corridor street S&C systems that can quickly modify signal timing plans in response to increased traffic are strong countermeasures for combating the adverse effects of freeway diversion. Further improvements are likely to be realized through the implementation of integrated freeway and arterial control systems now in place or under development in several cities (*53*). Knowledge about the location and severity of freeway incidents immediately after they occur could be very useful in adjusting traffic signal and other corridor street controls to help offset the anticipated diversion from the freeway.

Incidents are not unique to freeways; blockages occur on surface streets also. The ability to detect these incidents, and adjust the traffic controls in the area in a coordinated fashion to accommodate the traffic that diverts to another surface street or to a nearby freeway is another important aspect of corridor street S&C. Many jurisdictions with new systems are installing changeable-message signs and highway advisory radio on arterial streets in a freeway corridor to provide improved traffic information to motorists on those facilities (*45,54*). Although proper response by an agency is complex enough when the incident and its effect in terms of diverted traffic occur within a single jurisdiction, the problem becomes even more difficult when effects cross jurisdictional boundaries. Similar multi-jurisdictional consequences are possible for large special events and for major work zone operations. Multi-agency traffic signal committees and areawide system control are mechanisms for dealing with traffic diversions on a regionwide basis (*27,52*).

APPLICATIONS IN THE U.S.

Recent advances in computer and communications technology have made it possible for even moderate-sized cities to purchase and operate computerized traffic signal control systems. A proliferation of systems of all sizes and prices has occurred over the past several years. No known efforts have been made recently to identify all of the computerized street S&C systems nationwide. In 1975, there were close to 150 cities and municipalities that were planning, implementing, or already operating computerized traffic control systems (*55*). More recently, one source indicates that, of the 204,000 traffic signals in urban areas, about 20 percent (about 41,000) are under computerized control (*3*). Efforts are now underway in several locations to develop an integrated freeway/arterial control system (Los Angeles, Seattle, Minneapolis, and others).

BENEFITS

In general terms, the benefits of corridor street S&C accrue because it allows the system to be more responsive to dynamic traffic conditions (*45*). Many different traffic signal timing plans may be available for immediate use, or they may be actually developed in real-time in response to traffic detector data received. Corridor street S&C provides improved data collection capabilities, useful not only for the continued operation of the signal system but for other operational and planning purposes. The surveillance benefits extend to the equipment, where detection of malfunctions is greatly enhanced by an S&C system.

From the driver's perspective, these systems provide the following traffic operations benefits:

- Reduced vehicle travel time along corridor routes;
- Reduced stops, fuel consumption, and vehicle air pollutant emissions;
- More effective use of available intersection capacity;
- Reduction of vehicle blockages of upstream intersections;
- Improved travel during incident conditions on both freeways and arterial streets;
- Reduced vehicle and pedestrian conflicts; and
- Personal benefits (less stress and fatigue).

Examples and Benefits of Selected Operating Systems

Miami

The Metro-Dade Traffic Control System of Miami, Florida is one of the nation's oldest computerized traffic signal control systems. Approved by the voters of Dade County in November 1972, the first phase of the system was placed in operation in 1975. At that time, 184 signalized intersections were brought under central control. Presently, more than 2,000 intersections are under system control.

A staff of 13 professionals operates the system. Engineers develop and fine-tune signal timing patterns along arterials and grid networks to maximize the safety and efficiency of traffic flow. Citizen suggestions and inquiries regarding traffic signals are taken into consideration by the engineers, who then decide on appropriate changes in signal control strategy. The traffic control system adjusts signal timing at each traffic signal as often as required to accommodate fluctuating traffic demands. The system is also capable of handling special circumstances. Signal timings are adjusted for events such as parades and races. Control of signals near schools is modified during appropriate hours to increase pedestrian safety. Lane control signals and signs are operated to increase traffic flow to and from the new football stadium. Signal timing patterns can be implemented to help move traffic away from coastal areas during a hurricane emergency.

The system provides significant benefits to the public. An evaluation found the following changes in traffic operations after implementation of the system:

- The number of stops decreased 41 percent,
- Average speeds increased 25 percent,
- Travel time decreased 20 percent,
- Fuel consumption decreased 15 percent,
- Other vehicle operating costs decreased 14 percent,
- Vehicle air pollutant emissions decreased 20 percent, and
- Signal equipment repair response time decreased 20 percent.

The 20 percent reduction in travel time has been computed to save about 35 million person-hours of driving time per year. In addition, the 15 percent reduction in fuel consumption corresponds to a $20 million savings to motorists annually (*56*).

Los Angeles

The city of Los Angeles, California implemented the first phase of its automated traffic surveillance and control (ATSAC) system in 1984, immediately prior to the 1984 Summer Olympic Games (*57*). This initial phase included 118 intersections and 396 detectors. Over the next several years, plans call for another 863 signals to be brought online in conjunction with the efforts to develop the "smart" corridor along the Santa Monica freeway. By 1998, 4,000 signals are expected to be part of the ATSAC system, accompanied by extensive region-wide detectorization (*58*).

The stated objectives of the ATSAC system are to detect equipment malfunctions, adapt traffic signal timing plans to short- and long-term traffic fluctuations, and to respond to unique traffic conditions created by special events, accidents, and construction activity. The system is built predominantly around the UTCS Enhanced and 1.5 Generation software. A hierarchial control scheme has been employed, whereby each of the different phases (sections) of the system is controlled by a central computer. These section computers are supervised by a main computer to integrate controls among the different areas in the network. Traffic surveillance throughout the system is accomplished through the extensive use of detectors, supplemented with closed circuit television at critical locations. A unique surveillance component of the system is a direct video feed from a police helicopter to the ATSAC control center. Consequently, operators can obtain a broad visual perspective of traffic conditions during special situations. Installation of changeable-message signs and highway advisory radio at various street locations are planned as part of the smart corridor demonstration project (*54*). These signs will be used on the approaches to freeway on-ramps to advise motorists of conditions on the freeway and to indicate when the highway advisory radio is transmitting (*59*).

The ATSAC proved to be extremely beneficial immediately after installation as a traffic management tool during the 1984 Summer Olympic Games. With the new capabilities of the system, engineers and operators were able to obtain volume counts during the first days of the Olympics, download and analyze them very quickly, and improve the controls on subsequent days of the games based on these early data. The benefits of the ATSAC system have also been estimated quantitatively. It is reported that the system has resulted in 35 percent fewer stops, 20 percent less delay, and a 13 percent reduction in travel times. Environmental benefits have also been noted as fuel consumption was reduced by 12.5 percent, and vehicle air pollutant emissions were lowered by 10 percent. Overall, an economic analysis has shown the ATSAC system to have a benefit-to-cost ratio of 9.8 to 1 (*59*).

Long Island

The first attempt at integrated corridor control of freeway and adjacent surface street traffic operations was that of the INFORM system in Long Island, New York (*60*). Initiated in the mid 1970s, the project has encountered many technological and administrative problems over the years, including cost overruns, loss of public support, and multiple changes in administrative leadership. As the result of a reorganization effort in 1985, the original goals of the project were scaled back somewhat, and more definitive, attainable short-term objectives were adopted. These objectives included the staged implementation of components of the system (as opposed to a single system "start-up" day), beginning with ramp metering along the freeway. Implementation of the arterial street control subsystem of the INFORM system was accelerated, and currently there are 112 signals under arterial subsystem control. An enhanced public information component has been included, using the variable-message signs, to educate the public on the uses of the system. A CB monitoring program provides some incident detection and verification to the INFORM operators.

The INFORM system, despite its problems, has begun to produce some measurable benefits to the motoring public. This is especially true for the arterial street control subsystem. On one route in the corridor, average travel times have been reduced from 43 minutes to 30 minutes (a 30 percent improvement).

CHAPTER SIX

HIGH-OCCUPANCY VEHICLE FACILITIES AND INCENTIVES

OBJECTIVES AND GENERAL DESCRIPTION

The purpose of providing separate facilities and other incentives to high-occupancy vehicle (HOV) users is to help maximize the person-movement capacity of a roadway by altering the roadway design or operation (*61*). HOV occupants in buses, vanpools, and carpools are provided a travel time reduction, improved travel time reliability and predictability, and/or monetary incentives to encourage motorists to shift away from single-occupant vehicles.

Within an urban freeway corridor, several strategies may be implemented to encourage the use of HOVs. Over the years, several different types of actions have been employed to provide preferential treatment to HOVs. These include (*61,62*):

- Special HOV lanes or areas (contraflow lanes, concurrent flow lanes, exclusive lanes, transit malls or auto-restricted zones) as illustrated in Figure 6,
- Other priority treatments (traffic signal preemption for transit vehicles, special preferential lanes at bridges and tollbooths, special parking privileges, exclusive HOV freeway entrance ramps, and metered entrance ramps with HOV bypass lanes), and
- Priority pricing treatments (free or reduced tollbooth charges, free or reduced parking for HOVs).

The selection and implementation of HOV strategies requires coordination with the overall regional mobility plan. Taken in isolation, very few of the actions listed will have their full potential effect; rather, it takes a system of strategies, support facilities, administrative policy decisions, and legislative actions to maximize the benefits from HOV incentives.

FIGURE 6 The travel time savings provided by HOV lanes encourage mode shifts from single occupant vehicles.

Furthermore, funding of major HOV strategies (e.g., transitways) will commonly be a multi-agency effort of Urban Mass Transportation Administration (UMTA), now known as the Federal Transit Administration (FTA), transit agencies, FHWA, state highway agencies, and cities. Also, an HOV plan typically will include both ridesharing programs (vanpooling and carpooling) and public transit systems. In some cases, the objectives and characteristics of these two markets may conflict with each other (*63*). Consequently, sound institutional relationships between highway agencies, transit agencies, regional planning organizations, councils of governments, and other organizations are necessary to the success of an HOV plan (*64,65*).

Because they are intended to provide incentives, HOV strategies are most appropriate where congestion is present on freeways and/or arterial streets. For example, research indicates (*66*) that transitways must provide at least a one minute per mile travel time savings, with a total travel time savings of at least five minutes over general-purpose freeway traffic lanes in order to be cost-effective. Of course, additional factors must also be considered when determining whether transitways or other HOV strategies, such as geometrics, trip lengths, or origin-destination patterns, are appropriate.

HISTORICAL PERSPECTIVE

Attempts at preferential treatments for HOVs can be traced back several decades. A busway through the East Side Tunnel in Providence, Rhode Island reportedly had its origins as early as 1914 (*67*). In the 1950s and 1960s, a few treatments were initiated on arterial streets in some of the larger cities (Chicago, New York, Washington, D.C., and others). However, the major thrust toward HOV usage occurred in the early to mid 1970s as a direct consequence of the energy crisis. Driven by strong political and public pressure, many preferential HOV treatments were employed across the country as commuters and public officials searched for ways to reduce fuel consumption and the pinch of drastically higher fuel prices. It should be noted that as the crisis waned and the public adjusted to higher prices, the incentive for many of the projects diminished, and priority treatments in several cities have been discontinued (*67*).

In the late 1970s and on through the 1980s, concern over increasing congestion in many urban areas replaced concern over fuel shortages and high fuel prices. It became apparent that increasing travel demands could not continue to be met through new roadway construction alone. Efforts were initiated in several cities to develop a strong HOV market to help accommodate increasing peak period travel demands. This emphasis continues even today, as more and more urban areas begin feeling the effects of continued growth in travel demands and subsequent congestion.

HOV APPROACHES

A variety of preferential treatments for HOVs has been developed. The following sections provide an overview of the common treatments that have been employed.

Contraflow Lanes

Typically, contraflow lanes operate by taking a traffic lane from the off-peak direction, and allowing HOVs to use it for peak direction movement during peak periods of the day. The lane is usually separated from oncoming traffic by cones or pylons. As a result, there are significant labor costs associated with the set-up and removal of this treatment. This technique is commonly employed on urban arterials (*67*), and has been employed at a limited number of freeway locations (*68*).

Typically, concern exists over the potential safety problems that may arise through contraflow operations; however, experience to date does not suggest that contraflow significantly increases the accident potential at a location. Furthermore, the development of moveable concrete barriers has helped alleviate some of the safety concerns that previously existed. Nevertheless, contraflow lanes should be considered temporary or interim HOV measures, not long-term solutions (*67*).

Concurrent Flow Lanes

Concurrent flow lanes have been employed on a number of freeway and arterial street facilities nationwide. One reference cited 18 freeway concurrent flow projects and more than 90 arterial concurrent flow lanes that were operational at one time (*67*). A concurrent flow lane is a separate lane for HOVs provided adjacent to peak-period, peak-direction traffic. Concurrent HOV lanes can be created by adding a lane (by using an inside shoulder or by restriping lanes to make them narrow and creating an additional lane) or by taking a lane from peak direction general-purpose traffic. Although both approaches are possible, experience indicates that only the add-a-lane approach is viable. All take-a-lane HOV projects to date have been terminated due to public opposition (*67*). Generally, concurrent flow lanes are not physically separated from general-purpose travel lanes, although a narrow flush median between them is sometimes provided. This has created enforcement problems in some instances (*69*). As with contraflow lanes, concurrent flow lanes are considered an interim HOV measure.

Exclusive HOV Lanes

Exclusive HOV lanes, transitways, or busways are lanes dedicated specifically for HOV travel and are physically separated from mixed-use traffic. Exclusive lanes can be created on right-of-way separate from regular freeway or arterial streets, or more commonly, can be incorporated into existing roadway right-of-way. As of 1988, five exclusive busways and nine exclusive HOV lanes were operational nationwide (*61*). Exclusive lanes can be built as reversible HOV lanes, or as two-lane, two-way facilities. Either way, exclusive lanes are generally permanent additions to the roadway network, rather than interim measures. Foresight and informed planning have resulted in successful integration of exclusive HOV lanes in several major freeway and arterial street rehabilitation projects. In fact, HOV lanes can be introduced as part of a traffic mitigation program for the actual construction project itself, as a means of introducing HOV lanes to an area and developing long-term support and usage (*70*).

In general, exclusive lanes are easier to enforce because motorists from mixed-use lanes cannot easily move into and out of the lanes. However, enforcement needs (e.g., safe observation and ticketing areas, special enforcement legislation, and access locations for enforcement vehicles) must still be considered during the planning and designing of exclusive HOV lanes (*71*).

Other Priority Treatments

In addition to special priority lanes for HOVs, other strategies are available to provide HOVs with travel time advantages or other special privileges. Among the more commonly used actions are:

- Exclusive freeway entrance ramps for HOVs,
- Special HOV bypass lanes at metered freeway entrance ramps,
- Preferential parking locations for carpools and vanpools, and
- Preferential lanes for HOVs at toll booth facilities.

Park-and-Ride Lots

Park-and-ride lots are centralized parking locations where HOV users may park (thus serving as a staging area for carpools and vanpools) and where connections with transit service can often be made. Park-and-ride lots are located and sized based on a number of factors including the roadway network, land use patterns, and commuter origin-destination patterns. Park-and-ride lots are also components to be considered in the design and operation of other HOV treatments (such as HOV lanes). Park-and-ride locations vary considerably, from simple mud lots with no lighting or security, to leased spaces at shopping centers or other private parking areas, to large complexes with on-site security and covered transit boarding areas. Although park-and-ride lots have existed in concept for more than 50 years, the emphasis in their design and operation is much different today from the early years. While the intention of initial park-and-ride lots was to accommodate the parking demand that already existed, current planning procedures focus on the generation of new demands for the proposed lots, attempting to encourage people to switch from single-occupant automobiles to carpools and buses (*72,73*).

Priority Pricing

Priority pricing actions for HOVs include free or reduced fees at toll facilities as well as free or reduced parking costs downtown or at major employment centers. This category differs from the others in that the incentive is monetary as opposed to travel time savings or improved travel time reliability. As a stand-alone item, priority pricing techniques do not appear to have much effect upon HOV usage. Locations where preferential tolls have been implemented have not resulted in significant changes in HOV use (*67*). However, such techniques do serve as support mechanisms, in conjunction with other HOV treatments, as part of an overall regional HOV and TSM plan. Of course, coordination and cooperation are necessary between the public and private parking locations as well as with the toll authority.

APPLICATIONS IN THE U.S.

There have been more than 200 applications of the various HOV treatments nationwide (*74*). Most large urban centers have employed one or more of the HOV treatments previously described, as have a number of medium-sized cities (*74*). More detailed information about the majority of the projects can be found in the literature (*62,67*).

HOV lanes on freeways provide the biggest travel time incentive to HOV use. In 1990, 16 cities or counties had one or more HOV lane facility (exclusive lanes, concurrent flow lanes, contraflow lanes) in operation on urban freeways or expressways. Table 2 presents a summary of the HOV lanes in existence as of 1990 (*75*). The number of HOV lanes will undoubtedly continue to grow in the coming years as urban congestion and the need to use existing roadway space more effectively increases. As an example, over 75 miles of barrier-separated HOV lanes are being implemented on most of the freeways in the Houston, Texas area (*76*).

BENEFITS

HOV strategies provide incentives to encourage a shift to HOV use and to reduce the number of single-occupant vehicles. Among the potential benefits from these strategies are:

- Increased peak-period person movement in the corridor,
- Increased average vehicle occupancy,
- Reduced travel times for HOVs and improved travel time reliability,
- Reduced parking and toll booth charges for HOVs,
- Increased transit ridership,
- Reduced fuel consumption, and
- Reduced air and noise pollution.

To date, HOV strategies have not been shown to reduce peak-period congestion in general purpose lanes used by all types of vehicles (*62*). Apparently, enough latent demand has existed in these corridors that new HOV drivers are replaced by more single-occupant vehicles, resulting in no net reduction in peak-period vehicle demand. Nevertheless, HOV strategies make it possible for the corridor to accommodate more person travel in the peak period without increased congestion.

HOV facilities, particularly exclusive HOV lanes, also offer certain advantages over regular general purpose freeway capacity increases or rail transit systems as a means of addressing peak-period travel. Although differences do exist on a project by project basis, these advantages can be characterized as follows (*77*):

- Lower implementation costs relative to other fixed transit facilities,
- Quicker implementation time relative to other fixed transit facilities,
- Possible staged opening of each section of an HOV lane as it is completed,
- Limited risk since HOV lanes can readily be converted to additional general purpose lanes or shoulders,
- Consistently cost-effective when applied to congested highways,
- Multi-agency funding is usually possible on HOV facilities,
- Multiple user groups (buses, carpools, vanpools) typically use HOV projects,
- High operating speeds on the facility because most bus (as well as carpool and vanpool) trips are express and have few stops,
- Flexibility is possible in the design and operation of the facility, and
- Timed adjustable operation is possible on many HOV facilities.

Examples and Benefits of Selected Operating Systems

Houston

Houston, Texas is developing an extensive system of exclusive HOV lanes in the right-of-way of its major freeways. These lanes are being constructed in conjunction with the rehabilitation and reconstruction of the general purpose freeway mainlanes and frontage roads. When completed, 75 miles of HOV lanes, or transitways, as they are called locally, will be in place, expected to serve more than 134,000 person-trips per day by the year 2000. In addition, it is expected that the transitways will save HOV users 20 to 30 minutes per commuting trip (*76*).

Originally, a 3+ person occupancy requirement for HOVs on the transitways was planned; however, that was soon reduced to 2+ persons due to public criticism. Demands have now grown to the point that one freeway (I-10 Katy Freeway) has raised the occupancy requirement back to 3+ persons during the peak hour. At the present time, the Katy Freeway (I-10) transitway is carrying 47 percent of the peak-period person-trips on that freeway, meaning that it is handling as many person-trips as the adjacent three general purpose freeway lanes (*77*).

The Houston HOV project is an excellent example of the benefits of extensive coordination and cooperation between public agencies, namely the Texas Department of Public Transportation (TxDOT) and the Harris County Metropolitan Transit Authority (METRO). The transitways are being funded jointly by UMTA (42%), METRO (38%), and the TxDOT (20%) (*76*). The operation and enforcement of the transitways will be handled primarily by METRO, with both METRO and TxDOT participating in the maintenance of the facilities. It should be noted that METRO is also contributing heavily ($600 million) toward general mobility improvements on the arterial street system in Houston (*78*). Such a commitment indicates the vision shared by both public agencies of an improved integrated transportation system for Houston in which HOV lanes are an important component.

TABLE 2
SUMMARY OF OPERATING HOV LANES, 1990

Transitway Facility	Number of Lanes	Length Miles	Year Implemented	Hours of Operation	Separation from Non-HOV Lanes
Exclusive Facilities, Freeway Right-of-Way					
Hartford, CT					
I-84	1 per dir.	10.0	1989	24 hours	17' painted buffer
Houston, TX					
I-45N (North)	1, reversible	9.1	1979-1984	5:45 am - 8:45 am,3:30 pm - 7 pm	Concrete barrier
I-45S (Gulf)	1, reversible	6.5	1988	4 am - 1 pm, 2 pm - 10 pm	Concrete barrier
I-10 (Katy)	1, reversible	11.5	1984-1987	4 am - 1 pm, 2 pm - 10 pm	Concrete barrier
US 290 (Northwest)	1, reversible	9.5	1988	4 am - 1 pm, 2 pm - 10 pm	Concrete barrier
Los Angeles, CA					
I-10, San Bernadino Freeway Busway	1 per dir.	12.0	1973 and 1989	24 hours	Concrete barriers and paint striping
Minneapolis, MN					
I-394	1, reversible	3.4	1985	6 am - 9 am, 2 pm - 7 pm	Concrete barriers
Pittsburgh, PA					
I-279	2, reversible	4.1	1989	5 am - noon, 2 pm - 8 pm	Concrete barriers
San Diego, CA					
I-15	2, reversible	8.0	1988	6 am - 9 am, 3 pm - 6:30 pm	Concrete barriers
Washington, DC					
I-395 (Shirley)	2, reversible	11.0	1969-1975	6 am - 9 am, 3:30 pm - 6 pm	Concrete barriers
I-66	2, peak dir.	10.0	1982	6:30 am - 9 am, 4 pm - 6:30 pm	Both freeway lanes used
Exclusive Facilities, Separate Right-of-Way					
Ottowa, Ontario, Canada					
Ottowa-Carleton Transitway	1 per dir.	14.5	1982-1989	24 hours	Separate R.O.W.
Pittsburgh, PA					
South Busway	1 per dir.	4.0	1977	24 hours	Separate R.O.W.
East Busway	1 per dir.	6.8	1983	24 hours	Separate R.O.W.
Concurrent Flow Facilities					
Denver, CO					
US 36 (Boulder Turnpike)	1, eastbound only	4.1	1986-1988	6 am - 9 am	Striping
Fort Lee, NJ/NYC					
I-95		1.0	1986	7 am - 9 am	Striping
	1, eastbound				
Honolulu, HA	only				
Moanalua Freeway		2.5	1978	6 am - 8 am	Striping
H-1		7.0	1987	6 am - 8 am, 3:30 pm - 6:00 pm	Striping
	1, eastbound				
Los Angeles/Orange Co., CA	only				
Rte. 55 Commuter Lane	1 per dir.	11.0	1985	24 hours	Striping
I-405 Commuter Lane		14.0	1989	24 hours	Striping
Rte. 91 Commuter Lane		8.0	1985	24 hours	Striping
	1 per dir.				
Miami, FL	1 per dir.				
I-95	1, eastbound only	14.0	1976-1978	7 am - 9 am, 4 pm - 6 pm	Striping
Orlando, FL					
I-4		30.0	1980	7 am - 9 am, 4 pm - 6 pm	Striping
	1 per dir.				
Phoenix, AZ					
I-10		7.0	1987	24 hours	4' painted buffer
	1 per dir.				
Richmond, CA					
I-580		6.0	1990	5 am - 10 am, 3 pm - 6 pm	Striping
	1 per dir.				
Sacramento, CA					
Rte. 99		4.0	1990	24 hours	Striping
	1 per dir.				
San Francisco, CA					
Oakland Bay Bridge		2.3	1970	5 am - 10 am, 3 pm - 6 pm	Pylons
US 101	1 per dir.	7.0	1974	6:30 am - 8:30 am	Striping
			1986-1987	4:30 pm - 7:00 pm	Striping
San Jose, CA					
Montague Expressway	4, peak dir.	5.0	1982, 1984, 1988	6 am - 9 am, 3 pm - 7 pm	Striping
Rte. 85	1 per dir.	4.0	1990	5 am - 9 am, 3 pm - 7 pm	Striping
Rte. 101		12.0SB 11.0NB	1986, 1988	5 am - 9 am, 3 pm - 7 pm	Striping
San Tomas Expressway	1 per dir.	11.0	1982, 1984	6 am - 9 am, 3 pm - 7 pm	Striping
	1 per dir.				
Rte. 237	1 per dir.	4.0	1984	5 am - 9 am, 3 pm - 7 pm	Striping
	1 per dir.				
	1 per dir.				

TABLE 2 *CONTINUED*

Transitway Facility	Number of Lanes	Length Miles	Year Implemented	Hours of Operation	Separation from Non-HOV Lanes
Concurrent Flow Facilities (Cont'd)					
Seattle, WA					
I-90	1, westbound	5.8	1988	24 hours	Striping
SR 520	only	2.8	1973	24 hours	Striping
I-5	1, westbound	6.2NB	1983	24 hours	Striping
	only	5.9NB			
I-405	1 per dir.	6.0	1986	24 hours	Striping
Vancouver, Canada	1 per dir.				
H-99		4.0SB	1980	24 hours	Striping
		1.0NB			
Washington, DC	1 per dir.				
I-95		6.8	1985-1986	6 am - 9 am, 3:30 pm - 6 pm	Striping
	1 per dir.				
Contraflow Facilities					
New York City, NY					
Rte. 495	1, inbound only	2.5	1970	6:30 am - 10 am	Drop-in cones
Long Island Expressway	1, inbound only	2.2	1971	7 am - 10 am	Drop-in cones
Gowanus Expressway	1, inbound only	0.9	1980	7 am - 9:30 am	Drop-in cones

Washington, D.C./Northern Virginia

HOV facilities have been a part of the transportation infrastructure in the Washington, D.C. and Northern Virginia area since the early 1970s. Three different HOV facilities are currently in place.

The first of these is the I-395 (Shirley Highway) reversible lanes. Two lanes carry buses, vanpools, and 3+ carpools to and from Northern Virginia and Washington, D.C. The occupancy requirement on I-395 was reduced from 4+ persons in January 1989. In the morning peak period, the HOV lanes carry 38,900 people at level-of-service C (stable flow range in which the operation of individual users is affected by interactions with others in the traffic stream), compared with the four general purpose lanes which carry 29,000 people at level-of-service F (breakdown flow). The HOV lanes provide an average 16–minute travel time advantage to HOV users.

The second HOV facility is the I-95 concurrent flow lane. Occupancy requirements for the lane, originally 4+ carpools, was also reduced to 3+ carpools in January 1989. The HOV lane carries 14,800 people during the morning peak period compared to the three conventional lanes which together carry 10,700 people. The diamond-marked carpool lane saved about 10 minutes travel time compared to the conventional lanes.

The third HOV facility is on I-66, a four-lane freeway. This roadway is unique in that it operates as an exclusive HOV facility (two lanes) in the peak direction during the peak period. Buses and 3+ carpools are authorized to use the facility. Right-of-way has been provided within the roadway for an existing rail transit line (*79*). The facility carries approximately 30,000 people total during the morning and afternoon restricted periods (*61*). Because it is an exclusive HOV lane during the peak periods, there are no general purpose lanes on which to base travel time comparisons.

These HOV facilities have generated some political battles because of their proximity to the nation's capital. Enforcement of the concurrent flow lane has been a serious problem over the years because of the lack of physical barriers. In January 1989, a program based on the successful Seattle HERO program was implemented on the Shirley Highway and I-66 that allowed HOV users to report violators to a central number. The HERO program was an effort to reduce the number of violators and to inform the traveling public of the need for HOV lanes (*75*). The program was terminated in November 1990 due to budget constraints.

CHAPTER SEVEN

POLICE ENFORCEMENT AND TRAFFIC CONTROL

OBJECTIVES AND GENERAL DESCRIPTION

Traditionally, the goals and objectives of law enforcement with respect to traffic operations have been defined from the perspective of improving or preserving public safety. More recently, however, the role of enforcement in urban corridors has been growing with the effective use of police officers as a means of enhancing the operational efficiency of transportation facilities. Enforcement personnel perform two types of functions in freeway corridor management (*80*):

- Traffic Control Functions—situations where a uniformed officer improves the effectiveness of traffic control measures or expedites traffic flow. It is the threat of enforcement, not necessarily carried out, that results in improved traffic operations.
- Enforcement Functions—situations where regulations must be enforced to ensure the successful operation of transportation facilities.

These two functions should not be thought of as mutually exclusive. In many instances, such as the enforcement of ramp metering or HOV restrictions, the role of enforcement in freeway corridor management involves both of these functions simultaneously.

While enforcement and police patrols are essential components of a freeway corridor system, they are not isolated components. An effective freeway corridor enforcement program also encompasses the courts, state licensing agencies, and transportation agencies (*81*). The demands placed on enforcement agencies with respect to freeway corridor management are of critical concern. The success of enforcement as a traffic management tool has led to its increased use at a time when manpower and budgets of many enforcement agencies are being cut. Furthermore, traffic-related tasks are generally only one part of a police officer's duties. Without planning and interaction among all agencies involved in freeway corridor management, adequate enforcement resources may not always be available on a consistent basis.

HISTORICAL PERSPECTIVE

The history of enforcement for traffic regulation and control extends back to the 1930s, concurrent with the beginning of motor vehicle regulations. However, the increased role of enforcement in the management of traffic has a more recent history. The introduction of each of the many components of freeway corridor management (e.g., ramp metering, HOV restrictions, and hazardous material restrictions) has been paralleled by the initiation of enforcement to ensure their effectiveness.

The late 1960s began an era of increased concern for the management of large-scale urban traffic problems, with police involvement in traffic control increasing for non-recurrent congestion problems such as special events, work zone traffic control, and incident management. One of the most important concepts that has helped to increase the integration of enforcement agencies into freeway corridor management has been the initiation of corridor management teams. Originating in Texas (and termed "traffic management teams"), the organization of multi-jurisdictional teams that meet on a regular basis to discuss traffic management strategies, problems, and successes, has been very beneficial in fostering good working relationships between highway and enforcement agencies and developing a coordinated approach to addressing many urban traffic issues (*12*).

APPLICATIONS IN THE U.S.

The importance of enforcement personnel in freeway corridor management is evident in the number of different capacities they perform and the different activities in which they are asked to participate. The following sections present an overview of the major facets of freeway corridor management in which enforcement efforts are crucial to their success.

Ramp Control

Entrance ramp controls are the most common control systems used on freeways in urban areas. Such controls regulate traffic demands at entrance ramps to improve the operational efficiency of the freeway, or restrict use of the ramps to HOVs (providing bypass lanes or exclusive HOV entrance ramps) to improve travel time over general-purpose traffic. These controls are essential to efficient traffic operations on the freeway; hence, compliance with them is paramount to successful corridor operations. In some cases, ramp controls are not automatically obeyed, and enforcement is called upon to obtain the necessary compliance.

The role and requirements of enforcement for ramp control should be considered, and enforcement agencies consulted, during the planning and design stages of a ramp control system. Effective enforcement of ramp control requires good access locations for officers to apprehend violators as well as a safe refuge where citations can be issued, adequate numbers of enforcement personnel and support staff, support of ramp control citations by the courts, and a system of enforceable signs and signals (*82*). The proper application of selective traffic enforcement efforts can help stretch the manpower capabilities of the enforcement agency in this regard. Likewise, the use of automatic violation detection devices can help maximize enforcement efficiency.

Incident Management

Under incident conditions on either freeways or arterial streets, police officers are often the first to arrive on the scene, and are an important component in the incident management systems operating in a number of cities nationwide (*35,83*). The primary responsibilities of the police officer are to first protect the safety of the public at the incident site and then to maintain traffic flow and clear the incident using real-time, demand-responsive techniques. This involves assessing the severity of the incident and calling for appropriate medical assistance or hazardous material response, setting up and performing traffic control around the incident, ensuring emergency vehicle access, and assisting in diverting traffic off the freeway or arterial street if necessary.

Motorist "rubbernecking" at the scene of an incident can cause additional traffic congestion. To combat this, highway and enforcement agencies in several jurisdictions have worked together to establish accident investigation sites, as shown in Figure 7 (*84*). These sites are located off the freeway or major thoroughfares, and serve as secluded refuges where motorists can exchange information and enforcement personnel can complete their paperwork without adversely affecting traffic flow.

In addition to their functions in incident response plans, police patrols in some cases also serve as an important incident detection and verification source. The increased use of patrols reduces the headways between patrols and increases incident detection capabilities (*34*). However, the use of increased patrols must be carefully considered in light of the other types of incident detection methods (such as highway agency or private organization service patrols) that may be available, since the use of police for incident patrols is often regarded as an inefficient use of enforcement resources (*34*).

Some states require drivers to move their vehicles off the freeway when non-injury, minimal-damage accidents occur and the vehicles can be driven safely. In Texas, a law has been passed that requires moving vehicles in such circumstances; but most people are unaware of the law, and many drivers refuse to move the involved vehicles until a law officer can investigate the scene of the accident. In an effort to remedy this situation, TxDOT has instituted an accident management program entitled "MOVE IT." (More details of this program are presented in Chapter Thirteen.) The purpose of the program is to remove the vehicles and people from the travel lanes and thus avoid traffic congestion and potential injury. Georgia and Florida have similar laws and the Departments of Transportation have put signs along the highway to inform motorists of the requirement to move vehicles from the roadway. In addition, Georgia has incorporated this information into the Department of Motor Vehicles (DMV) driver's manual.

Work Zones

Police officers at work zones help to ensure the safety of the work site, both for the motoring public and the workers themselves. In addition, they may be needed to maintain acceptable traffic flow conditions through the work zone (*80*). The presence of enforcement can increase compliance with, and the perceived authority of, traffic controls (such as reduced speed limits) (*34*). Also, police personnel draw added attention to the work site, increasing motorist awareness and reducing conflicts in the vicinity of the work area.

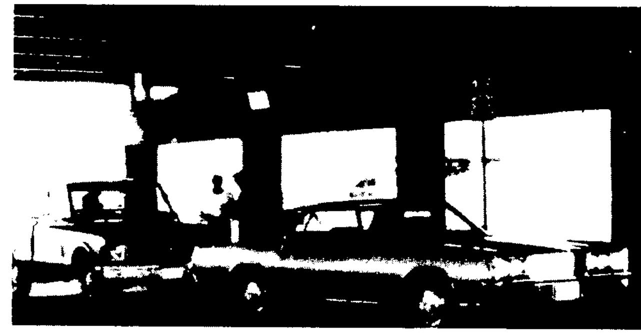


FIGURE 7 Accident investigation sites are another important law enforcement component in freeway corridor management.

Enforcement at work zones is most effective when patrol cars are stationary and visible. It is generally not desirable for officers to leave the work area to cite violators; rather, it is the threat of citation within the work zone that is most effective (*80,85*). However, enforcement agencies do have other responsibilities in addition to traffic management, and so it is possible that officers may be pulled from the work zone to tend to other more urgent tasks. To avoid this scenario, at least one highway agency has entered into agreements with enforcement agencies as part of a Selective Traffic Enforcement Program (STEP) to provide officers for work zones (*86*). Officers are present whenever a work zone involves a lane closure on an urban freeway. This specification also illustrates the need to establish objective criteria regarding the use of enforcement at work zones (*86,87*). Not all work zones need enforcement personnel; they should be used only when a specific need exists.

Hazardous Material Cargo Enforcement

The enforcement of hazardous material cargo restrictions is another vital area of freeway corridor management, due to the catastrophic potential of an accident involving these carriers. Activities of police personnel include enforcement of hazardous material routing plans around major population centers, vehicle inspections to ensure safe operating conditions, and inspection and verification of container placards and shipping records of carriers (*88*).

Again, the regulation of hazardous material cargo transportation consists of much more than the efforts by enforcement agencies. A complete regulation package is needed in an urban jurisdiction consisting of (*89*):

- Adequate legislation to support the regulations,
- An effective administration program,
- Adequate enforcement capabilities,
- Educational programs (for police responses to hazardous material and for hazardous material carriers), and
- Capabilities to accommodate hazardous material carrier accidents as part of the incident response program.

One of the major concerns that has been addressed on a national level is the lack of uniform, nationwide hazardous material transportation regulations. A need has been expressed for a "national" enforcement plan (*90*) as a means of improving carrier compliance with regulations. Because of the varying rules and regulations now in place across the country, carriers (particularly multi-state carriers) find compliance difficult.

Special Events

Although considered similar to both incidents and work zone, special events pose traffic management challenges unlike either. Special events usually involve higher traffic volumes than normally exist on area roadways, not lower as commonly occurs during freeway incidents or within work zones. Consequently, the flexibility of police control of traffic at critical locations is of great benefit for special event traffic management. Police officers are commonly used to provide real-time, demand-responsive traffic control at site access points and at critical intersections. Officers also play a role in adding credibility and authority to any special traffic signing that may be placed for the event (*80*).

HOV and Other TSM Actions

Priority treatments are implemented in urban corridors to provide travel time or other incentives to high-occupancy vehicles (HOVs). The subject of HOV operations in freeway corridor management is treated in detail in Chapter Six. The priority treatments provide an incentive to HOVs through the restriction of use from general-purpose traffic. In order to maintain the design and operational integrity of the priority treatments, the restrictions must be enforced. It should be noted that certain other transportation systems management (TSM) techniques, such as peak-period parking restrictions and left-turn prohibitions, also require regular enforcement in order to achieve their intended effects (*69*). Enforcement levels should be commensurate with the needs of the particular project. In some cases, it is possible to determine the maximum violation rate that can be accommodated without adversely affecting the priority treatment, and enforcement levels can be adjusted to maintain violation rates at or below that threshold (*91*).

Enforcing HOV treatments requires the detection, apprehension, citation, and prosecution of violators. The requirements for effective enforcement, with respect to each of these components, should be considered in the application of any HOV treatment. This is particularly true of permanent HOV facilities, many of which are being built across the country. Without adequate provisions, an HOV treatment may not be enforceable, resulting in reduced effectiveness or total failure (*69*).

In most instances, state and local enforcement agencies take on enforcement responsibilities for HOV treatments in a corridor. However, some transit agencies may provide their own enforcement, particularly of limited-access transit facilities over which they have significant responsibility and control (*61*).

BENEFITS

The benefits of enforcement in freeway corridor management are far-reaching; benefits accrue from each of the different types of applications just described. Overall, enforcement and police officer traffic control result in better traffic flows and reduced accident potential. For example, enforcement of HOV facilities results in a lower violation rate, which results in better HOV facility operation. Reducing speeds through the presence of police officers at work zones is felt to significantly improve work zone safety (*86*). Finally, enforcement of ramp metering systems reduces meter violations, resulting in improved traffic flow and reduced accident potential on both the freeway and the entrance ramp.

Examples and Benefits of Selected Operating Systems

Boston

An evaluation of enforcement of TSM strategies in Boston, Massachusetts performed in 1980 (*69*), illustrates the need for enforcement participation during TSM design rather than after implementation. The four TSM projects were a preferential HOV lane on an expressway, an auto-restricted zone in the central business district, a residential parking permit program, and a towing/booting program for delinquent parking tickets. Each of the TSM strategies was evaluated on a case study basis, with emphasis given to the role that enforcement agencies played in the design and implementation of the projects. All of the projects involved extensive enforcement agency participation and, with the exception of the preferential HOV lane, were successful. The towing/booting program netted the city approximately $2 million in past-due fines that were paid during the first year of operation, and apparently changed the public's attitudes about illegal parking. Enforcement of the residential parking program and the auto-restricted zone likewise were determined to be successful.

The HOV lane was discontinued after heavy enforcement reduced the violation rate, but caused increased congestion on the general purpose lanes. From the beginning of the project, police officials were concerned that the HOV lane was unenforceable, and they were correct in that violation rates as high as 80 percent were observed immediately after implementation. Only after approval was given to the enforcement agency to ticket violators by mail did the violation rate decrease and the travel time incentive for HOVs appear. However, strict enforcement resulted in the increased mainlane congestion and the ultimate cancellation of the project.

CHAPTER EIGHT

HAZARDOUS MATERIAL AND OTHER TRUCK TRAFFIC RESTRICTIONS

OBJECTIVES AND GENERAL DESCRIPTION

The control of hazardous materials as well as other truck traffic is another component of a freeway corridor management system. Over the past several years, truck traffic has grown tremendously in response to the general move away from the railroad as a primary method of transporting commercial goods. This increased truck traffic has resulted in a greater frequency of truck-related accidents as well as truck incidents involving hazardous materials. Often, these incidents are spectacular (*92*), involving innocent bystanders, and typically drawing considerable media and public attention. Consequently, there is increased public concern about the operation of truck traffic in and around highly populated urban corridors. It is a well-known fact that trucks, although capable of traveling as fast as or even faster than automobiles, do not have the same ability to stop or take evasive actions in emergency situations. Hence, there may be roadway situations for which trucks are not appropriate (*93*).

The first objective of controlling truck traffic is to reduce the risk (defined as the probability of an accident multiplied by its expected severity) to the driving public as well as to the surrounding population (*93,94*). A second objective is to improve the overall traffic operations on a segment of roadway that has been plagued by truck incident problems or where the restriction of trucks would result in improved traffic flow.

Nationwide, a number of specific truck restrictions have been implemented at various locations on either a permanent or a temporary basis. The following is a list of the major types of truck controls (*95*):

- Increased enforcement of existing traffic restrictions for trucks (such as differential speed limits, or safety inspections as shown in Figure 8),
- Route restrictions,
- Lane usage restrictions,
- Time-of-day restrictions, and
- Special insurance requirements for hazardous material carriers.

An overall approach to controlling truck traffic must consist of more than a list of restrictions, however. An effective approach to truck regulation and control must have consistency among the different agencies in the region (federal, state, local), identification of the items of responsibility for each agency, adequate enforcement capabilities, and a predefined emergency response plan (*89*).

Depending on the contents of the shipment, a multitude of agencies may have a role in truck regulations and responsibility in the event of an incident. A breakdown of these agencies by government level includes:

Federal Level Agencies:
- Department of Transportation
- Environmental Protection Agency
- Department of Energy
- Nuclear Regulatory Commission
- Federal Emergency Management Agency

State Level Agencies:
- Department of Transportation
- Public Service Commission
- State Highway Patrol
- Environmental Agency
- Civil Defense
- Health Department
- Fire Marshall

Local Level Agencies:
- Local police
- Local firefighters
- Local civil defense
- Local traffic engineering agency

It must be recognized that trucks cannot be completely restricted from urban areas. Consequently, truck restrictions are only appropriate when the expected benefits outweigh the anticipated costs from a regionwide perspective. Enacting restrictions on one highway segment may simply move the problem to another location. In some cases, this move may be less desirable than the original condition, if the local agencies are

FIGURE 8 Enforcement is essential for the successful application of truck restrictions.

not equipped to deal with increased truck incidents in their jurisdiction.

HISTORICAL PERSPECTIVE

One of the first regulations in this topic area was the 1866 Act to Regulate Transport of Nitroglycerin (*96*). Since then, 64 additional federal laws have been enacted, including the Hazardous Material Transportation Act of 1974 and the Motorist Carrier Assistance Program (established by the 1982 Surface Transportation Assistance Act) (*96*). These regulations, being of a national level, do not enumerate specific truck restrictions on certain routes. Instead, they establish policies regarding the safe transport of hazardous materials. Specific route/time/lane restrictions are carried out by state and local highway agencies.

The Superfund Amendments and Reauthorization Act of 1986 (*97*) was another piece of legislation with profound impact on, among other things, the transport of hazardous materials and response to hazardous material accidents. As part of the legislation, each state was required to establish an emergency response commission under the leadership of the governor. Within each state, emergency planning districts were established to prepare procedures for responding to and reporting hazardous materials accidents. The legislation also touched local municipalities, which were instructed to establish local emergency planning committees to develop local emergency response plans and public notification procedures to deal with hazardous materials accidents.

As stated previously, the potential hazard of trucks as perceived by the public is an emotionally charged issue. Cases have occurred where truck restrictions have been enacted almost overnight in response to a severe truck incident (*98*). Restrictions that result from such events can create more problems than those they were intended to solve.

APPLICATION IN THE U.S.

In the broadest sense, all 50 states have some type of truck restrictions. For the most part, however, these are size and weight restrictions implemented at bridges and tunnels. If the focus is narrowed to just hazardous material and operational restrictions, the list becomes much shorter. A recent survey of states illustrates the extent of truck restrictions nationwide (*95*). Since the survey was a mail-back questionnaire, it is likely that many of those without restrictions did not return the survey, and the results presented may be biased toward those that have enacted restrictions. Nevertheless, the survey does provide an interesting national perspective of this issue.

As previously stated, all states had some type of truck restrictions enacted. Most of these dealt with oversize and overweight truck shipments. Although many were related directly to the physical limitations of the roadway, 11 of 16 responses indicated that some of the oversize/overweight regulations were based on time-of-day criteria, to avoid peak-period or nighttime travel. With respect to lane usage restrictions, 10 of 23 states responding indicated that local agencies had imposed some type of lane restrictions. In comparison, 13 of 23 states had time-of-day truck restrictions, and 17 of 23 had route restrictions. Many of the states (13 of 20) allow local agencies to establish truck regulations on state highways in their jurisdictions.

BENEFITS

Properly substantiated truck restrictions can provide benefits to the driving public as well as to the safety of the general population of a region. From the safety perspective, truck restrictions can reduce the risk of injury to the general public, both by reducing the expected frequency of incidents and the population that would be exposed in the event of a hazardous material incident. From an operational perspective, truck restrictions can help to improve, to a small degree, traffic conditions on congested or nearly congested roadway segments. Recent research results indicate (*99*) that restricting trucks to certain lanes on moderate to high volume multi-lane facilities can increase non-truck speeds. At two locations, non-truck speeds were increased 3 to 11 mph, and truck speeds were only slightly affected.

Example and Benefits of a Selected Operating System

Hazardous Material Truck Route Restrictions, Dallas/Fort Worth

In 1978, the Dallas City Council amended its city code to restrict hazardous material shipments in the region to selected routes. The loop around the city was identified as one of the routes to be used. Since it was also an interstate highway, state and federal approval was required.

In response to this action, a regional level hazardous material truck route plan was established for the Dallas/Fort Worth area. The analysis was performed by the North Central Texas Council of Governments (NCTCOG) (*100*), and was based on the Federal Implementation Package for establishing hazardous material routing plans (*93*). The procedure employs a risk assessment methodology, where risk is defined as the expected frequency of hazardous material accidents multiplied by the severity of their expected impact on the public in the region.

The analysis resulted in a complete regionwide hazardous material route plan. It was estimated that the total risk to the population was reduced by 47 percent, and to the employment population (generally located adjacent to the major freeways) by 80 percent. The plan increased route circuity by 113 percent, but the benefits still exceeded the costs (*101*).

The suburban communities were allowed to take part in the review process of the routing plan prior to approval. Although most were concerned about their local emergency response capabilities to handle hazardous material incidents, the communities for the most part recognized the recommended routes as the best for the overall region and eventually accepted the plan.

CHAPTER NINE

ALTERNATIVE ROUTE PLANNING

OBJECTIVES AND GENERAL DESCRIPTION

Traffic congestion caused by an incident or a work zone requires a multi-faceted management approach involving a number of different strategies. One of the strategies that has been shown to be very successful is to reduce the freeway traffic demand during an incident or work zone operation by encouraging the traffic to use other routes in the corridor. This is accomplished by placing changeable-message signs or other temporary diversion signs upstream of the congestion indicating the need to divert. In order to effectively implement such a strategy, however, it is necessary to know to which route or routes traffic should be diverted and how far upstream from the incident or work zone this diversion should take place. Furthermore, equipment and manpower needs for implementing this diversion must also be established. The objective of alternative route planning is to obtain and categorize this information beforehand so that it can be readily accessed and used when it is most needed.

Alternative route planning is a systematic process that involves examining where and how much traffic should be diverted whenever an incident or other blockage occurs on any section of freeway at any time of the day. In effect, alternative route contingency plans are developed for various levels of freeway incidents anywhere in the system. Once it is determined how much traffic must leave the freeway and where it should go, equipment and manpower needs for handling traffic on the alternative routes can be established. The process also includes designations of duties and responsibilities, and point of contact for each agency and contacts between agencies. An example of an alternative route map is shown in Figure 9. Alternative route plans can also be developed for incidents on major city streets.

Alternative route planning must be accomplished as a team effort consisting of state and local transportation and enforcement officials (*36*). Not all arterials near a freeway may be desirable or even feasible as diversion routes; the arterial may pass by large schools, hospitals, or sensitive neighborhoods. Local city officials have this type of knowledge, and can help avoid such routes in the planning process. Enforcement agencies can provide additional input about localized trouble spots, and provide assistance in implementation procedures for the plans.

HISTORICAL PERSPECTIVE

California has led the way in the development of alternative route plans, having created a database of nearly 2,500 alternative route maps for the Los Angeles area by the mid 1970s (*102*). A more recent estimate indicates that more than 3,500 freeway segment locations in Los Angeles now have alternative route maps established (*103*). Meanwhile, the number of locations that have or are developing such plans has grown slowly. Part of the reason that development has been so slow is that this process is extremely labor-intensive and time-consuming. Nevertheless, the demonstrated benefits of having alternative route plans have been such that highway agencies are placing greater and greater emphasis on their development.

APPLICATIONS IN THE U.S.

Alternative route planning was implemented several years ago in the Los Angeles area (*100*) as well as in northern California (*103*). More recently, plans have been developed for the Capital Beltway in the Washington, D.C. area (*104*), as well as for locations in Northern Virginia (*83*), Florida (*105*), Michigan (*44*), and Ohio. Work is also underway on alternative route plans in the New York/New Jersey area (*44*). In Houston, the potential application of Geographic Information Systems (GIS) computer technology for maintaining and using alternative route plans is currently being developed (*106*).

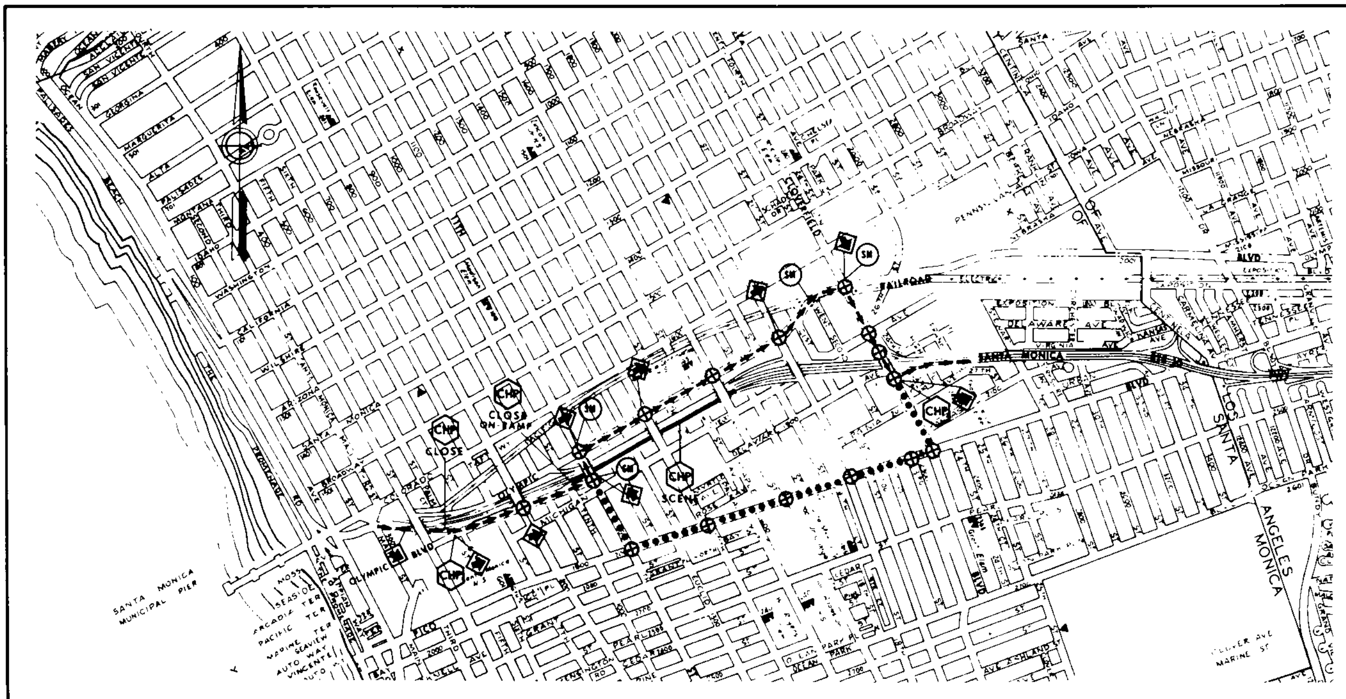
BENEFITS

Developing alternative route plans reduces the time required for decision making and implementation of alternative route diversion activities by all agencies involved in incident management. In addition, the planning process helps to establish the necessary communication links among the agencies involved (*103*). The actual experience of the planning process itself has helped highway officials make better decisions "on the fly" during emergency traffic situations for which no route plans had been developed (*103*). Ultimately, traffic is better accommodated during incident conditions, resulting in the standard reduction in delay, congestion, and secondary accident potential. At least one agency has also used the plans when establishing traffic diversions during maintenance and construction work zone operations (*36*).

Example of Selected Operating Systems

Los Angeles

The California Department of Transportation (Caltrans), in conjunction with the Los Angeles Transportation and Police departments and the California Highway Patrol, began to develop alternative route plans in the early 1970s. It was believed that such plans formed the necessary foundation on which to build an effective incident management program (*102*). According to one source, alternative route maps have been de-



STAGES OF IMPLEMENTATION

NO OF LANES CLOSED

	ESTIMATED DURATION	1	2	3			
MID	1 HOUR	—	I	IV			
TO	2 HOURS	I	II	IV			
0500	2-6 HOURS	III	III	IV			

	ESTIMATED DURATION	1	2	3			
0500	1 HOUR	II	III	IV			
TO	2 HOURS	III	III	IV			
1900	2-6 HOURS	III	III	IV			

	ESTIMATED DURATION	1	2	3			
1900	1 HOUR	II	III	IV			
TO	2 HOURS	II	III	IV			
MID	2-6 HOURS	II	III	IV			

I FIELD CHECK ALTERNATE ROUTES
II ALTERNATE ROUTE TRAFFIC ADVISORIES
III OFFICER & SIGN DEPLOYMENT (VOLUNTARY DIVERSION)
IV EMPLOY ALTERNATE ROUTE (MANDATORY DIVERSION)
V CLOSE FREEWAY CONNECTORS
VI BARRICADE ON-RAMP & CONNECTOR CLOSURES
NOTE ROMAN NUMERALS ARE STAGES OF IMPLEMENTATION UP TO AND INCLUDING THE STAGE SHOWN

PERSONS TO NOTIFY

AGENCY	TEL NO
CALIFORNIA HIGHWAY PATROL	213 620-3456
DEPT. OF TRANS MAINT COMM	213 620-3270
SANTA MONICA POLICE DEPT	213 395-9931

SPECIAL NOTES:

YES NO
☐ ☐ MEDIAN SHOULDER OK FOR TRAFFIC
☐ ☐ OUTSIDE " " " "
(MAJOR PORTION OF CLOSURE AREA, FIELD CHECK AT INCIDENT AREA)

OTHER - CLOVERFIELD BLVD ONE LANE

LEGEND

LIMITS OF CLOSURE
PRIMARY ALTERNATE ROUTE
SECONDARY ALTERNATE ROUTE
SIGNALIZED INTERSECTION
STOP SIGN INTERSECTION
SIGNING
CALIFORNIA HIGHWAY PATROL
SANTA MONICA POLICE DEPT
FIRE STATION

LIMITS OF CLOSURE

BETWEEN LINCOLN BLVD ON-RAMP AND 20TH ST OFF-RAMP

ALTERNATE ROUTES

PRIMARY:
LINCOLN BLVD OFF-RAMP TO E/B OLYMPIC BLVD TO N/B 11TH ST TO E/B OLYMPIC BLVD TO S/B CLOVERFIELD BLVD TO ON-RAMP

SECONDARY:
LINCOLN BLVD OFF-RAMP TO E/B OLYMPIC BLVD TO S/B 11TH ST TO E/B PICO BLVD TO N/B CLOVERFIELD BLVD TO ON-RAMP

ALTERNATE ROUTES
SANTA MONICA FREEWAY
ROUTE 10
EASTBOUND

DATE REVISED 10/75

LA-10-E24

FIGURE 9 Alternative route plans also specify equipment and manpower needs.

veloped for potential incident closures at more than 3,500 locations (*104*).

All existing streets that might serve as alternative routes were identified and inventoried for every section of freeway in the Los Angeles area. The best possible route(s) for each potential incident location was identified. City transportation and enforcement played a key role in alternative route identification. Their opinions and knowledge of the facilities themselves were extremely important to the planning process. Certain details, such as locations of churches or schools, hospitals or sensitive neighborhoods, were extremely valuable when deciding whether or not a surface street was suitable as an alternative route. The information about alternative routes was then transferred to a local map of the area, along with the equipment and manpower efforts required to implement the alternative route plan.

Implementation of a given alternative route map is the responsibility of the freeway incident management team. The team, made up of Caltrans traffic engineers and technicians, responds to every incident that is estimated to block two or more lanes for two or more hours (*36*). After evaluating the situation, the Caltrans traffic engineering team member has the responsibility of determining the alternative routes to be used and supervising their implementation. The alternative route plans have been very beneficial to the incident management team, reducing time needed for decision making and diversion strategy implementation, and improving effectiveness (*104*).

Maryland

The Maryland State Highway Administration, Maryland State Police, and several county police forces and traffic staffs have worked together to develop alternate route strategies. The Freeway Incident Traffic Management (FITM) program establishes alternative routes along each interstate and all major arterial routes in Maryland, and the Chesapeake Highways Advisories Routing Traffic (CHART) program operates several Traffic Operations Centers (TOC) to monitor traffic conditions. The CHART/TOC's serve as a clearinghouse for traffic incidents and coordinate response activities with other state agencies. The TOC's are responsible for reporting and verifying roadway incidents, coordinating emergency response services and informing motorists of necessary changes in routes.

Freeway incident traffic management alternative routes have been developed for lane closures on all major highways in the Maryland/D.C. metropolitan area. The plans indicate preferred alternate routes, the locations where signs should be placed, signal timing modifications that should be made on the alternate route, and the responsibilities of each involved agency. The diversion signs, enough to divert and direct all traffic along alternate routes in case of freeway blockage, are stored in FITM trailers, which are located at each maintenance shop (28 total) throughout the state.

CHAPTER TEN

MOTORIST ASSISTANCE PATROLS

OBJECTIVES AND GENERAL DESCRIPTION

Motorist assistance patrols offer another tool to combat the impacts of non-recurrent (incident) congestion in urban freeway corridors. The patrols consist of vehicles equipped to quickly remove minor incidents (stalls, flat tires, minor accidents) from the freeway, and are operated by personnel trained in motorist assistance and traffic management procedures. Typically, these vehicles patrol all or parts of an urban freeway corridor system, trying to maintain traffic flow by keeping lanes clear of accidents, disablements, and debris. Motorist assistance patrols also serve as a detection, and often more importantly, as a verification mechanism for major incidents that cannot be handled by the motorist assistance patrol alone. Also, they provide valuable public relations benefits to the operating agency or agencies.

Incident management can be thought of as consisting of four components: detection, response, clearance, and traffic management/motorist information (*107*). The objective of a motorist assistance patrol is to consolidate techniques for dealing with all four of these components into one vehicle (*108*). In this way, the total time of an incident can often be reduced, resulting in reduced traffic delays and safety problems. An example of a motorist assistance patrol vehicle is shown in Figure 10. It has been estimated that each minute of incident detection and response time saved results in 4 or 5 minutes of delay savings to the motorists (*109*). Motorist assistance patrols are able to handle a large majority of the "minor" incidents that make up a large portion of all incidents that occur (*107*).

HISTORICAL PERSPECTIVE

The earliest applications of motorist assistance patrols were in tunnels and on bridges, where little, if any, shoulders were present and where an incident could have a debilitating effect on traffic operations (*108*). Many of these systems remain in place today. Over time, the use of motorist assistance patrols spread to major sections of freeways and entire freeway systems. One of the first of these types of systems was the "Minuteman" emergency patrol initiated in Chicago in 1961 (*110*). The success of this and other early systems has led to the recent initiation of patrols in a number of urban areas.

MOTORIST ASSISTANCE PATROL APPROACHES

The establishment and operation of a motorist assistance patrol depends on the local approach to a number of traffic management issues. First, motorist assistance patrols vary in terms of the type of incident they are designed to accommodate. Many motorist assistance patrols provide only light-duty vans or trucks to push or tow a vehicle from the freeway. Towing assistance for larger vehicles is handled via agreements with private towing companies. In other systems, large vehicle towing capabilities are incorporated in the overall motorist assistance patrol system. This latter approach makes it easier to coordinate incident management activities when large vehicles are involved, by having all necessary equipment under the jurisdiction of the incident management system. However, this also increases the capital and operating expenses of the system.

Motorist assistance patrol approaches also differ in terms of their method of response. For spot locations, such as tunnels or bridges, the patrol can be stationary and respond to calls from some fixed location. However, for coverage of a section of freeway or freeway network, experience has shown that roving patrols are more effective (*109*).

The final area where motorist assistance patrols differ is in the sponsoring organization and funding sources. Motorist assistance patrols may be operated by any of the following organizations:

- Enforcement agencies,
- Highway agencies,
- Private organizations (citizens groups, large corporations), or
- Multi-jurisdictional cooperative arrangements.

Because of their responsibility to public safety and traffic mobility, most motorist assistance patrols are operated by enforcement or highway agencies. However, in some parts of the

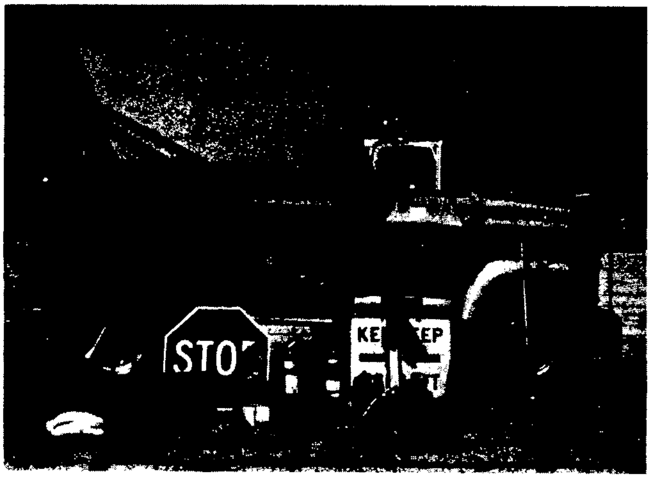


FIGURE 10 Motorist assistance patrols combine incident detection, response, clearance, and traffic management techniques into one vehicle.

country, private corporations or citizens groups have established motorist assistance patrols as a community service and public relations promotion (*108,111*). Finally, at least one system has been developed around a multi-jurisdictional agreement involving enforcement, highway and transit departments, and private businesses in order to spread the economic and labor burden among several agencies (*112*).

Experiences with existing patrols stress the need for authorization from the appropriate enforcement agency to assist motorists stopped within the highway right-of-way. Such authorizations are especially important for privately operated motorist assistance patrols.

APPLICATIONS IN THE U.S.

Table 3 provides a listing of cities with motorist assistance patrols in operation or under development (*103,108,111*). As can be seen in the table, private businesses have sponsored motorist assistance patrols in at least nine cities. The costs of the operation are apparently offset by the improved public image the sponsoring business receives as well as the direct advertising obtained from the service vehicles themselves.

TABLE 3
U.S. MOTORIST ASSISTANCE PATROLS

Type of Patrol	Location
Areawide Patrols:	Chicago, IL
	Fort Worth, TX
	Houston, TX
	Jacksonville, FL
	Los Angeles, CA
	Minneapolis/St. Paul, MN
	Northern Virginia
	San Antonio, TX
	San Diego, CA
	San Francisco, CA
Corridor Patrols:	I-10, Los Angeles, CA
	US-50, MD
	I-95, MD
	I-495, MD
	New Jersey Turnpike, NJ
	New York State Thruway, NY
	I-4, Orlando, FL
Bridges, Tunnels, and Spot Locations:	East St. Louis, IL
	Elizabeth River Tunnels, Norfolk/Portsmouth, VA
	I-64, Hampton Rd. Bridge and Tunnel, VA
	Howard Franklin Bridge, Tampa, FL
	SR 17, James River Bridge, Newport News, VA
	Lehigh Tunnel, Pennsylvania Turnpike, PA
	Lincoln and Holland Tunnels, NY/NJ
	Oakland Bay Bridge, San Francisco, CA
	Tappan Zee Bridge, NY/NJ
Privately Sponsored Patrols:	Albany, NY (Samaritania, Inc.)
	Boston, MA (Samaritania, Inc.)
	Bridgeport, CT (Samaritania, Inc.)
	Hartford, CT (Samaritania, Inc.)
	New Haven, CT (Samaritania, Inc.)
	Stamford, CT (Samaritania, Inc.)
	Providence, RI (Samaritania, Inc.)
	Washington, DC (Samaritania, Inc.)
	Westchester Co., NY (Samaritania, Inc.)
	Seattle, WA (radio stations KOMO and KIRO)

BENEFITS

Motorist assistance patrols provide measurable and non-measurable benefits both to the motorists, to highway and enforcement agencies, and to participating private organizations. Motorist assistance patrols, by reducing the total time that an incident is present, reduces incident delay and congestion (*103,108,111*). In addition, safety is improved because the potential time for secondary accidents to occur is reduced. Services provided by the patrol, for example gasoline and flat tire repairs, also benefit the public, and it has been suggested that they improve the motorist's sense of security on roadways where the patrols operate. Highway agencies, enforcement agencies, and private sponsors or operators of motorist assistance patrols benefit from the positive public relations the service generates (*105*). Also, motorist assistance patrols provide a direct benefit to enforcement agencies by reducing the amount of time officers spend on non-enforcement activities. Finally, the patrols can assist in picking up debris from the freeway as part of patrol activities, reducing the time highway agency maintenance personnel spend on this task.

Studies that have quantified the benefits of motorist assistance patrols have shown them to be quite cost-effective. A mid 1970s study of patrols in Houston found the benefit-to-cost (B/C) ratio for the system to be approximately 2 to 1 (*113*). The study included motorist benefits (time and accident savings, out-of-pocket expenses for towing or gasoline), and benefits to the highway department. A more recent traffic simulation analysis of the Houston Motorist Assistance Program (MAP) during major freeway reconstruction suggested a B/C ratio of 17 to 1 (*114*). In San Antonio, an analysis was performed to compare accident experiences during and immediately prior to the start of motorist assistance patrols. It was estimated that 160 secondary accidents were eliminated by the motorist assistance patrol, resulting in an estimated accident cost savings of $1,600,000 (1979 dollars) for one year. Expenses during the same year were $226,100 (again in 1979 dollars). Consequently, the patrols had a B/C ratio of about 5:1, even without considering any delay cost reductions that may have also resulted (*115*).

Examples and Benefits of Selected Operating Systems

The following sections summarize the organizational structure and activities of three different motorist assistance patrol systems: (1) the Chicago Minuteman Emergency Patrol, (2) Houston MAP patrol, and (3) Samaritania, Inc., a private company operating motorist assistance patrols in several cities.

Chicago Emergency Traffic Patrol

One of the first major motorist assistance patrols to monitor sections of urban freeways was undertaken by the Illinois DOT in 1961 (*110*). The patrol, termed the Emergency Traffic Patrol (ETP), now covers 135 miles of freeway on a continuous basis, using a special fleet of radio-equipped trucks and drivers trained to handle nearly every type of emergency likely to occur. The ETP also possesses several heavy duty tow trucks, one crash crane, one sand spreader, and one heavy rescue and extricator truck.

The Illinois DOT Communications Center serves as the coordinating unit for the ETP, handling all incoming incident reports and directing the nearest patrol unit to the scene. The center maintains direct communication with city and state police, city fire department, city traffic engineering center, expressway surveillance system, and local radio stations operating aerial traffic surveillance or traffic hotlines (*43*).

During 1988, it was reported that the ETP assisted more than 100,000 motorists, at an average cost of $33 to $35 per assist (*108*). It was also reported that the ETP has cut in half the time needed to clear major incidents due to the training and equipment they have available. ETP response time reportedly is 35 minutes or less to any incident that occurs in its boundary. For incidents blocking travel lanes, detection and response are even quicker (about 5 minutes).

Houston Motorist Assistance Program

The Houston Motorist Assistance Program (MAP) is a combined public and private venture to provide Houston freeway drivers with safe and expedient assistance. Originally a small effort during peak periods initiated in 1986 by the Harris County Sheriff's Department, the program now involves three public agencies,

- Harris County Metropolitan Transit Authority (METRO),
- Texas Department of Public Transportation (TxDOT), and
- Harris County Sheriff's Department.

These agencies jointly fund and operate the MAP system and Interim Control Center (ICC) for the Houston area. In addition, new MAP vans have been purchased and donated by the Houston Automobile Dealers Association. Cellular telephone equipment and airtime have been donated by the Houston Cellular Telephone Company, providing the MAP program with good two-way communication abilities.

The multi-organizational structure of the MAP program distributes the cost of the service among several agencies and corporations. All participating entities receive benefits from the positive public relations that the program creates, and the public benefits in terms of reduced delays and secondary accidents and improved driving conditions (*112*). Unfortunately, quantitative estimates of the benefits of the system are not available at this time.

The Samaritania Program

The Samaritania program is a corporately sponsored community service now operating in several eastern cities (*111*). The program patrols from 150 to 300 freeway miles per day during rush hours. Local personnel operate the patrols in each city, and are trained in basic emergency medical procedures, traffic pattern analysis and reporting, and emergency mechanics. The policy of the patrol is never to pass a stopped vehicle within its assigned highway right-of-way. If the motorist needs more assistance than the patrol can provide, patrol personnel will contact the appropriate organizations.

All services provided by the patrol are free to the motorist. The program itself is funded by corporate sponsors in each area, and managed by Samaritania, Inc. The agency contacts potential corporate clients; demonstrates the benefits of the patrol in terms of marketing, public relations, and public service; and develops the necessary contracts, cooperative agreements among corporations and between area highway and enforcement agencies (*108*). Three-quarter ton vans are used for the patrol, with sponsoring company logo(s) displayed on the side.

Samaritania reports that 75 to 90 percent of all disabled motorists encountered on patrol are returned to the freeway at no cost to the motorists (*111*). The patrols also reportedly provide traffic information to radio and television stations so that drivers can adjust their travel patterns.

CHAPTER ELEVEN

DISSEMINATION OF INFORMATION TO MOTORISTS AND OTHER CITIZENS

OBJECTIVES AND GENERAL DESCRIPTION

Transportation systems are designed, constructed, operated, and maintained for the public good and consumption. In addition, most transportation projects are funded with public monies collected from taxes and user fees. Because the public is the ultimate owner and consumer of these transportation commodities, they have a right to be kept abreast of changes in the transportation system. Furthermore, as citizens are made aware of how the system has been changed, they can make adjustments to their travel. This, in turn, can help extend the impacts of positive changes (such as improvements in traffic signal control) to the system, or help reduce the negative impacts (such as incidents) on system operations.

One of the objectives of public information dissemination is to warn citizens about unusual circumstances such as incidents, work zones, and special events, that result in a change in roadway operating conditions. Another objective is to promote highway agency credibility and to build public support for proposed transportation projects. A final objective of public information dissemination is to alter traffic demands.

Figure 11 shows examples of the two basic types of public information:

- Information presented to the public in advance of some anticipated event or condition, and
- Information presented in real-time to motorists immediately prior to the start of their trip, or as they are traveling about in the transportation network.

The print and broadcast media offer the broadest-based means for disseminating information to the public. Advance transportation-related information can be presented to the public via television, radio, and newspaper. Real-time information from the media, on the other hand, is limited to radio and television. A highway agency itself is another important public information source. Pamphlets, brochures, and newsletters can be distributed in advance of unique transportation situations such as special events or major freeway reconstruction activities. When traffic surveillance systems are in place, the highway agency has access to the most current data regarding traffic in the system, and is usually responsible for operating any changeable-message signs (CMS) or highway advisory radio available to assist motorists in responding to these conditions in real time. Depending on circumstances, more than one agency may be involved in this information system. For example, changeable-message signs located on arterial streets may be the responsibility of the local transportation department, while those on an adjacent freeway are operated by the state highway agency. Coordination between these two agencies is necessary to provide accurate and timely information that can improve traffic conditions from a corridor perspective.

HISTORICAL PERSPECTIVE

The media have always been an important means of providing the public with information about changes in the status of the transportation system. Over the years, increased emphasis on public agency accountability for tax dollars spent has provided additional incentives to highway agencies for keeping the public adequately informed.

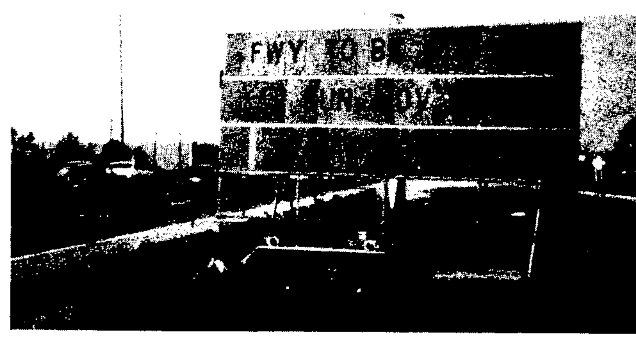


FIGURE 11 Public information systems in a freeway corridor include both advance and real-time traffic information components.

Interest in real-time motorist information systems (MIS) as tools for combating non-recurrent traffic congestion and for improving traffic operations at a given location began in the late 1960s and early 1970s (*116*). Beginning in the 1970s, human factors research has continued to provide valuable guidance in the design and use of real-time MIS (*39,40*). Other research was focused on specific operational details of different MIS components (e.g., changeable-message signs, highway advisory radio) (*117,118*). Technology has progressed to the point that many urban areas are including extensive real-time information capabilities in the sophisticated surveillance and control systems being implemented (see Chapters Four and Five).

More recently, a key traffic management component at several major urban freeway reconstruction projects and extremely large special events has been an extensive public information program having both advance and real-time information elements (*21,119*). Through a coordinated planning and implementation effort, it has been possible to increase public knowledge and acceptance of the unusual conditions and to promote the use of alternative routes, modes, and departure times to minimize the impacts of the projects or events.

APPROACHES

Methods for Providing Advance Information to the Public

Several methods exist for disseminating information to the public about upcoming events that will affect traffic conditions. The most common of these are announcements to the media (press conferences, news releases, press tours, on-camera interviews). While these techniques are inexpensive, the agency making the announcement does not have total control over the report made to the public, as media personnel must often interpret and edit coverage to fit their own time and space limitations.

Another common technique is public service announcements. For example, a public service announcement used a Hollywood celebrity to encourage Los Angeles commuters to share rides during the 1984 Summer Olympics (*21*). Public service announcements have also been employed in several major reconstruction projects to keep the public informed (*119*).

Special publications are another mechanism for providing public information. These publications can take on a number of different forms:

- Posters,
- Pamphlets,
- Newsletters,
- Maps, and
- Special mailings (e.g., utility bill inserts).

Toll-free hotlines have also been used during reconstruction projects to obtain information about construction progress and travel conditions (*119*). Another method used at one special event was to actually suggest specific alternative routes and modes to event patrons at the time that they purchased their tickets (*120*).

Methods for Providing Real-Time Information to the Public

For the most part, real-time information is made available by two sources, the media and the highway or responsible public agency. At the present time, most radio stations in urban areas provide traffic information during peak periods. Furthermore, local morning television news shows in major metropolitan areas also provide traffic reports. A mid 1970s study showed that the accuracy and timeliness of this information varied dramatically from station to station (*121*). This has likely improved in recent years with special traffic reporting companies in some areas now selling traffic information. Also, highway agencies in some cities provide access to traffic information collected through their daily surveillance and control efforts (*122*).

Real-time information is provided by highway agencies primarily through changeable-message signs (both permanent and portable signs), highway advisory radio, and portable signing. Flaggers and police traffic controllers are other methods of providing real-time information during certain types of non-recurrent traffic conditions. In the future, in-vehicle route guidance systems (one component of intelligent vehicle/ highway systems, (IVHS)) will be another source of real-time traffic information for motorists.

Private organizations in several cities have established real-time subscription information services to the public. In Boston, subscribers may obtain information from SmartRoute Systems through various methods, including landline or cellular telephone, voice mail or E-mail, direct fax, or computer-modem link. Information is gathered from aircraft, helicopters, electronic scanning of police and emergency bands, and observation vehicles. This information is fed into a control center where information managers, using other data and computer mapping, prepare reports on traffic conditions and bypass routes for dissemination to clients.

There are similar private sector information systems in Westchester County, New York (Metro Traffic Control); San Francisco, California (Traffic Info Now); Houston, Texas (Infobank); and Chicago, Illinois (Information Command). The Westchester County arrangement is notable in that the county has contracted with a private corporation to merge the public and private information sources into a single-source distribution system. In San Francisco a private firm provides current traffic status and parking and event information in voice-recorded form that is updated every ten minutes during peak hours. The service is free to telephone callers who can select a region of interest in the San Francisco Bay area. Revenue to sustain the service will be derived from commercial advertisement preceding the requested traffic information.

BENEFITS

It is difficult to quantify the benefits of providing public information. At past reconstruction projects and special events, it has not been possible to separate the benefits of public information from benefits created by other traffic management actions implemented. The effects of real-time information have been slightly better defined, although the database is extremely limited. Studies have shown MIS can alter driver diversion and route choice patterns, leading to improved operating conditions (*39*).

Qualitatively, the dissemination of information to the public results in the following benefits:

- It improves the public image of an agency (*123*);
- Depending on how travel patterns are affected, public information can indirectly lead to improved operating conditions in the corridor (reduced congestion, delay, fuel consumption, vehicle emissions); and
- Public information can indirectly improve traffic safety by making drivers more aware of unusual downstream congestion or other conditions and by changing travel patterns so as to reduce the magnitude of the downstream congestion and accident potential.

Examples and Benefits of Selected Operating Systems

Chicago

Chicago, Illinois serves as an excellent example of how public information is used as part of a comprehensive incident management program. The Traffic Systems Center (TSC), operated by the Illinois Department of Transportation, has committed substantial resources to disseminating real-time traffic information to motorists. The TSC provides access to its information concerning incidents and travel times to more than 40 radio and television stations in the Chicago area (*122*). Also, the TSC operates both changeable-message signs and highway advisory radio in the region to directly inform motorists about operating conditions downstream.

Philadelphia

The recent reconstruction of a 21-mile segment of I-76, the Schuylkill Expressway in Philadelphia, Pennsylvania illustrates a multi-faceted public information effort (*124,125*). The reconstruction project involved closure of one directional roadway at a time while maintaining two-lane, two-way operation on the other directional roadway. Within the construction zone, most of the entrance ramps and some of the exit ramps were closed to limit access to the expressway by local drivers. The overall traffic management plan adopted for the project was to encourage trucks and long-distance motorists traveling through Philadelphia to remain on the expressway, while local traffic would be encouraged to use alternative routes and modes.

The extensive public information undertaken for the project had the following components (*119*):

- Traditional public relations tools (press conferences, news releases, interviews, media events, and public service announcements);
- A visitor's guide which encouraged truckers, tourists, and long-distance travelers to remain on the expressway;
- A commuter's guide which encouraged local drivers to take alternative routes; and
- A toll-free hotline drivers could call to find alternative routes, make inquiries, or register a complaint.

The traffic management plan, of which the public information program was one component, served the motorists of I-76 quite well, even though more than 60 percent of the traffic that normally used the expressway diverted to other routes or modes. While the actual effect of the public information program could not be determined, it was apparently very effective. No massive traffic jams materialized at the beginning of the project, suggesting that drivers were well aware of the potential problems at the construction zone and avoided the area during the beginning days of work.

Dallas

A number of studies conducted in Dallas, Texas during the late 1970s provide an indication of the effectiveness of properly designed real-time motorist information systems for special events (*37,126*). Field studies were conducted on three weekends during special events at the Dallas Fair Park. These studies were designed to determine the amount of diversion that occurred from the main freeway route to the event (that typically became congested during special events) to an alternative arterial intersecting the freeway approximately 5 miles upstream from the event.

Several different messages were evaluated during the various weekends. The results of the studies showed that all of the changeable-message signs greatly influenced diversion to the alternative route. Depending on the event and time, it was estimated that up to 85 percent of traffic destined to the event took the diversion route to Fair Park. Surveys of motorists attending the event and exposed to the information displayed found that drivers who were unfamiliar with the area were more likely to divert than those who were more familiar with the road network.

CHAPTER TWELVE

TRAFFIC MANAGEMENT OF RECURRENT CONGESTION

OBJECTIVES AND GENERAL DESCRIPTION

Recurrent traffic congestion occurs when normal traffic demands overload a roadway segment. In an urban freeway corridor, managing recurrent peak-period congestion is perhaps the simplest application of freeway corridor management. This is because the location, time, and severity of this type of congestion can be predicted fairly accurately. Hence, it can be combated quite effectively through applications of, or changes to, control and management strategies on a time-of-day basis within the corridor.

In general, the objective of recurrent congestion traffic management is to optimize normal traffic operating conditions within the corridor during peak periods, without incidents or other disturbances affecting traffic (the management of incidents from a corridor perspective is treated in the next chapter). This is accomplished through a range of controls and management actions involving several different agencies operating within the corridor.

HISTORICAL PERSPECTIVE

Efforts to more effectively control and manage recurrent congestion have been ongoing for a number of years. Actually, the efforts to encourage use of high-occupancy vehicles (a travel demand reduction strategy), which began as early as the 1920s, were the first attempts at managing and controlling peak-period (recurrent) congestion (*62*). Nearly 30 years ago, entrance ramp controls were developed to deal with the recurrent congestion that was developing on many urban freeways (*23*). On corridor street systems, the introduction of multi-dial signal controllers made it possible to set separate signal timings for peak and off-peak periods (*27*). Subsequent advancements in traffic signal optimization methods have also helped accommodate peak-period travel demands on corridor streets (*27*), thereby reducing congestion.

MANAGEMENT STRATEGIES

A number of strategies play a role in freeway corridor management of recurrent congestion. These strategies are categorized as "vehicle demand management" and "travel demand management" actions (*5*), the former relating to controls of vehicles that want to use the facilities during given time periods and the latter to actions to help reduce the overall demand for travel in the freeway corridor during those periods. The details about the components under each category have been presented in the previous chapters. The following sections describe the components that play a role in the active management of recurrent congestion.

Freeway Surveillance and Control

Entrance ramp controls are the primary components of freeway surveillance and control essential for managing recurrent congestion. Because of the predictability of recurrent congestion, a set of fixed-time controls can provide substantial benefits to the public by reducing mainlane congestion. However, since traffic demands during peak periods do fluctuate slightly from day to day, traffic-responsive and integrated ramp metering control can provide somewhat better improvements in actively managing recurrent congestion. In addition, they are capable of adjusting to unusual traffic conditions (because of incidents, work zones, or special events), something that fixed-time ramp metering cannot do.

Corridor Street Surveillance and Control

With respect to recurrent congestion, corridor street surveillance and control systems allow traffic signal timing patterns to be configured to match expected traffic demands during the peak period. More sophisticated systems adjust traffic signal timings in real-time to match current vehicle demands. Given the high level of peak-period congestion on corridor streets in many urban areas, even small changes in traffic signal timing to maximize the capacity of the intersection improve recurrent congestion levels.

Traffic signal preemption capabilities for transit vehicles is another way to combat recurrent congestion. In addition, a host of low-cost TSM actions (such as parking prohibitions, left-turn restrictions, and reversible lanes) can be implemented to increase roadway capacity and help reduce recurrent congestion problems.

Peak-Period Truck Restrictions

Peak-period restriction of trucks from certain roadways or lanes in the corridor is another way to relieve recurrent congestion. It is well known that trucks have poorer accelerating and decelerating characteristics than automobiles. Thus, trucks can cause significant reductions in operating efficiencies. This is especially true at signalized intersections or under stop-and-go traffic conditions on freeways where traffic accelerations and decelerations are necessary.

On the freeway, truck restrictions can call for trucks to exit the freeway completely during peak periods, or specify a certain lane or lanes to be used by trucks. Off the freeway system, banning delivery loading and unloading during peak periods is another effective means of reducing recurrent congestion.

Peak-Period Enforcement Activities

Police officer enforcement and traffic control duties as part of the overall strategy for combating recurrent congestion include both the freeway and corridor street components. On the freeway, enforcement of entrance ramp controls, any truck restrictions, and high-occupancy vehicle priority treatments is essential to the effective operation of these other components. Likewise, enforcement of traffic signal controls, peak-period TSM actions on corridor streets, and HOV treatments is also essential to their continued success in mitigating recurrent congestion. Of course, the benefits of these activities must be weighed against the potential disruptions to traffic that they may cause. In some instances, it may be prudent to avoid issuing citations on congested freeways during peak periods to avoid creating bottlenecks caused by motorist rubbernecking.

High-Occupancy Vehicle Facilities and Priority Treatments

Efforts to reduce the total number of vehicles attempting to travel during the peak period through incentives to encourage HOV use is another method of reducing the impacts of recurrent congestion in urban freeway corridors. Exclusive transitway facilities, concurrent or contraflow lanes, and toll or parking fee reductions all serve as incentives to those making use of these travel modes.

BENEFITS

Perhaps the most important benefit of a freeway corridor management system is the exchange of information between and within agencies. Greater dialogue among agencies allows each to expend its resources more judiciously, avoiding duplication of effort, or worse yet, actions that contradict one another. For example, changes in occupancy requirements on an HOV facility will shift demand patterns not only on the facility itself, but at the entrance and exit points as well. It may be necessary to adjust traffic signal timings at these points to better match new demand patterns, which could be done quickly, provided the agency responsible for the signals is made aware of the change. As another example, state and local agencies may need to be notified if the number of enforcement personnel available for traffic control is reduced so that adjustments can be made for special events or work zone activities.

Of course, improved active management of traffic conditions within the corridor can provide substantial benefits to motorists in terms of:

- Reduced recurrent delay,
- Reduced fuel consumption and vehicle air pollutant emissions, and
- Reduced road user costs.

CHAPTER THIRTEEN

TRAFFIC MANAGEMENT FOR INCIDENTS

OBJECTIVES AND GENERAL DESCRIPTION

An incident can be an accident, a vehicle breakdown, a spilled load or any other unusual event that reduces the effective capacity of the roadway and disrupts the normal demand/capacity relationship that exists in the corridor at that time. Estimates indicate that 40 to 60 percent of all urban delay is due to incidents; in 1984, user costs due to incidents were calculated at more than 5 billion dollars (*1*). To combat the delay, wasted fuel, and driver frustration arising from incidents, several large metropolitan areas have implemented incident management systems with varying degrees of complexity.

Incident management is a coordinated and planned approach to restoring freeway traffic to normal operation after an incident by using human and mechanical resources (*109*). Through the years, a significant amount of attention has been given to the planning and implementation of incident management systems, as they have been found to be extremely valuable in mitigating the impacts of roadway incidents (*24,108*). Incident management must be an active multi-jurisdictional effort involving enforcement agencies, highway agencies, emergency services, and possibly private citizen and corporate involvement. This multi-agency effort is necessary because incident management requires a service role that is typically beyond the traditional missions and resources of any single agency (*44*). Also, the goals and objectives of each agency with respect to a given incident may be quite different. A coordinated effort helps to resolve these different objectives, promoting a more successful incident management system.

An incident management system will include components to assist or reduce incident detection time, incident response time, incident clearance time, and traffic management/queue clearance. A list of components that may be incorporated into an incident management system (*47*) includes:

- Roving towing or service vehicles,
- Emergency motorist call boxes,
- CB radio monitors,
- Cellular phone hotlines,
- Incident management teams,
- Freeway and/or corridor street surveillance and control, and
- Motorist information systems.

HISTORICAL PERSPECTIVE

As early as 1920, concern was expressed over the potential problems caused by traffic incidents (*110*). As freeways were constructed and began carrying more traffic, the need for methods of effectively handling accidents and other unpredictable traffic problems increased. One of the first efforts to deal with the problem of incidents was the Emergency Traffic Patrol (the "Minutemen") established in 1961 in Chicago by the Illinois Department of Transportation (*110*). In the mid 1970s, an extensive FHWA study provided comprehensive guidelines on the evaluation and implementation of low-cost incident management techniques (*24*). Through the years, recognition of the potential benefits these roving patrols and other incident management components can have on traffic operations has grown to the point that a number of areas have or are implementing incident management systems in varying degrees of complexity.

COMPONENTS OF AN INCIDENT MANAGEMENT SYSTEM

Incident Detection

Incident detection can be accomplished by a number of different mechanisms that vary in terms of their initial and operating costs, reliability, and breadth of coverage. These methods include:

- Electronic surveillance,
- Closed circuit television,
- Aerial surveillance (i.e., the "eye in the sky"),
- Emergency call boxes,
- Emergency telephone numbers,
- Cellular phone hotlines,
- CB radio monitors, and
- Patrol vehicles (increased police patrols, motorist assistance patrols).

Typically, electronic surveillance and reports from emergency call boxes require verification by official highway or police personnel. Consequently, these systems may be installed in conjunction with one or more other techniques. In some freeway corridors, almost all methods are present. For instance, the highway agency may be operating the electronic surveillance and closed circuit television systems, a private radio station may have its own helicopter in the air for traffic reporting, and police and private service patrols may also be roving the corridor, assisting disabled vehicles or accidents. Each of these methods adds to the incident detection capability of the freeway corridor; however, some means of collecting, processing, and disseminating this information in a cohesive manner is essential. A traffic information center that monitors all potential incident detection sources is a vital component in an incident management system (*110*).

Incident Response

The response to a given incident depends on its severity. Minor incidents, such as a disabled vehicle, can often be handled by a single response vehicle. In contrast, major incidents, such as a hazardous material cargo spill, may require the implementation of an extensive action plan involving multiple agencies and requiring several pieces of emergency and clean-up equipment. The number and type of incident response approaches used in a given system depend on site-specific factors such as response objectives, anticipated incident frequency (by severity), financial constraints, and agency policies.

The key components of incident response include quick detection and response, effective on-site active traffic management, and reduction of traffic demands (where possible) to the incident location via alternative route diversion. Extensive operational guidelines regarding these activities are available elsewhere (*24,34*). For purposes of this report, only the organizational requirements regarding incident response will be reviewed.

Actually, incident response begins with coordination and planning efforts prior to establishing an incident management system. Chief agency administrators should be involved in the early stages of developing an incident management system to identify boundaries of responsibility and coordination activities for each agency (police, state and local highway agencies, toll authorities, transit operators, radio and television traffic reporting) (*24*). Next, formal agreements should be established regarding responsibilities and liabilities during incident management efforts. Finally, operational issues should be addressed.

Special incident management teams established in several cities have proved successful as incident management techniques. These teams, typically made up of or headed by state highway agency personnel, as shown in Figure 12, respond to major incidents and focus their attentions directly on facilitating the orderly and safe movement of traffic through or around an incident location. Objective criteria are established to identify when the team should respond to an incident. For example, the incident management team in Los Angeles is activated for any incident that is expected to block two or more traffic lanes for two or more hours (*82*). In addition to the incident management team, other incident response techniques include:

- Accident investigation sites (*84*),
- Alternative route plans (see Chapter Nine),
- Prompt vehicle removal laws,
- Pay back agreements between agencies, and
- Agreements for contractor tow services or for private citizen or corporate service patrols.

These arrangements are reviewed periodically and adjusted as new situations and problems arise (which are then discussed at subsequent team meetings).

Traffic Diversion

A key component in an incident response system is the ability to reduce traffic demands to an incident location by encouraging traffic to divert upstream and use an alternative route around the incident. Because of the unpredictability of incidents, real-time motorist information systems play an important role in traffic diversion during freeway incidents.

FIGURE 12 Incident management teams focus on facilitating the orderly and safe movement of traffic through and around an incident location.

Real-time information includes those efforts by the highway agencies or the Traffic Operations Center to provide motorist information using changeable-message signs or highway advisory radio. In addition to these sources, commercial radio and television also provide real-time information to motorists, although not necessarily with the frequency or accuracy desired by the motorist (*127*).

Experience in Los Angeles (*36*) and elsewhere (*44*) has shown that planning alternative routes for each section of freeway improves incident management capabilities dramatically. Conditions that may hamper or encourage use of an alternative route can be identified beforehand, as can equipment (signing, barricades) and personnel requirements. When an incident requiring traffic diversion does occur, the plan can be readily selected and implemented, reducing response time and potential problems.

The TxDOT "MOVE IT" campaign to encourage motorists to move vehicles from the roadway in the case of non-injury, minimal damage incidents was tested in Dallas and plans were made to introduce the program statewide early in 1992. The traffic management teams in the six largest urban areas of the state are monitoring and evaluating the program. Over 500,000 brochures, public service radio and television announcements were prepared and solicitations for corporate sponsors to help defray the costs have been initiated. The focus of the campaign is to inform motorists of the law, to provide proper accident management directions to follow, and to encourage compliance with the law (*128*).

APPLICATIONS IN THE U.S.

Table 4 presents a recent summary of existing or proposed incident management systems nationwide (*129*). For each type of incident management system (areawide, corridor, spot

TABLE 4
INCIDENT MANAGEMENT SYSTEMS

SYSTEM TYPE AND LOCATION	DETECTION & VERIFICATION							RESPONSE				MOTORIST INFO				GENERAL COMMENTS
	OPER CENTER	SERV PATROL	ELECTRONIC	CCTV	CITIZEN CALL	CALL BOXES	OTHER	TEAMS	WRCKR AGRMT	AGENCY EQMT	OTHER	ALT ROUTES	HAR	MEDIA	VMS	
EXISTING AREAWIDE SYSTEMS																
Anaheim, CA	X			X		X		X			X	P	P	P	X	Integrated Freeway/Arterial System
Baltimore, MD	X	X					X	X	X	X	X	X	X	X	X	Init. phase of statewide CHART program
Chicago, IL	X	X	X		X		X	X		X	X		X	X	X	Illinois DOT operating since 1960
Detroit, MI	X		X	X	X	X			X						X	Major expansion underway
Fairfax Co., VA	X				X		X	X	X			P		X		Nonfreeway - County Police
Fort Worth, TX	X	X	P	P				X	X		X	P	P	X	X	20-year project over 260 mi of freeways
Houston, TX	P	X	X	X		P	P	X	X		X	P		P	C	20-year project over 555 mi of freeways
Los Angeles, CA	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	System expansion/upgrade underway
MD suburbs of D.C.	X	X			X		X	X	X	X	X	X	X	X	X	Init. phase of statewide CHART program
Minneapolis/St.Paul	X	X	X	X	X	X	X	X	X		X		X	X	X	Major system expansion underway
Northern Virginia	X	X	X	X	X	X	X	X	X			X		X	X	Major system expansion underway
Phoenix, AZ	P		P	P	P			X	X			P	P	P	P	20-year plan - 200+ mi of fwy
Richmond, VA	P	X						X	X			X		X	P	Init. phase of long term program
San Antonio, TX	P	X	P	P				X	X						P	10 year plan developed
San Diego, CA	X		X	X		X		X	X				P	X	X	Major expansion underway
Seattle, WA	X		X	X				X	X	X	X	P	X	X	X	Major expansion underway - FAME program
TRANSCOM - NY/NJ	X						P	X			X	X	P	X		Regional info/response coordination
NEW AREAWIDE SYSTEMS																
Atlanta, GA																Init. scoping phase-lead ARC (Atl MPO)
Austin, TX																Initial scoping phase-lead SDH&PT
Cincinnati, OH	P		P	P	P			P					P	P	P	Feasibility study complete-PE init phase
Columbus, OH	X	X	P	X			X	X		X	X			X	P	10-yr plan.
Connecticut Fwys.		X											X		X	Feasibility study complete-I-95,91,& 84
Dallas, TX	P	X	P	P				X							P	10-yr plan under development-lead SDH&PT
El Paso, TX	P		P	P				X							P	10-yr plan under development-lead SDH&PT
Fresno,CA	P							P							P	Init scoping phase - Caltrans Dist 6
Jacksonville, FL								X								Fwy Management Team
Kansas City, MO																Init scoping phase - MO Hwy & Trans Dept
Massachusetts Fwys.	P				X							P				All I fwys, tied to HazMat evac planning
Miami, FL	P	P	P					X	P			P		P	P	Feasibility study complete
Michigan Fwys.					X			P				P				Incl all I fwys-plan under development
Milwaukee,WI	P	P	P	P	P			P	P			P		P	P	Area study compl.-Impl. plan in develop
Montgomery Co, Md	X			P	P		P	X			X	X		X		County Trf Engr Dept
Orange, CA	X	X	X	X		X		X					X	X	X	Long term plan in development
Orlando, FL	P	P	P	P	P		P	X	X		P	P		P	P	Incl. TravTek IVHS Demo Proj.
Portland, OR	P		P	P	P	P		P				P		P	P	6-yr plan developed
Sacramento, CA	X		P			P		X					X	X	X	Initial scoping phase - Caltrans Dist 3
San Bernardino,CA	P							X					X		X	Initial scoping phase - Caltrans Dist 8
San Francisco, CA	P	X	P	P	P	P		X	X					P	P	20-yr plan developed for 500 mile system
Spokane, WA																Initial scoping phase - Wash SDOT
St. Louis, MO																Init scoping phase - MO Hwy & Trans Dept
Tacoma, WA																Initial scoping phase - Wash SDOT
Tampa/St.Pete Fl																2 Fwy Management Teams
Tidewater Area, VA	P	X	P	P	P			X	X			X	X	X	X	Tie w/ exist br/tunnel systems & new
Westchester Co. NY	P	X		P	P		P	P	X			X	P	P	P	Joint County/State effort

TABLE 4 *CONTINUED*

SYSTEM TYPE AND LOCATION	DETECTION & VERIFICATION							RESPONSE				MOTORIST INFO				GENERAL COMMENTS
	OPER CENTER	SERV PATROL	ELECTRONIC	CCTV	CITIZEN CALL*	CALL BOXES	OTHER	TEAMS	WRCKR AGRMT	AGENCY AGMT	OTHER	ALT ROUTES	HAR	MEDIA	VMS	
CORRIDOR SYSTEMS																
Dallas, TX, US-75	P	P		P			P	P					P	P	P	Const oriented-will become perm
Dayton, OH I-75												X		X		
Delaware Interstate						X										Call boxes
El Paso, TX/I-10			P	P				X	X	X	X	X			X	Construction oriented-will be permt
Florida rural I						X										Call boxes
NW Indiana I-80	P		P	P				P						P	P	Borman Expy-Impl. plan under development
Ft. Lauderdale/I-95								X								Const oriented. Fwy Management Team
Los Angeles/I-10	X	X	X	X	X	X	P	X	P	X	P	X	X	X	X	"Smart" Corridor Demonstration Project
Maryland(West)/US40					X			X	X	X	X	X	X		X	Init phase of CHART
Maryland/US-50	X	X			X		X	X	X	X	X	X	X	X	X	"Reach-the-Beach" Program
Michigan/I-75					X			X				X				Mich DOT/St Police Dist 6 - nonurban I
NJ Turnpike	X	X	X	P				X	X	X	X	X		X	X	Expansion/upgrade of system underway
NY/Long Island Expy	X	X	X	P	X			X	X	X	X	X		X	X	INFORM-30 mile x 5 mile corridor
NY State Thruway	X	X		P	X			X	X	X		P	X	X	X	559 miles of Toll Road-plan under devel
Pittsburgh I-376	P	P	P	P			P	P							P	Study completed by PaDOT
Penn Turnpike						P										Call boxes planned, tunnel systems
Rhode Island/I-95						X		X				X			X	Public/private Team
BRIDGES, TUNNELS, AND SPOT LOCATIONS																
Baltimore Tunnels	X		X	X			X		X	X		X	X	X	X	Md Transportation Authority
Boston, MA I-93/90	P	P	P	P	P		P	P	P	P	P	P	P	P	P	
Buckman Br, I-295 Jacksonville, FL		X						X	X	X						Florida DOT
Duluth, Mn I-35 and tunnels	X		X			X				X	X				X	Operated by State Police
Eisenhower Tunnel I-70, Colorado	X		X	X						X		X			X	Colorado Dept. of Hwys.
East St.Louis, IDOT		X			X	X				X			X	X		Miss River brs & adj. rwys.
Eliz. River Tunnels Norfolk/Ports., VA	P	X	P	P	X	X	X			X				X	P	
Escambia Bay Brs(2) Florida I-10/US98	X					X		X	X						X	
Hampton Rd.Br/I-64 and Tunnel, VA	X	X	X	X	X		X	X		X	X		X	X	X	
Howard Franklin Br. Tampa, FL	X	X	X	X		X		X	X			X		X	X	
James River Br/SR17 Newport News, VA	X	X		X	X	X				X	X		X			4 mi. of 4-lane divided with no shoulders, ADT=23,000
Lehigh Tunnel, Penn. Turnpike	X	X					X			X					X	
Lincoln & Holland Tunnels, GW Bridge	X	X	X	X			X		X	X	X	X	X	X	X	Port Authority of NY&NJ
Mobile,AL I-10/US98	X			X												
Oakland Bay Br (SF)	X	X	X	X		X	X	X		X	X			X	X	
Sunshine Skyway, FL	X			X		X		X	X			X		X	X	
Tappan Zee Br. NY	X	X		P	X			X		X		X		X	X	3 mi. long across Hudson River
Triborough Bridge & Tunnel Auth., NY	X		P	X		X				X				X	X	7 Bridges, 2 Tunnels

X = In-Place P = Planned or Proposed

* Citizen reports via cellular, CB, other

TABLE 4 *CONTINUED*

SYSTEM TYPE AND LOCATION	DETECTION & VERIFICATION							RESPONSE				MOTORIST INFO				GENERAL COMMENTS
	OPER CENTER	SERV PATROL	ELECTRONIC	CCTV	CITIZEN CALL*	CALL BOXES	OTHER	TEAMS	WRCKR AGRMT	AGENCY EQMT	OTHER	ALT ROUTES	HAR	MEDIA	VMS	
SERVICE PATROLS																
Albany, NY		X														Corporate sponsored vans operated by Samaritania, Inc.
Boston, MA		X														" " "
Bridgeport, CT		X														" " "
Hartford, CT		X														" " "
New Haven, CT		X														" " "
Stamford, CT		X														" " "
Philadelphia, PA																
Providence, RI		X														" " "
Westchester Co., NY		X														" " "
Washington, DC		X														" " "
CALL BOXES																
Imperial Co, CA						P										100 boxes in cooperation w/ San Diego
Kern Co, CA						P										534 CB system under const.
Los Angeles Co, CA						X										3,500 active,4,200 plan: 55,000 calls/mo
Orange County, CA						X										1,100 CB: 15,000 calls/mo
Riverside Co., CA						X										Under const. - 600 planned
Sacramento Co, CA						P										Approx. 1,600 planned
San Bernadino Co,CA						X										1,200 active, 200-300 add'l planned
San Diego Co., CA						X										1,170 CB - 16,000 calls/mo.
SF Bay Area, CA						P										2,100 CB system under const.
Santa Barbara Co,CA						P										310 CB system under const.
Ventura Co., CA						X										464 CB system
Connecticut, I-91						X										
DE/I-95, 295 & 495						X										
Florida Turnpike						X										360 push button boxes, 1-mile spacing
Florida Rural Interstates						X										434 push button boxes in operation @ 1 mile spacing, 900 boxes proposed
Louisiana, I-10						X										
MA/I-93, 95, & 91						X										1-mile spacing, push button
New York/I-87						X										64 call boxes @ 2-mile spacing
Rhode Island I-95						X										

X = In-Place P = Planned or Proposed
* Citizen reports via cellular, CB, other

location), information is presented on incident detection and response capabilities included. The table illustrates the wide range of system capabilities that are possible for an incident management system, depending on the needs and objectives of the participating agencies. An incident management handbook with accompanying videotape (*130*) has been developed recently to assist agencies in establishing and maintaining incident management systems.

BENEFITS

Incident management provides measurable benefits to the motoring public in terms of quicker detection and response times, resulting in less delay and congestion. It has been estimated that incident management systems reduce detection and response times by 10 minutes, on the average (*47*). According to Caltrans, for every minute that the duration of an incident is reduced, 4 to 5 minutes are saved from the total time the incident affects traffic (*108*). In Virginia, an incident management system has reduced incident durations from 50 minutes to about 20 to 30 minutes (*83*).

Along with the reduced congestion, incident management systems have the potential for improving safety by reducing secondary accidents that occur as a result of increased congestion and queuing, as well as reducing accidents involving motorists outside of their vehicles, by reducing the exposure time of motorists to freeway traffic flows. Incident management systems also provide motorists with an improved sense of security, improve public relations for all involved agencies, and can improve utilization of police personnel resources by reducing the number of non-enforcement activities they are called on to perform (*47*).

Examples and Benefits of Selected Operating Systems

Chicago

In 1961, the Illinois Department of Transportation initiated the Emergency Traffic Patrol (ETP) and the Expressway Surveillance Project (the Traffic Systems Center, or TSC), joining them to its existing Communications Center as part of a coordinated management system of over 100 freeway miles. Incident management continues to be one of the major activities of the TSC.

Although relying heavily on its electronic surveillance system and ETP fleet for incident detection, the TSC and Communications Center maintains contact with a number of outside agencies and other DOT vehicles to assist in incident detection. These agencies include the Chicago Police, State Police, Chicago Fire Department, and Illinois Tollway Commission (*110*). The center also uses CB monitoring stations located strategically throughout the network to pick broadcasts about incidents and traffic conditions.

The TSC readily disseminates traffic congestion and travel time information to the media in order to improve real-time traffic information to motorists. More than 40 radio and TV stations receive traffic information (directly or indirectly) from the TSC (*122*). Changeable-message signs and highway advisory radio are also used to display information to motorists about travel conditions in the corridor. The TSC is operated by 11 DOT staff employees and is supplemented by 16 cooperative education students from Chicago-area colleges.

In 1986, the ETP fleet handled 108,000 incidents (*122*). According to one source, it is estimated that all incidents in the service area (including those stranded motorists sitting on the shoulder) are detected and responded to within 35 minutes (*107*). It was also estimated that incidents that block freeway lanes are detected even sooner.

Los Angeles

Incident management in the Los Angeles area is coordinated through the Traffic Operations Center (TOC) located in the district headquarters for Caltrans. The 475 miles of electronic freeway surveillance and control is overseen at the TOC. In addition to normal electronic incident detection capabilities, 15 closed circuit televisions strategically located within the system assist in incident detection and verification.

The TOC is jointly staffed by Caltrans and the California Highway Patrol (CHP). In fact, one of the special features of the Los Angeles system is the close working relationship that has evolved between Caltrans and CHPs (*44*). When an incident occurs, important decision-making time is saved as the two agencies work together to estimate the expected severity and duration of the incident. When a major incident occurs (generally defined as a blockage of two or more lanes for two or more hours), the TOC may call upon the Caltrans Incident Management Team for assistance.

The Incident Management Team consists of approximately two dozen volunteers with traffic engineering backgrounds. The team operates in a fashion similar to a volunteer fire department, with members "on call" 24 hours a day. When notified of a major incident, team members meet at the site together with police and other responding agencies to actively manage the situation. The primary objective of the team is to expedite the safe, orderly movement of traffic through and around the incident. In recent times, the team has responded to about 220 incidents per year (*44*). Another major component of the Los Angeles incident management system is an extensive catalog of alternate route plans for potential closures at more than 3,000 freeway locations. The Incident Management Team refers to the plans when necessary, to obtain guidance about such things as diversion locations and equipment and personnel needs (see Chapter Nine). Also, after major incidents, the team meets with the other responding agencies to critique operations and to determine how to improve incident response in the future.

Northern Virginia

In 1987, the Fairfax County Traffic Information Center was developed to serve as the traffic information focal point in Northern Virginia (*83*). The center obtains information from the Virginia DOT Traffic Management Center or Public Affairs Office, Virginia State Police, Washington D.C. Metropolitan Police Communications Center, private traffic services, radio air traffic reporters, the Fairfax City Police Department Communications Center, the Fairfax County Police Department Helicopter, and REACT of Washington, D.C. The TIC communicates directly with each of these agencies on a half-hour basis during peak travel periods. Incident detection is accomplished via electronic surveillance, closed circuit television, media traffic reports, observations by Virginia DOT or fire or police personnel, and reports by local citizens.

The Fairfax County Police Department has established a special "rush-hour" traffic response unit that works directly with the TIC. The police helicopter has also been assigned to work with the TIC during rush hours. This direct assignment ensures that the officers will not be used for non-traffic-related calls.

Other operating agencies have participated in improving incident management. A multi-disciplinary response group, the Northern Virginia Freeway Incident Management Team, has been formulated to assist in responding to major incidents. The team has drawn up formal agreements detailing command and control, media releases, and communications links to be used during incident response and clearance. In addition, alternate route plans have been developed for all interstate and most primary roads in the region. Highway signs and traffic control materials have subsequently been placed at strategic locations within the area to provide near-immediate access when incidents occur. Cross-training between different members of the team is done to assure that each member is aware of the needs and resources of the other agencies involved. Planning and post-incident analysis are performed to improve responses in the future.

The combined efforts of the TIC, Fairfax County Police, and Freeway Incident Management Team have profoundly improved traffic operations in Northern Virginia. It has been estimated that incidents are now handled in one third the time they previously required (it previously took an average of 50 minutes to clear an incident) (*83*).

CHAPTER FOURTEEN

TRAFFIC MANAGEMENT FOR SPECIAL EVENTS

OBJECTIVES AND GENERAL DESCRIPTION

Special events occur in virtually every major metropolitan area, and often strain the capabilities of the transportation system to accommodate them. In some cases, this strain is due not only to the large numbers of people who come to the event and whose transportation needs must be met, but also to the short-term blockages of parts of the transportation network that may be caused by the event itself (because of crowd control, security concerns, or if the event takes place within the roadway right-of-way, e.g., parades). The unique nature of the transportation concerns caused by special events poses a significant challenge to freeway corridor management.

The specific characteristics of each special event, such as frequency, popularity, and location, influence the effort necessary to develop and implement a traffic management plan for the event. Regardless of these characteristics, however, the overall objectives of special event traffic management remain fairly constant, to facilitate the orderly and efficient movement of event patrons to and from the event site while at the same time minimizing its adverse impacts on non-event-bound traffic. Even for the largest events, experiences have shown that this objective can be met through

- Advance planning;
- Interaction, cooperation, and an overall commitment to a transportation plan by all affected agencies;
- Implementation of appropriate active traffic management techniques; and
- The dissemination of accurate and timely information to the traveling public.

HISTORICAL PERSPECTIVE

Special events are not new phenomena; activities such as state fairs or sporting events have been around for quite some time. Often, the traffic management plans for these types of regularly scheduled events evolve over the years through trial and error and through suggestions from affected agencies. On the other hand, a number of cities have had to cope with special events that occur only once or very infrequently within their boundaries. These types of events have typically required more intense study and planning, because previous local experience concerning the potential traffic impacts of the events were not available (*131*).

Although special event traffic management has existed in some form for a number of years, emphasis has increased over time toward a more systematic and corridor-wide planning, implementation, and monitoring approach to the transportation problems that are created. The scope of special event traffic management has grown from an initial concern of event location traffic management (on-site circulation, ingress and egress capacity, and parking limitations), to an awareness of the need to maximize the capacity of roadways leading to and from the event, finally to an overall corridor demand and capacity management approach that emphasizes transit usage and ridesharing of both event-bound and non-event trips in a corridor (see Figure 13).

LEVELS OF TRAFFIC CONTROL

The level and sophistication of a traffic management plan for special events depend on a multitude of factors. Some factors identified from past special events include:

- Location, expected patronage, and timetable of the event (single event start and end times versus spectator arrivals and departures spread over several hours),
- Parking availability and location,
- Available capacity at access points to the event, and
- Normal traffic conditions on nearby roadways during times of spectator travel to and from the event.

As the size of the event increases, so does the level of traffic control required to effectively meet the objectives of special event traffic management. Based on experiences at past events, three levels of traffic control can be identified:

- Control of traffic on-site,
- Control of traffic elsewhere in the corridor, and
- Control of traffic demands.

FIGURE 13 Special events often require a multi-modal management approach.

On-site traffic control includes issues such as parking analysis and design, on-site circulation planning, pedestrian and vehicle conflict analysis, and concerns about transit boarding and departing locations. At the next level, *corridor traffic control*, efforts are expanded to maximize use of existing roadways to and from the event. At this level of control, certain temporary TSM actions may be employed to increase the capacity and operating conditions of these roadways. Also included at this level are efforts to encourage the spreading of traffic volumes over all available routes using advance and real-time information. At the final control level, *traffic demand control*, efforts are focused on managing traffic demands generated by both spectator and non-spectator travel. In managing spectator travel, emphasis is placed on the use of transit (via express routes, park-and-ride shuttles, and rail systems, for example) and ridesharing programs to reduce vehicular demands. Efforts have been made at some past events to reduce non-spectator traffic during certain times by encouraging ridesharing and transit usage, altering work schedules (including leaving work early on certain days), and discouraging business travel in the area during the special event (*19,132*).

TRAFFIC DIVERSION

A key to successful traffic management for special events is the efficient use of all available transportation resources, if necessary, in the region. Often, it is necessary to promote diversion from normal spectator and non-spectator travel patterns to achieve a better utilization of resources.

Research and experience have shown that it is possible to divert event-destined traffic from the normal route to a less congested alternative by providing motorists with advance and real-time information about traffic conditions and/or the availability of the alternative route. Portable and permanent changeable-message signing, temporary static informational and guide signing, highway advisory radio, and commercial radio advertisements have all demonstrated the ability to influence motorist route choices to and from an event (*37,133, 134*). Likewise, advance publication of alternative routes to an event (through brochures or newspaper announcements) has also been used to encourage the spreading of event-bound traffic among several routes (*132*).

The provision and promotion of transit and ridesharing has been an important part of an overall traffic management plan for many special events. This diversion has benefits both in terms of reducing parking demands and on-site congestion as well as in reducing traffic volumes elsewhere in the corridor. Techniques to encourage this type of diversion include parking restrictions or increased parking costs for single-occupant vehicles, special express buses from special park-and-ride lots, reduced fare or free travel by spectators on established bus or rail transit routes, and public information campaigns to promote transit use and ridesharing.

Finally, temporal diversion can be accomplished by adjusting the starting time(s) of the event to avoid peak-period traffic. Obviously, this technique requires cooperation and coordination between traffic agencies and the promoters of the event. This is perhaps the best example of the need for direct communication and cooperation between all private and public entities at an early stage in the planning process. Event promoters may have some flexibility in scheduling during the initial planning stages. However, once tickets and promotions have been prepared, it is very difficult to make changes in event schedules.

APPLICATIONS IN THE U.S.

Special events occur often throughout the country. Table 5 summarizes the different traffic management actions identified from documented experiences with special events nationwide. The list is not intended to be exhaustive, but rather illustrates the range of actions that have been taken to date. Traffic management for extremely large events such as the 1984 Olympics in Los Angeles involved most of the actions listed (*19-21*). For other events, only a few actions from each category were implemented. For still other events, efforts focused primarily on one category (i.e., to improve roadway utilization or to increase transit usage).

BENEFITS

Special event traffic management serves to reduce event-induced congestion and to inform the public about travel options in the corridor during the event. Consequently, a good special event transportation management plan results in the following general benefits:

- Less delay, fuel consumption, and vehicle emissions at access locations to the event, on nearby roadways, and throughout the corridor;
- Fewer accidents;
- Improved public acceptance of travel-related inconveniences caused by the special event, less motorist frustration, and an enhanced public image of the transportation agencies involved; and
- A potential for increased financial success of the special event.

A simulation study of the traffic management actions employed during the 1984 Olympics in Los Angeles provides an interesting comparison of the relative benefits of actions to increase roadway use versus actions to reduce vehicular demand (*20*) (via increased transit usage for spectator travel or reduced non-event travel). The study suggested that rescheduling the events to avoid peak-periods had the most pronounced estimated benefit in terms of system operating speeds and delays. Increased spectator use of transit and fewer work trips made during the event were also estimated to be quite beneficial. Actions to maximize roadway capacity were less effective because of the high level of congestion that was already present in the corridor prior to the event.

Examples and Benefits of Selected Operating Systems

Detroit Grand Prix (1988)

The Detroit Grand Prix, initiated in 1982, is an annual event that attracts an estimated 250,000 fans to the city during the race weekend (*135*). Special traffic management tech-

TABLE 5
SPECIAL EVENT TRAFFIC MANAGEMENT ACTIONS

Types of Actions	Actions Implemented
Actions to Improve Roadway Conditions	Locating parking facilities to encourage use of all routes Metering traffic exiting from parking lots (via enforcement) Temporary signal timing changes/signal deactivation Police officer control of critical intersections Temporary one-way streets or reversible streets/lanes Restricting on-street parking Restricting left-turns at critical intersections Temporary pedestrian overpasses at vehicle/pedestrian conflict points Using real-time information systems (CMS, HAR) to encourage diversion to alternative routes Suggesting routes to spectators when tickets purchased Implementing an operations response team Using computerized, aerial, and human real-time surveillance of traffic conditions
Actions to Improve HOV Use	Providing park-and-ride and shuttle bus service Extending normal transit operating hours Providing express route service to and from event Creating bus-only streets near event Providing spectators with free or reduced transit fares Increasing parking fees for single occupant vehicles Eliminating nearby parking for single occupant vehicles
Actions to Improve Public Understanding, Cooperation, and Acceptance	Developing public information programs to encourage spectator usage of alternative routes, transit usage, or early travel to the event Developing public information programs to encourage non-event traffic to utilize transit, ridesharing, alternative work hours, etc. Rescheduling start and end times of the event to avoid peak-period traffic Developing agreements with trucking agencies to avoid peak-period travel and deliveries

niques are required to mitigate the traffic impacts caused by the fans and by the need to close several roadways in the downtown area to create the racetrack. Transportation planning for the event is handled by a multi-agency group consisting of:

- The Michigan Department of Transportation,
- Michigan State Police,
- Detroit Department of Transportation,
- Detroit Department of Public Works,
- Detroit Police Department,
- Detroit City Engineering Department,
- Detroit Department of Public Information,
- Detroit Renaissance (race organizer),
- Detroit-Windsor Tunnel Company, and
- The Southeastern Michigan Transportation Authority.

Over the years, a standard transportation plan has evolved to handle the event. The plan includes:

- Providing barricades and signing to close certain streets,
- Placing signs to detour traffic around the racetrack site,
- Installing prefabricated pedestrian bridges over the racetrack to provide access,
- Deactivating traffic signals on the racetrack proper to avoid distracting the drivers,
- Making special parking arrangements to accommodate the influx of spectators,
- Rerouting transit routes that infringed upon the racetrack, and
- Expanding the hours of operation of the elevated rail transit system.

Even though the event occurs each year, pre-race meetings are still held every year to reacquaint everyone with the procedures, recognize and resolve new problems, and bring any new participants onto the "team." Decisions regarding transportation issues are generally made by consensus, and no major conflicts have arisen to cause problems. Officials reportedly recognize the city's commitment to the race and the short-term nature of the event, and so have accepted any inconveniences to date.

1986 U.S. Open Golf Tournament, Long Island

Traffic management for the 1986 U.S. Open Golf Tournament at Shinnecock Hills Golf Club on Long Island was handled in a manner slightly different from either the 1984 Summer Olympics or the Detroit Grand Prix. The public agencies involved (New York State Department of Transportation, Suffolk County, and the Town of Southhampton) along with the United States Golf Association hired a traffic consultant (*136*). The consultant performed a feasibility study of the proposed event and the impacts on the street and highway network, developed a traffic management plan, designed the traffic operations and signing details necessary to implement the plan, supervised the implementation of the plan, provided coordination between agencies during the event to modify the plan as necessary. The public agencies reviewed and approved the traffic management plan prior to its implementation, and provided resources as necessary for its implementation. Actions in this traffic management plan include:

- Parking management activities,
- Shuttle bus service from remote parking lots,
- Temporary pedestrian overpasses over moving roadways,
- Special route marking/destination signing,
- Temporary reversible lane operations on two routes to handle anticipated directional peak-period demands,
- Highway advisory radio,
- Left-turn restrictions at critical locations,
- A traffic management command center and two-way communications,
- Aerial surveillance to monitor traffic conditions,
- An exclusive bus roadway,
- Manual traffic control at key intersections,
- Assigned access routes for spectators picking up tickets, and
- Other on-site management actions.

As a result of the transportation plan enacted, the excessive congestion and delays feared did not materialize. Among the key factors attributed to the success of the plan was the input and participation of the agencies involved, and the ability to modify the plan to monitor and accommodate real-time traffic flows.

CHAPTER FIFTEEN

TRAFFIC MANAGEMENT THROUGH AND AROUND WORK ZONES

OBJECTIVES AND GENERAL DESCRIPTION

Planned roadway disruptions due to routine maintenance work and major reconstruction have become quite common in most urban areas. Because of the large volume of traffic that these roadways carry, effective traffic management through and around a work zone is critical for safe and continued traffic flow. The effects of a work zone (particularly if it involves a significant reduction in roadway capacity) on traffic operations may extend not only upstream of the work zone, but onto other nearby roadways as well. For major reconstruction projects that last several months to several years, transit use or ridesharing in a corridor may even be affected. Hence, work zone traffic management, by nature, must often be a multi-organizational effort.

When a work zone generates a significant level of congestion, a redistribution of traffic occurs among different routes or modes in the corridor. Some of this redistribution occurs naturally in response to the congestion that develops. Still other changes in travel patterns can be achieved by providing information to motorists about the amount of congestion and about suitable travel (route, mode, departure time) alternatives. The objective of work zone traffic management may be to accommodate the normal redistribution of traffic, or to actually attempt to influence the redistribution. Either way, the key to work zone traffic management is to actively use the transportation resources of the corridor in the most effective way possible (Figure 14).

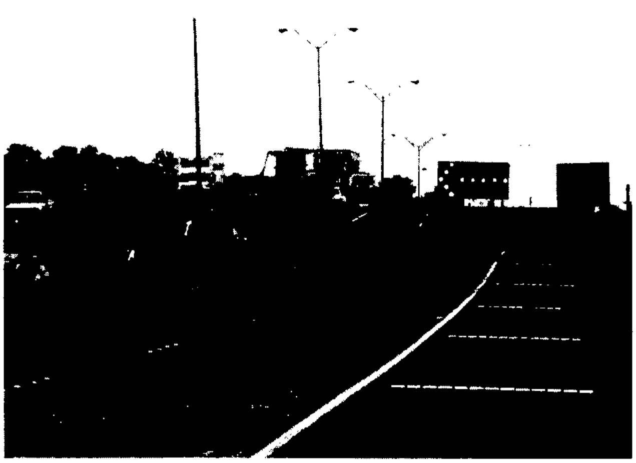


FIGURE 14 The key to work zone traffic management is to actively utilize the transportation resources of the freeway corridor.

HISTORICAL PERSPECTIVE

Work zone traffic control on urban freeways has always been a major concern, because of the high speeds and volumes normally present on these facilities and because of the different expectations drivers have when traveling on these roadways. Increasing levels of maintenance required on many of the larger urban areas brought the issue of urban freeway work zone traffic management to the national forefront, beginning in the late 1960s and early 1970s (*137*). Increases in accidents documented at many work zones (*138*) prompted an extensive national emphasis on improved work zone traffic safety and management during the 1970s and into the 1980s. Much of this effort was oriented toward urban freeway settings. The focus of activities during this time was on how to best control and manage the traffic approaching and traveling through the work zone, although some consideration was given to reducing traffic demands through the use of real-time motorist information.

During this same time, the need for traffic management and control throughout the freeway corridor during major reconstruction projects began to be acknowledged. Among the concerns with such major reconstruction is the impact that traffic diverted from the freeway will have on the rest of the corridor, on streets and other travel modes not under the jurisdiction of the state highway agency and which are commonly not capable of accommodating large increases in traffic. This concern was addressed in the early 1980s when the federal government began allowing interstate construction monies to be used to fund traffic system improvements elsewhere in the corridor to help mitigate the impact of diverted traffic during freeway construction (*138*).

TRAFFIC MANAGEMENT APPROACHES AND APPLICATIONS IN THE U.S.

Maintenance Operations

Maintenance activities must occur periodically on all types of roadways, including urban freeways. These activities can last from a few minutes to a few hours. Depending on the reduction in capacity and on normal traffic demands, serious traffic congestion and operational problems can arise unless effective traffic management measures are applied.

General guidelines for work zone traffic control are provided in the *Manual on Uniform Traffic Control Devices* (*139*). A number of reports have been prepared for FHWA and for various state agencies that provide supplemental guidance for work zone traffic management, particularly on urban freeways (*140-143*). Various work zone traffic control schemes (such as middle lane closures and temporary shoulder usage) have been developed so that work activities can be accommodated while maintaining as much roadway space as possible for traffic movement. Also, the importance of static and real-time information displays to warn and guide drivers through a work zone or to encourage them to seek alternative routes has been demonstrated (*38*). In addition, analytical techniques have been developed to assist in determining when freeway lanes and entrance ramps can be closed (based on expected traffic volumes) without causing intolerable levels of traffic congestion (*144*). In general, it has become common practice to avoid closing freeway lanes for maintenance work during peak-period travel times.

A key feature of maintenance operations is that they are usually of short duration and typically have fairly short lead times. Because of this, both intraagency and interagency coordination must be in place before they are needed for a maintenance operation. For example, blanket agreements can be established between a highway agency and local law enforcement so that police officers are available to help reduce speeds and facilitate safe traffic flow whenever maintenance operations require a freeway lane to be closed; this is an approach that has been successfully used in Houston (*86*). As another example, coordination with the local traffic agency is generally necessary when diverting traffic from the freeway to nearby arterial streets. It may be necessary for the local agency to adjust traffic signal timings or otherwise implement actions to mitigate the impacts of diverted traffic.

Well-established procedures for intraagency coordination are also important. Coordination is particularly vital between the maintenance department and the public information department of a highway agency so that adequate advance notice of work zone activities is provided to the public:

Major Freeway Reconstruction

Because of the short duration of many maintenance operations, most can be scheduled to avoid peak traffic periods. Unfortunately, this is often not the case for major freeway reconstruction, where long-term lane closures and other minor capacity reductions may be necessary over a period of several months to several years. The effect of such a capacity reduction during peak periods can be devastating if appropriate actions are not taken. If at all possible, the same number of lanes should be provided during construction as existed before construction began. Special emphasis should be given to advance motorist information when traffic control is shifted during staged reconstruction.

Experiences at past projects have shown that interagency coordination and a "team" approach to traffic management have been extremely important to successfully accommodating traffic during major freeway reconstruction. Different organizational approaches have been taken to obtain the necessary coordination and cooperation between agencies, including:

- Multi-jurisdictional task forces that meet periodically to develop plans as a group,
- Private consultants hired to develop a traffic management plan and to serve as the coordination link between various agencies during implementation of the plan, and
- In-house planning efforts by the primary agency (usually the state), who coordinates actions with the other necessary agencies.

Major freeway reconstruction projects can involve numerous public and private entities during initial traffic management planning and implementation as well as on a continuing basis throughout the project. The types of agencies and organizations that have been involved in traffic management efforts at past projects include (*25*):

- State, local, and federal highway agencies (representing traffic, construction, and design departments);
- Regional government councils, planning commissions, and chambers of commerce;
- Automobile and trucking associations;
- Transit agencies operating in the region;
- Private ridesharing organizations;
- Enforcement agencies; and
- Contractors.

Traffic management for major freeway reconstruction focuses not only on how to best accommodate traffic through the work zone, but how to mitigate the effects of traffic that may be forced to divert from the freeway because of the reduced capacity of the facility. A recent synthesis of traffic management techniques for major freeway reconstruction (*119*) documents the different types of TSM actions and techniques that have been employed to counteract the effects of freeway traffic diverted from the work zone. A summary of these actions is presented in Table 6.

Selection and implementation of these techniques must be performed within the context of a well-defined corridor management plan to maintain mobility in the corridor and mitigate the impacts of freeway reconstruction. Experiences at past projects indicate that this is particularly true for actions designed to encourage HOV use during construction. Projects where an existing comprehensive system of transit availability, park-and-ride facilities, preferential lane/ramp treatments, and marketing was enhanced experienced moderate increases

TABLE 6
TRAFFIC MANAGEMENT ACTIONS DURING MAJOR FREEWAY RECONSTRUCTION

Types of Actions	Actions Implemented
Actions to Improve Roadway Utilization	Traffic signal timing adjustments
	Traffic signal equipment improvements
	Left-turn restrictions at critical locations
	Parking restrictions
	Police control of critical intersections
	Reversible lanes
	Implementation of alternating, one-way pairs
	Intersection widening and channelization
	Resurfacing and other pavement repairs
	Signing and lighting improvements
Actions to Improve HOV Utilization	New or expanded commuter rail service
	Expanded rapid transit service
	New or expanded bus service
	Implementation of HOV only ramps and lanes
	New or expanded park-and-ride lots
	New or expanded ridesharing programs
Actions to Improve Public Understanding, Cooperation, and Acceptance	Traditional P-R tools (press conferences, new releases)
	Special publications
	Toll-free hotlines
	Highway advisory radio systems
	Special freeway signing
	Employment of an ombudsman

in HOV usage during construction (*119*). At other projects where new or less-coordinated systems were implemented, very little shift away from drive-alone automobile trips was observed.

Traffic management during major freeway reconstruction does not stop once construction begins and the management plan has been established. A key asset at several past projects has been the ability to modify traffic management actions in the corridor in response to changing traffic conditions (*118*). Continued coordination between agencies to possibly expand beneficial activities while decreasing or eliminating those less effective has been very important. For example, police enforcement has been used to control traffic at critical intersections at the beginning of some projects. As commuters became accustomed to traffic conditions and adjusted their route, departure time, or travel mode, police control was gradually reduced or eliminated (*119*).

Real-Time Traffic Management

Real-time traffic management refers to actions taken in real-time at the work zone to best facilitate continued safe and efficient traffic flow. For instance, it may be desirable to manipulate work zone capacity and demand in real-time so that enough traffic is approaching to discourage high-speed travel but does not exceed capacity enough to cause significant congestion (*145*). Other types of work zones may dictate other real-time actions.

Real-time management of either traffic demand or work zone capacity (or both) is possible. One very useful method of adjusting work zone capacity is to manipulate the use of a shoulder as a temporary travel lane when congestion develops, and to encourage its use via highway advisory radio or changeable-message signs. If traffic demands drop to the point that speeds begin to increase, the radio or signs would then be turned off, and the shoulder would not be used for travel.

Traffic demands can also be managed in real-time to some degree. Entrance ramps can be closed and opened as necessary to control demands. Also, changeable-message signs in advance of the work zone can be used to encourage diversion from the freeway upstream of the work zone when demands are high and congestion is developing. If traffic demands decrease, the signs can be turned off. Research using portable changeable-message signs at work zones showed that they could increase diversion from the freeway to other routes, thereby reducing the traffic demand at the work zone (*38, 146*).

In order for real-time traffic management to be effective, a specially-trained crew (generally highway agency personnel) must be assigned to the task of managing traffic through the work zone. This crew must have an understanding of traffic operations and traffic flow concepts, as they continuously monitor the situation and make adjustments and decisions regarding traffic operations as necessary. Members of the crew must coordinate their decisions and actions with each other to avoid overcompensating for the reduced capacity of the work zone. For example, placing too much emphasis on diversion from the freeway via upstream exit or entrance ramps could lead to a situation where the freeway is relatively void of traffic while the frontage road or adjacent arterials are congested with diverted traffic (*142*).

BENEFITS

Work zone traffic management, including adequate advance planning and organization, results in a multitude of benefits to the highway agencies, contractors, and the motoring public. With respect to the public, proper management can reduce user costs by reducing delays and congestion and improving safety. For the highway agencies, proper management can reduce citizen complaints, reduce tort litigation problems (through smoother and more efficient traffic flows which promote safer operations), and can help maintain an acceptable construction or maintenance schedule. For the contractor, proper traffic management in work zones helps protect the safety of the workers, and can, in some instances, help reduce the cost of the project. As an illustration, analyses prior to the reconstruction of the Lodge Freeway in Detroit indicated that it was feasible and cost-effective to close down one direction of the freeway and allow the contractor to occupy the entire roadway (*147*). During the resurfacing of a section of I-5 in Seattle, project officials modified the traffic control plan to allow long-term lane closures to remain in place throughout the remainder of the project, and the contractor was able to work more efficiently (*148*).

For major freeway reconstruction, establishing interagency coordination and cooperation early on can be beneficial in minimizing conflicts between agencies farther into a project, where injunctions and litigation may increase its cost and disrupt its progress. In Hartford, Connecticut, for example, reconstruction of the freeway was delayed for several months by local townships in legal battles over the compensation of the effect of diverted traffic on local streets (*119*).

Examples and Benefits of Selected Operating Systems

Major Freeway Reconstruction: I-376, Penn-Lincoln Parkway East, Pittsburgh

The reconstruction of the Parkway East was the first project in which FHWA approved the use of interstate funds for efforts to mitigate the impacts of reconstruction elsewhere in the travel corridor (*149*). Planning for the project began about two years before reconstruction began. The Pennsylvania Department of Transportation employed the services of the Southwestern Pennsylvania Regional Planning Commission to predict the travel impacts of reconstruction and to analyze the anticipated effectiveness of the various impact mitigation strategies. It was determined that not enough capacity existed to accommodate all diverted traffic in the corridor, so an extensive $11 million program was developed to increase the people-carrying capacity of the corridor.

As part of the program, a new commuter train was purchased and operated on existing rail lines. A third-party vanpool organizer and the local transit authority were contracted to add several express bus routes in the corridor. Agreements were also established with several property owners to use existing parking lots as park-and-ride lots. Traffic operations improvements were made on a number of the other routes in the corridor. These improvements included the use of police officers for traffic control at key intersections. Costs of the strategies were paid using interstate construction funds.

Based on the results of an extensive traffic monitoring program during reconstruction, it was found that the traffic operations improvements on alternative routes were the most effective measure implemented. The ridesharing options that were provided during construction were underused, to the point that the new commuter train was discontinued after 182 days of use because of low ridership. Among the possible reasons given for the failure of the train were that express bus service already served many of the same potential markets for the train, that the train did not provide convenient enough service (not enough trips), and that door-to-door travel times were just as long using the train as by driving alone (*149*).

Real-Time Traffic Management: Houston

In the mid 1980s, the Houston District of the Texas State Department of Highways and Public Transportation established a special traffic-handling crew to manage traffic during maintenance operations on high-volume roadways. The crew was given the authority and capability to implement proven work zone techniques (in a manner consistent with the MUTCD) and to react to changing traffic conditions. As one technique, the crew would use changeable-message signing to indicate the use of the shoulder as a temporary travel lane through the work zone. When traffic demands reduced, the sign would be turned off and the lane returned to a shoulder.

A test of this management approach was made on a high-volume Houston freeway carrying 175,000 to 200,000 vehicles per day (vpd) and in dire need of repair (*145*). It was reported that a project of this type normally would have lasted several months. However, efforts were undertaken by the traffic-handling crew to allow the work to be completed in a more timely fashion. These efforts included:

- Coordinating the information about daily lane closures with the Public Affairs section of the TSDHPT,
- Coordinating with the City Traffic and Transportation Department to modify intersection signal timings to accommodate diverted traffic,
- Arranging for the use of off-duty police officers at the work zones as part of the Selective Traffic Enforcement Program, and
- Managing the use of the roadway shoulder and entrance ramps in real-time.

The work was completed much more quickly than would have been possible normally, and with no citizen complaints about traffic congestion due to the work zone. Only on one day did a traffic queue develop, and it was quickly dissipated after the crew modified the work zone traffic control slightly.

The experiences of Houston, Pittsburgh, and other cities throughout the United States demonstrate that a comprehensive strategy for effective management of the many components of urban freeway corridors can optimize traffic operation and provide benefits to motorists, government agencies, and private industry.

CHAPTER SIXTEEN

SUMMARY AND CONCLUSIONS

Freeway corridor management begins with consideration of three fundamental questions:

- Who will develop the plan to establish freeway corridor management?
- Who will fund the system and implementation of the plan?
- Who will operate the system once established?

Once these issues are resolved, a freeway corridor management plan can be developed. Development involves three main phrases:

- Freeway corridor management plan development,
- Preparations for freeway corridor management plan implementation, and
- Freeway corridor management plan implementation and system evaluation.

A freeway corridor management plan involves the coordination of the following components:

- Freeway surveillance and control,
- Corridor street surveillance and control,
- High-occupancy vehicle facilities and incentives,
- Police enforcement and traffic control,
- Hazardous material and other truck restrictions,
- Alternative route planning
- Motorist assistance patrols, and
- Dissemination of information to motorists and other citizens.

A freeway corridor management plan is tailored to address specific concerns and types of congestion problems that exist in an urban area. Four types of traffic management strategies exist, namely,

- Traffic management for recurrent congestion,
- Traffic management for incidents,
- Traffic management for special events, and
- Traffic management through and around work zones.

Finally, experiences nationwide indicate that several political and administrative concerns must be considered and addressed in order to successfully implement freeway corridor management.

- A definable need must exist for freeway corridor management.
- Top administrative officials within the various agencies must support freeway corridor management efforts.
- The support of one or more local politicians assists in the implementation and funding efforts of freeway corridor management.
- It is important to be able to demonstrate the actual or expected benefits (operations, safety, economic) of freeway corridor management.
- The ability to maintain continuity of key personnel involved in freeway corridor management development is important to its long-term success.
- Sources of funding for the continued operation and maintenance of components of a freeway corridor management system must be considered and identified prior to its implementation.

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