259

National Cooperative Highway Research Program

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NCHRP Synthesis 259

Management of Surface Transportation Systems

A Synthesis of Highway Practice

Transportation Research Board
National Research Council

National Cooperative Highway Research Program

Synthesis of Highway Practice 259

Management of Surface Transportation Systems

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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.

In recognition of these needs, the highway administrators of the American Association of State Highway and Transportation Officials initiated in 1962 an objective national highway research program employing modern scientific techniques. This program is supported on a continuing basis by funds from participating member states of the Association and it receives the full cooperation and support of the Federal Highway Administration, United States Department of Transportation.

The Transportation Research Board of the National Research Council was requested by the Association to administer the research program because of the Board's recognized objectivity and understanding of modern research practices. The Board is uniquely suited for this purpose as it maintains an extensive committee structure from which authorities on any highway transportation subject may be drawn; it possesses avenues of communication and cooperation with federal, state, and local governmental agencies, universities, and industry; its relationship to the National Research Council is an insurance of objectivity; it maintains a full-time research correlation staff of specialists in highway transportation matters to bring the findings of research directly to those who are in a position to use them.

The program is developed on the basis of research needs identified by chief administrators of the highway and transportation departments and by committees of AASHTO. Each year, specific areas of research needs to be included in the program are proposed to the National Research Council and the Board by the American Association of State Highway and Transportation Officials. Research projects to fulfill these needs are defined by the Board, and qualified research agencies are selected from those that have submitted proposals. Administration and surveillance of research contracts are the responsibilities of the National Research Council and the Transportation Research Board.

The needs for highway research are many, and the National Cooperative Highway Research Program can make significant contributions to the solution of highway transportation problems of mutual concern to many responsible groups. The program, however, is intended to complement rather than to substitute for or duplicate other highway research programs.

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NOTICE

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The members of the technical committee selected to monitor this project and to review this report were chosen for recognized scholarly competence and with due consideration for the balance of disciplines appropriate to the project. The opinions and conclusions expressed or implied are those of the research agency that performed the research, and, while they have been accepted as appropriate by the technical committee, they are not necessarily those of the Transportation Research Board, the National Research Council, the American Association of State Highway and Transportation Officials, or the Federal Highway Administration of the U.S. Department of Transportation.

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The Transportation Research Board evolved in 1974 from the Highway Research Board, which was established in 1920. The TRB incorporates all former HRB activities and also performs additional functions under a broader scope involving all modes of transportation and the interactions of transportation with society.

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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 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 officials of municipal, regional, and statewide transportation agencies who are responsible for the management of surface transportation systems in metropolitan areas. It presents information on the processes used by transportation agencies to monitor, evaluate, and implement a variety of solutions to the management of surface transportation systems. This is a complex and dynamic area of application, and the examples presented herein represent a selection of such applications in 1997. The concept of transportation system management is constantly changing and will continue to change, especially with further implementation of intelligent transportation systems.

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.

This report of the Transportation Research Board provides an overview of the generalized process that transportation agencies have found to be effective in managing the various aspects of their transportation systems. Specific case examples of effective management strategies are described for several metropolitan areas including Houston, Seattle, metropolitan New York, Los Angeles, San Francisco, and Minneapolis/St. Paul.

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 research in organizing and evaluating the collected data, and to review the final synthesis report.

This synthesis is an immediately useful document that records the 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.

CONTENTS

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Valuable assistance in the preparation of this synthesis was provided by the Topic Panel, consisting of Guzin Akan, Principal Transportation Engineer, City of Norfolk, Division of Transportation; Richard A. Cunard, Engineer of Traffic and Operations, Transportation Research Board; Leslie N. Jacobson, Traffic Systems Manager, Washington State Department of Transportation; Jaclyn K. Landsman, formerly Traffic Maintenance Engineer, Federal Highway Administration, Region 9; Morris Oliver, Senior Project Manager, Federal Highway Administration; George J. Scheuernstuhl, Director, Transportation Services, Denver Regional Council of Governments; and Douglas W. Wiersig, Executive Director, Houston TranStar.

This study was managed by Sally D. Liff, Senior Program Officer, who worked with the consultant, the Topic Panel, and the Project 20-5 Committee in the development and review of the report. Assistance in Topic Panel selection and project scope development was provided by Stephen F. Maher, P.E., Senior Program Officer. Linda S. Mason was responsible for editing and production.

Crawford F. Jencks, Manager, National Cooperative Highway Research Program, assisted the NCHRP 20-5 staff and the Topic Panel.

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MANAGEMENT OF SURFACE TRANSPORTATION SYSTEMS

SUMMARY

The surface transportation system in the United States is owned and operated by an array of agencies with individual missions. No single agency has a focus on the overall surface transportation system. This fragmentation is the result of institutional structures and funding mechanisms. Traditionally, the specialized focus of these diverse agencies has been an asset to the development of the premier surface transportation system in the world. However, as the surface transportation system has matured and the public has become concerned about a complex set of issues, the present structure poses significant challenges to the development of an integrated intermodal surface transportation system operating at maximum effectiveness and efficiency.

The institutional structure of surface transportation comprises many jurisdictions, several modes, and many functions and disciplines within the various agencies. The institutional issues are compounded by complex funding arrangements that further cut across the institutional structure. The result of the institutional and funding structures is a variety of overlapping programs that make it difficult to take a holistic, systems approach to providing and managing surface transportation.

The traditional systematic process to monitor, evaluate, and implement effective and efficient multimodal solutions to maximize surface transportation system performance has not been implemented in practice in a truly all-encompassing context. The challenge is to reconcile the desirable process with the institutional realities to achieve a user perspective of mobility and accessibility. Although the basic process for transportation system management is reasonably easy to describe because it follows well-established principles, it is difficult to implement in practice for several reasons. First, not all the technical tools are adequately developed. Second, it is especially difficult to conduct analyses when trade-offs between modes must be considered. And third, there are even institutional considerations within agencies caused by the differing perspectives within the various departments.

A variety of strategies have been applied to the management of the surface transportation system. The management strategies affect either the demand for transportation, the supply of transportation services, or sometimes a combination of supply and demand. These strategies are generally organized along traditional service delivery programs, which historically have been driven by the federal-aid program. These categories of strategies are:

- Traditional transportation system management,
- Incident management strategies,
- Information systems,
- Access management,
- Parking management,
- Travel demand management,
- Intelligent transportation systems, and
- Added capacity.

This synthesis presents a limited set of case studies of places where progress is being made toward a more holistic and synergistic approach to management of the surface transportation system. The selected case studies describe six metropolitan areas: Houston, Texas; Metropolitan New York, New Jersey and Connecticut; Los Angeles and San Francisco, California; Minneapolis/St. Paul, Minnesota; and Seattle, Washington. The case studies illustrate that the process is difficult, still developing, and must be approached recognizing the unique local institutional structure.

Improved surface transportation system management has usually begun with a specific project. As the partners become successful in their undertaking, they develop expansions of their projects or new ideas for collaborative activities. As the process continues, the projects tend to expand in scope and involvement. The projects and approaches tend to have unique characteristics depending on the types of problems being addressed and local institutional structures. It does not appear feasible to prescribe a particular approach for universal application. Several stories suggest that it is possible to improve management of the surface transportation system by building on prior successes. The Los Angeles example also illustrates that a "failure," such as the Santa Monica diamond lanes, is still a learning process and that the setback can be overcome.

Although the examples would suggest there is a long way to go to realize a truly integrated surface transportation system, they also suggest that improvements can be made, and that progress breeds further action. There is evidence that progress could be speeded up through the implementation of incentives.

CHAPTER ONE

INTRODUCTION

This synthesis updates *NCHRP Synthesis 81: Experiences in Transportation System Management* (*1*). *NCHRP Synthesis 81* developed a classification scheme for the more than 150 transportation system management (TSM) actions identified at the time. Since the 1981 synthesis, TSM has evolved significantly as the result of new techniques and changes in law. One key difference in the current concept of TSM is that it includes consideration of capital projects as part of managing the surface transportation system. The title of this synthesis reflects this broader concept.

BACKGROUND

The surface transportation program as embodied in federal assistance has historically focused, since the Federal Highway Act of 1921, on road building (*2*). For the 35-year period from 1956 to 1991, America's surface transportation policy centered on the world's largest public work project, the Interstate Highway System (*3*).

Management of the transportation system has taken place largely after construction of a facility. Traffic engineers were initially responsible for the application of traffic signs, traffic signals, and traffic markings to existing facilities to address operational problems. The evolution of traffic engineering practice included the expansion of street capacity, parking facilities, and traffic-control strategies to accommodate the quality and safety of ever-increasing automobile flows. The Federal-Aid Highway Act of 1968 initiated the Traffic Operations Program to Improve Capacity and Safety (TOPICS), a predecessor to TSM (*4*).

Management of the transportation network was not conceptualized as *systematic* until federal rules defined TSM as "a philosophy about planning, programming, implementation, and operations that calls for improving the efficiency and effectiveness of the transportation system by improving the operations and/or services provided." The philosophy, however, was based on a concept of TMS as a short-range approach to improve operations "prior to capital projects."

The enactment of the Clean Air Act Amendments of 1990 (CAAA) challenged the transportation profession to maintain the nation's mobility while enhancing our air quality (*5*). The CAAA established criteria for attaining and maintaining National Ambient Air Quality Standards (NAAQS). These requirements specify the actions required to be taken by nonattainment areas.

The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) charted a new course in management of the surface transportation system. Its goals include reduced congestion, maintenance of mobility, an enhanced role for state and local governments, and additional focus on environmental issues. The programs include a National Highway System, an Interstate Program, a Surface Transportation Program, a Congestion Mitigation and Air Quality Improvement Program, a Bridge Replacement Program, a Federal Lands Program, and Special Programs. These programs provide the primary federal funding mechanism for surface transportation. They also set a new direction for surface transportation that is more supportive of management of the surface transportation system (*6*).

ISTEA has other important provisions that are relevant to management of the surface transportation system. Transportation planning must be more broad-based and include additional considerations such as land use, intermodal connectivity, methods to enhance transit service, and needs identified through management systems. Management systems include highway pavement, bridge, highway safety, traffic congestion, public transportation facilities and equipment, and intermodal transportation facilities and systems. In addition, the Act requires a statewide planning process, a statewide transportation plan, and a statewide transportation program (*6*).

The importance of the law is that it provides a legal framework for a broad approach to management of the surface transportation system. It also reflects a philosophy that is consistent with management of the surface transportation system because it includes many aspects of a system-based approach to transportation. This synthesis takes a holistic view of management that considers how a system operates from a user perspective and includes all aspects of the process, as presented in chapter 2.

INSTITUTIONAL CONSIDERATIONS

Institutional considerations exist because the surface transportation system is not operated by a single agency. In most metropolitan areas, the transportation system is managed and operated by multiple jurisdictions and many different agencies. Even within agencies, various functional divisions perform the various agency tasks. In essence, the surface transportation system is divided into a large number of separate parts to provide for specialization and task efficiency.

The following sections describe the various institutional frameworks that make up the surface transportation system. The more detailed examples are limited to highway transportation for simplicity, and are not meant to diminish the importance of considering linkages to other modes. The examples demonstrate the complexity of institutional relationships in the management of the surface transportation system. Figure 1 shows one way of viewing the surface transportation system. A cube is selected to allow the presentation of six views of the system. The selection of six is not intended to represent all possible views, but to illustrate the complexity. The fact that

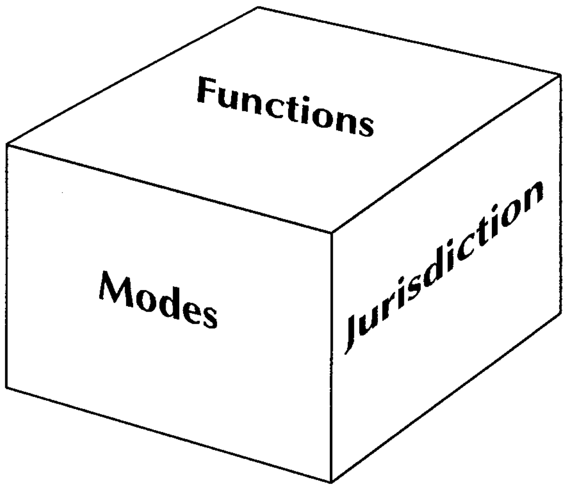

FIGURE 1 Three views of the surface transportation system.

only three of the views can be seen in Figure 1 is useful to illustrate that it is not easy to see the big picture. Figure 2 presents six views by unfolding the cube.

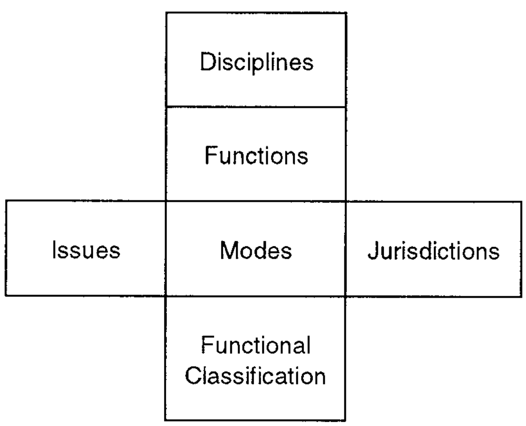

FIGURE 2 An expanded view of the surface transportation system.

The next set of figures further illustrates the institutional issues within the framework of a hypothetical highway transportation system. Figure 3 shows a conceptual highway transportation system comprising freeways, arterials, and local streets. State transportation agencies are generally concerned with the freeway portion of the system, represented in Figure 4, while local agencies are generally concerned with the arterial and local streets, as shown in Figure 5. These figures also illustrate that an agency's viewpoint is generally limited by its area of responsibility.

Another important view of the system is that of the user. Users travel on all levels of the system and across jurisdictional boundaries as shown in Figure 6. For the user to experience a high quality of service, the trip must be seamless and function as a complete system. Otherwise, the user is not well served. Management of the surface transportation system is a concept that promotes consideration of the user perspective of the transportation system. In order for the system to perform from a user perspective, it will be necessary to transcend the various institutional arrangements that define surface transportation system.

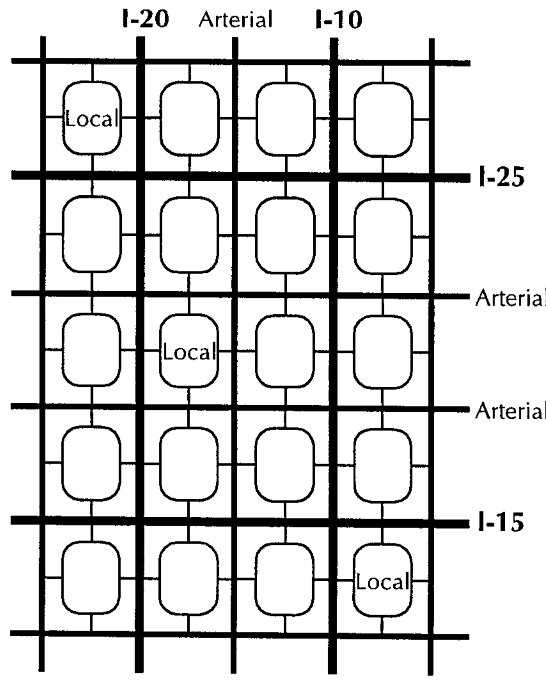

FIGURE 3 A conceptual highway transportation system.

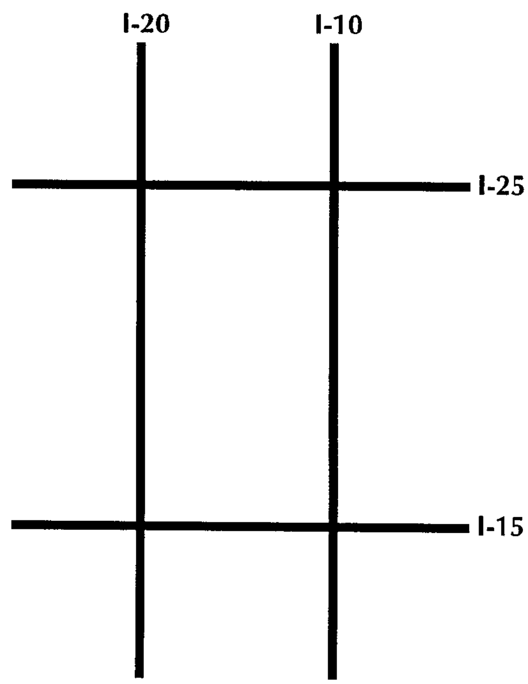

FIGURE 4 Freeway transportation system.

Returning to Figure 2 to focus again on the broader perspective of the surface transportation system, several additional

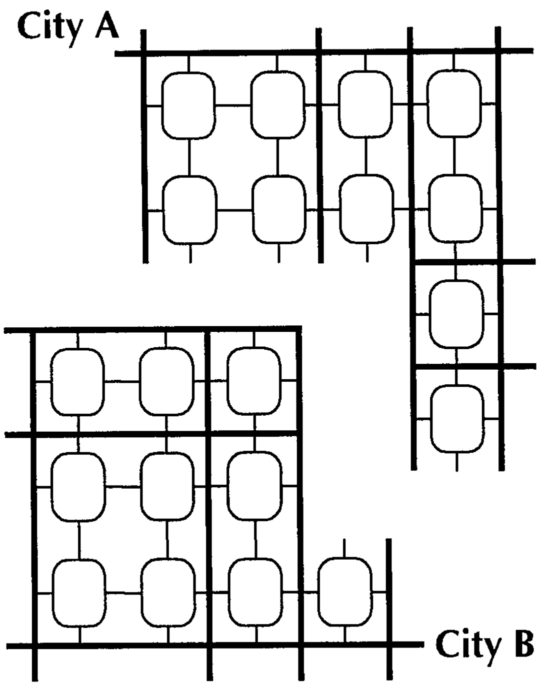

FIGURE 5 Arterial/local transportation system.

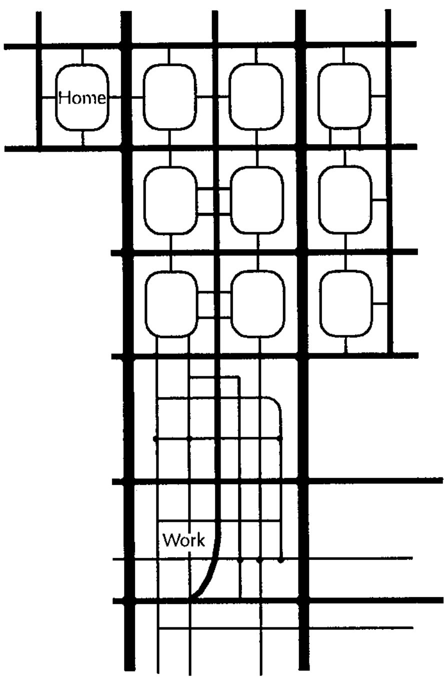

FIGURE 6 User's view of the highway system.

views are illustrated. These views are discussed to provide additional insight into the complexities of institutional issues.

Functional classification is an engineering perspective that focuses on traffic service in a hierarchical manner in order to balance traffic movement and local access. This view of the system is intended to provide an appropriate balance between two competing issues.

Another view of the system is categorized as disciplines. These might include planning, design, construction, operations, and maintenance. Traditionally, these have been viewed largely in isolation as separate specialties. In recent years, more emphasis has focused on the interaction between areas such as design and operations, design and maintenance, and construction and maintenance. In order to manage the system in a comprehensive manner, the various functions will have to work more closely together.

The transportation system also has a geographical perspective brought about by individual jurisdictions. Each jurisdiction may have a traffic signal system operating independently of the neighboring jurisdiction. So, although a street may be functionally classified as an arterial, it may not operate as such, especially in those areas where it may pass through several jurisdictions in a relatively short distance.

Still another view could be categorized as functional, such as police, fire, and traffic. An example of the need for integration would be an incident involving a hazardous material vehicle. In order for these different views of the incident to receive appropriate consideration, it is necessary for the various functions to have good working relationships. Otherwise, for example, the emergency response agencies may not anticipate the secondary accidents caused by poor traffic management, which is not an emergency response function. Working together can result in better emergency response and less traffic impact.

The modal view of transportation would include automobile, bus, truck, rail, air, bike, and pedestrian traffic. The various modes have different needs and perspectives, yet they each share at least a portion of the system. In order for the system to function in harmony, the various views must be balanced.

The last view to be presented is categorized as issues, which might include political, social, and environmental issues. These issues, and others, affect the management of the surface transportation system.

The preceding view of institutional barriers is supported by a study of "Institutional Impediments to Metro Traffic Management Coordination" (*7*). A major conclusion was that the main barriers to implementing new technologies and improving metropolitan traffic management and operations are institutional; that is, fragmentation of responsibility.

This discussion is intended to give perspective on the institutional complexity that must be addressed in the management of the surface transportation system. The desire is to promote a holistic view of the surface transportation system to provide appropriate balance between competing views. Therefore, better management of the system requires coordination and implementation by multiple jurisdictions and many agencies with sometimes conflicting objectives. However, if the surface transportation system is to be managed with adequate consideration of the user, then the various institutional issues need to be addressed.

Management of the surface transportation system is not a new concept. It is part of the natural evolution of the surface transportation system. The key aspect of the current approach is to bring all the pieces of the system and its processes into one integrated whole. This will not occur all at once, but through an understanding and appreciation of the goal by all affected parties.

CHAPTER TWO

THE MANAGEMENT PROCESS

Management of the surface transportation system is a process for resource allocation, investment decisions, and other actions taken to maximize the performance of the system. It is a process of monitoring, performance evaluation, identification of improvement strategies, evaluation of strategies, prioritization, programing/funding, implementation, operations, and maintenance of the surface transportation system. The process, which is cyclic and ongoing, is shown in Figure 7. This process is needed because the surface transportation system is fragmented largely because of the institutional make up of the system, which makes it difficult to manage in a practical sense. It is, therefore, desirable to have a process to provide a system perspective to management.

Management of the surface transportation system is a systematic process to enhance accessibility and mobility by making more effective and efficient use of the system. Many of the pieces of the process are in place, however they are not traditionally viewed as part of the overall integrated management approach for the surface transportation system and its linkages to other parts of the transportation system.

MONITORING

Monitoring is generally the first step in the management process. It provides the data on which all subsequent analysis and decision making is based. The collection of information on traffic volumes, vehicle types, and truck weights has formed a foundation of planning data for highways for many years. The *Traffic Monitoring Guide* (*8*) provides a comprehensive and scientific basis for collecting traffic data. The result of these traffic counting programs is an understanding of how the transportation system is currently operating. This information on traffic conditions can then be used in all phases of transportation. Table 1 is adapted from the *Traffic Monitoring Guide* to show how traffic data can be the basis of many management activities.

It should be noted that the above data and examples are based on traditional highway planning activities. The underlying methods are based on sound data collection principles. An example of an opportunity for different functions to collaborate is planning and traffic. Traditionally, planning collects its own data. Yet many traffic management systems count for traffic control. Through working together, traffic control data could be used for planning. Additional limitations in the traditional approach to traffic data will become apparent in the next section, which discusses performance measures.

In addition to a move toward a more operational focus in transportation system management, there is increased focus on reconstruction and preservation of existing facilities. This has led to a demand for more reliable, relevant, and economical data. *NCHRP Synthesis 133: Integrated Highway Information*

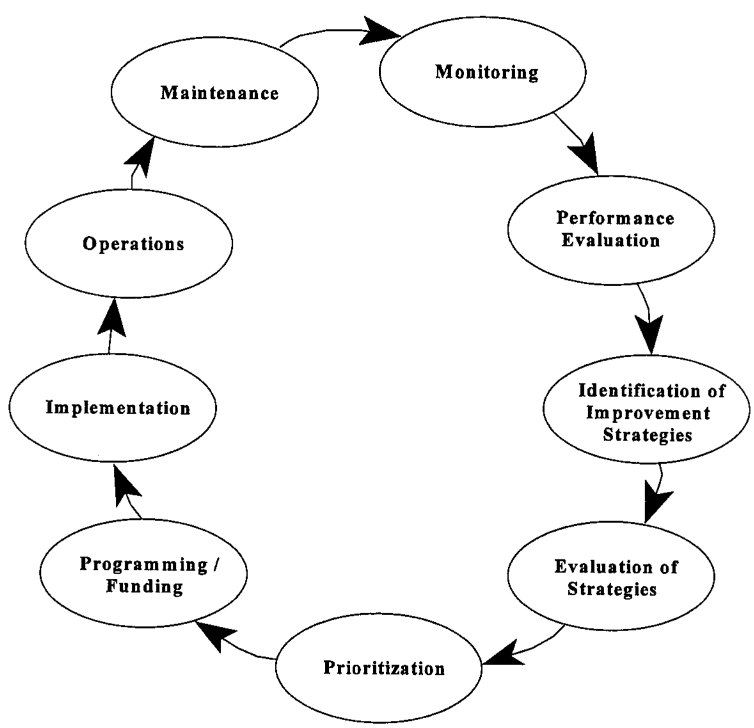

FIGURE 7 The surface transportation system management process.

TABLE 1
USES OF MONITORING DATA

Management Phase	Traffic Counting	Vehicle Classification	Truck Weighing
Engineering	Highway geometry	Pavement design	Structural design
Economy	Benefit of improvements	Cost of vehicle operation	Benefit of truck climbing lane
Finance	Estimates of revenue	Cost allocation	Weight distance tax
Legislation	Selection of routes	Oversize policy	Weight permits
Planning	Location and design	Forecast by vehicle type	Resurface forecasts
Safety	Accident rates	Vehicle mix	Bridge loads
Statistics	Average daily traffic	Travel by vehicle type	Weight distance traveled
Private sector	Location of service areas	Marketing to particular vehicle types	Trends in freight movement

Systems,(*9*) describes an integrated highway information system containing geometric, traffic, accident, roadway features, and other data related to the planning, design, construction, maintenance, and operation of a highway system.

Iowa (*10*) is developing a Pavement Management program as the first step toward an integrated transportation management database containing crucial data from each management system (pavement, multimodal, congestion, bridge, and safety). The Iowa program emphasizes the enormity of the effort and the potential large benefit anticipated from a comprehensive approach to coordinated data.

PERFORMANCE EVALUATION

Evaluation involves a bringing together of all the benefits, costs, and impacts of alternatives so that judgments can be made concerning the relative merits of alternative actions. A variety of techniques are available to analyze and evaluate alternatives (*11*). The following discussion highlights the key issue of multimodal performance evaluation. This area is a critical issue in system management.

To evaluate the performance of the surface transportation systems, one must select appropriate performance measures to evaluate. There is no single performance measure or set of performance measures to meet all needs. It is necessary to evaluate the strengths and weaknesses of alternative approaches to meet alternative needs. This process should be done with the various partners in the process before undertaking any evaluation. Performance measures that facilitate this process are (*12*):

- Clearly understood,
- Measurable,
- Sensitive to modes (person-based),
- Time based (travel time or speed, not volume-to-capacity or level-of-service based),
- Link or trip based (to provide system monitoring),
- Sensitive to time period (e.g., spreading of peak-period, at least hourly, not daily data),
- Not too difficult or costly to collect,
- Can be forecast into the future, and
- Sensitive to the impact of congestion mitigation strategies (on people and/or goods).

Transportation performance measures involve both adequacy and quality of transportation systems. Crucial aspects of adequacy are readily described using congestion measures for determination of sufficiency or deficiency. To describe quality, the complement of congestion must be quantified, namely, mobility or accessibility.

Past definitions of congestion have fallen into two basic categories, those that focus on cause and those that focus on effect. Performance measurements clearly require a definition that addresses effect, or symptoms, of congestion. Travel time or delay are the typical measures. Congestion is then the travel time or delay in excess of that normally incurred under light or free-flow travel conditions. However, congestion measures have limitations in cross mode comparisons.

Moving to a comprehensive management approach makes it essential that the performance measures be consistent with the goals and objectives of the process in which they are being employed. It is also important to consider how the performance measures may be used, including policy, planning, and operational situations (*13*).

Mobility is the converse of congestion and can be measured as speed of travel. Mobility is the ability to move people and goods to their destination in an acceptable amount of time or at an acceptable speed. This concept is applicable across all modes, and when used with a measure such as number of persons or tons of goods, is a strong indicator of efficiency.

Accessibility is a measure of the relative access to an area by people and goods from other areas. Accessibility is the achievement of travel objectives within time limits regarded as acceptable. It is as close to an ideal measure for multimodal performance analysis as can be achieved from the user perspective. It also allows recognition that travel needs can be more easily satisfied not only if the transportation system is improved, but also if land use arrangements are rationalized.

Travel time or difference in travel time can be a basic measure. It can be used to compare door-to-door travel times by different modes. It becomes a performance measure for both the transportation system and land use configurations. Travel rate (e.g., minutes per mile) can be used to account for link-specific differences in the transportation network.

Currently, cost and data limitations make it difficult to construct an ideal performance measurement system. Implementing such a system requires a performance monitoring plan. The performance monitoring plan is a way to organize the gathering of data, the collection of performance measures, and the documentation of results using the collective resources of the various agencies involved. The components of the plan include (*10*):

- Performance measure specifications (including output formats),
- Data collection plan,
- Data management plan,
- Analysis plan,
- Agency responsibilities, and
- Schedule.

IDENTIFICATION OF IMPROVEMENT STRATEGIES

The management process includes identification of appropriate improvement strategies for possible implementation. Conceptually, there are two categories of approaches to providing the best possible system operation. Supply management strategies work on improving the efficiency and effectiveness of the existing infrastructure or adding additional capacity. Demand management strategies work on controlling, reducing, or eliminating vehicle trips on the system while providing a wide variety of mobility options to those who wish to travel. However, in actual application, strategies may address both sides of the supply/demand equation. The important point is that there are two ways to improve system performance.

Supply management strategies are intended to increase effective capacity. Supply management has been the traditional form of surface transportation system management for many years. This is logical because many of the agencies involved with the transportation system are, in fact, the operators of the system. Although the focus for many years has been more on constructing new systems than improving the operations of existing systems, the effective completion of the Interstate system and the passage of ISTEA have elevated system operation to a higher level. Nevertheless, the fundamental concepts of supply management, at least within a particular operating environment, are well established, if not well used.

As opportunities for building new and bigger roads decrease because of cost and environmental and social concerns, other approaches have been sought to deal with the problem of traffic congestion. Increasingly, focus is turning to demand management as a tool to address surface transportation problems. Demand management programs are an alternative to reduce vehicle demand on the transportation system by increasing the number of persons in a vehicle, or by influencing the time of travel, or reducing the need to travel. To accomplish these types of changes, demand management programs must rely on incentives or disincentives to make these shifts in behavior attractive (*14*).

Although surface transportation system management strategies can be conceptually divided into supply management and demand management, the actual strategies and related tools will be presented using categories that more closely follow current practice and programs:

- operational improvements,
- incident management strategies,
- information systems,
- access management,
- parking management,
- travel demand management,
- intelligent transportation systems, and
- added capacity.

Operational Strategies

Traffic engineers were initially responsible for the application of traffic signs, traffic signals, and traffic markings to existing facilities to address operational problems. The evolution of traffic engineering practice included the expansion of street capacity, parking facilities, and traffic-control strategies to accommodate the quality and safety of ever-increasing automobile flows.

Typical operational projects include:

- Improved intersection geometrics (correcting offsets, addition of left-turn and right-turn lanes, bus stop bays, channelization, and grade separations),
- Improved traffic signalization (modernization, interconnection, timing improvements, central control, and bus priority),
- Arterial traffic management (HOV lanes, turn prohibitions, unbalanced flow, reversible-flow lanes, one-way streets, parking removals, off-street loading, narrow lanes/restriping),
- Freeway traffic management (HOV lanes, restriping to add lanes through narrow lanes and the use of inside shoulders, motorist information systems, ramp metering and ramp closure),
- Pedestrian and bicycle improvements (pedestrian signalization, bike lanes, and pedestrian malls),
- Goods movement improvement programs,
- Demand management (alternative work schedules, and ridesharing), and
- Transit improvements.

The Federal-Aid Highway Act of 1968 initiated the Traffic Operations Program to Improve Capacity and Safety (TOPICS). The TOPICS program was an early example of federal funding promoting operational approaches to the surface transportation system. This program was followed by what was called transportation system management (TSM). TSM had the basic objective of more efficient use of existing facilities through improved management and operation of vehicles and the roadway.

NCHRP Synthesis 81: Experiences in Transportation System Management, provides a comprehensive overview of transportation management concepts in 1981. At that time, more than 150 different actions had been identified since TSM was introduced as a concept in the mid-1970s. It also established the concept of operating environments. *NCHRP Synthesis 81* also broadened the original concept of TSM from a list of low-cost actions to fulfill federal requirements to a concept for the most productive use of the existing transportation resources through coordinated operations and improved management. The lack of a classification scheme for TSM actions lead to the development of the concept of operating environments in *NCHRP Synthesis 81*. Operating environments were suggested as subsystems within the transportation network through which TSM analysis and implementation could be organized. The defined operating environments were:

- Freeway corridors,
- Arterial corridors,
- Central Business Districts,
- Regional operating environments,
- Neighborhoods, and
- Major employment centers outside the Central Business District.

The approach of operating environments is both useful and limiting. It is useful in breaking the overall problem into manageable components. Operating environments limit the scope and number of involved jurisdictions and agencies to more easily address problems. However, it may overlook some important linkages. A simple example has to do with managing the freeway corridor, perhaps through ramp metering. The freeway management project, which does not necessarily need to involve the local jurisdiction for implementation, does impact the arterial street system. The success of the project may be compromised by lack of support or even opposition by the local jurisdiction.

The important point is that various project-oriented strategies must be viewed in a larger context. In some cases, the interactions between operating environments may be minimal. These types of projects may be easy to implement if they do not compete with other projects for customers or resources.

These techniques are widely known and have been used to varying degrees across the country. A related concept that could be expanded and more widely used is the Transportation Management Team (*15*). The basic concept is that there is a need for communication, cooperation, and coordination among the various agencies and jurisdictions involved in transportation management. The approach brings together personnel from different agencies involved in transportation management to work as a team on problems identified by the various participants. Team members include traffic engineering, planning, design, construction, maintenance, transit, law enforcement, fire, emergency medical services, and others as required, such as military police, port operational personnel, and railroad personnel.

Incident Management

Incidents are events that impede traffic flow and reduce the capacity of the highway. Examples are traffic accidents, disabled or stalled vehicles, spilled cargo, failure of a highway component, emergency or unscheduled maintenance, traffic diversions, and adverse weather. Incidents are the major cause of nonrecurring congestion. Quick and appropriate response to incidents can do much to alleviate resulting congestion.

The impact of incidents depends on incident duration, which is determined by detection time, evaluation/response time, and removal time. Incident management refers to a coordinated and planned approach to restoring normal traffic conditions as quickly as possible. This is accomplished by:

- Improving detection, response, and removal activities to reduce the duration of an incident;
- Increasing the capacity around the incident by effective on-site management; and
- Reducing the traffic demand by providing timely and accurate information to the public.

NCHRP Synthesis of Highway Practice 156: Freeway Incident Management (*16*) presents a comprehensive approach to freeway incidents. Although specifically for freeways, the procedures and processes that highway agencies use to respond to traffic congestion caused by incidents on freeways can be applied to other operating environments.

Information Systems

One means of reducing congestion and improving the operations of a transportation system is to reduce or relocate demand. Demand on the system can be reduced or reallocated by providing users with information about traffic conditions. With this information, users may decide to choose an alternate route to their destination, change their mode of transportation, alter their departure time, or cancel their trip.

Highway and transit users need to be provided with current, accurate, and reliable information in order to make informed and intelligent mode, route, and departure time decisions. The key is to provide information in ample time to affect appropriate changes that improve the efficiency and safety of the system. Systems that advise travelers of changing or unusual conditions must be dynamic in nature.

The following are types of information currently in general use or evolving systems that are sometimes considered a part of intelligent transportation systems, discussed in a later section and included here for continuity.

- Changeable (or Variable or Dynamic) Message Signs use visual words, numbers, or symbolic displays that can be electronically or mechanically varied to inform motorists of changing traffic conditions.
- Highway Advisory Radio is another means of providing highway users with information through the AM radio receiver in their vehicle.
- Telephone call-in services are means of providing both highway and transit users with pre-trip or en-route information.
- Commercial radio and television provide pre-trip information, while radio also offers en-route information.
- Citizen-Band radio was once considered an excellent means of providing two-way communication, but is now primarily used by truckers.
- Lane-use control signals are used in some jurisdictions to alert motorists to changing traffic conditions by indicating what lanes are not available during incidents, maintenance, or other unusual conditions.
- Teletext is a means of providing visual and up-to-date pre-trip information to travelers using the vertical blanking interval of a television video signal and a special device added to a television set.

• Video text is a variation of the dial-in or bulletin board information services currently available to personal computers via modem applied to pre-trip information for travelers.

• FM-side carrier allocation is a method to provide continuous traffic information on existing commercial radio frequencies using a special device to receive and process the information.

• The Internet World Wide Web.

• In-vehicle information systems.

Access Management

Access management is a strategy to maintain the maximum capacity of the roadway system. The basic conflict in a highway system is between the need to provide access to property and the desire to provide efficient movement of traffic. The freeway, with control of access, provides the highest type of facility. The local street, with driveways at each residence, provides the maximum access and minimum movement capability. Unfortunately, most of the arterial street system, which is intended for movement, has higher levels of access than is desirable. Access management is the concept of managing access to arterial highways to maximize capacity and safety.

The application of access management techniques varies widely throughout North America. Travel time and safety benefits have been reported in various case studies. These case studies, taken together, indicate that: (1) removing left turns from the through lanes is essential; (2) installing a properly designed median improves safety and access control over painted turn lanes; and (3) closing the median further improves safety. It should be noted that all changes in traffic operations are not on the positive side. Limiting left-turn access may only transfer the problem to another location (*17*).

Setting useful standards and keeping them are the key to access management success. Standards for driveway spacing and median openings are two of the more important areas. To make it work without hurting businesses, creative solutions are needed. Shared driveways, rear access, and internal service roads are examples. The success of implementing access management depends on an effective legal basis and a cooperative working relationship with those who are potentially adversely affected.

Parking Management

Currently, parking lots and parking garages are not covered in most transportation management systems in the United States, although examples do exist in Europe. The few exceptions to this focus on park-and-ride lots associated with freeway HOV lanes. In Minneapolis, the I-394 lanes that directly enter parking garages are monitored at the MnDOT transportation center. Also in the Minneapolis/St. Paul area is an implementation in St. Paul of a parking management system. Parking management is seen as a necessary part of system management to minimize unnecessary or excessive travel searching for available parking spaces. An obvious intermodal application is airports. The Dallas/Ft. Worth airport has experienced difficulties in communicating to drivers where to park in order to be close to the appropriate gate. The traditional dynamic message sign has not been effective in conveying all the information needed. More effective means will require working with others outside the airport to accomplish effective communication with travelers.

Travel Demand Management

Travel Demand Management (TDM) describes a wide range of programs designed to reduce vehicle demand by increasing the number of persons in a vehicle, or by influencing the time of, or need to, travel. To accomplish these types of changes, TDM programs rely on incentives or disincentives to make shifts in behavior attractive. The term TDM encompasses both alternatives to driving alone and the techniques or supporting strategies that encourage the use of these modes.

TDM alternatives include:

• Encouraging drivers to use carpools and vanpools

• Encouraging drivers to use public and private transit

• Encouraging non-motorized travel, including bicycling and walking

• Compressed work weeks, 40 hours in less than 5 days

• Flexible work schedules, shifting start and ending times to less congested times

• Telecommuting

• Conversion of existing lanes to preferential lanes for HOV to provide time savings to those using ridesharing

• Financial/time incentives, such as preferential parking for ridesharers, subsidies for transit riders, and transportation allowances

• Parking management programs

• Land use/growth management

• Priority treatment for ridesharers, such as preferential access to and egress from parking lots

• Information and marketing

• Application of site or area-wide cost surcharges or subsidy measures designed to make the relative cost of single-occupant vehicle use higher than that for high-occupancy vehicles

• Congestion pricing.

Congestion pricing is one of the newest tools to be considered in the United States. Experience in other countries is summarized in *Road Pricing for Congestion Management: A Survey of International Practice* (*18*). One example of a recent U. S. project is covered in chapter 3.

Intelligent Transportation Systems

Intelligent Transportation Systems (ITS) involve the application and interaction of a group of advanced technologies to make our surface transportation system operate more safely and efficiently. ITS is the application of information processing, communications, and electronic technologies to effectively and efficiently operate the surface transportation system. Although ITS is neither an entirely new concept nor completely different from many of the traditional approaches to transportation systems management, it offers a significant opportunity to realize the benefits of an integrated approach to surface transportation system management. Recent advances in technology also make possible tools to implement strategies that were previously not possible. For example, it is now possible to electronically exchange information between trucks and roadside ports of entry making it possible for trucks to pass inspection points without stopping. ITS is, therefore, a tool to help deliver better system performance.

The ITS program is focused on the development and deployment of a collection of user services. Thirty user services have been defined to date as part of the national program planning process. Some of these user services (including incident management, travel demand management, traveler services information, and traffic control) are traditional TSM strategies as previously discussed. ITS combines existing and new user services into a system-oriented approach.

User services are defined to meet the safety, mobility, environmental, and other transportation related needs of a specified user or group of users. The user services are bundled into six groups, including travel and traffic management, public transportation management, electronic payment services, commercial vehicle operations, emergency management, and advanced vehicle safety systems. The user services are listed in Table 2.

One key aspect of achieving an integrated system is the national ITS architecture, which is initially being put into action through the intelligent transportation infrastructure. While the ITS architecture will be invaluable in helping to design and deploy ITS, it is essential for development of an integrated transportation system. It will ensure national compatibility of systems and capture the synergy of the various components of the system. The systems will meet a number of data and information needs in ways not currently possible (*19*). A second key aspect of achieving an integrated system is the National Transportation Communications for ITS Protocol (NTCIP). NTCIP provides a communications standard that ensures the interoperability and interchangeability of traffic control and ITS devices. The NTCIP is the first protocol for the transportation industry that provides a communications interface between disparate hardware and software products. The NTCIP effort not only maximizes the existing infrastructure, it also allows for flexible expansion in the future, without reliance on specific equipment vendors or customized software (*20*).

Added Capacity

Adding capacity either at a spot location, over an extended section, or on a new location is an alternative management strategy that can be considered in addition to those already discussed. Consideration of added capacity projects can be included in the same process discussed for noncapacity based techniques. Added capacity projects should not be considered unless the alternatives discussed have also been considered. In other words, the process should be holistic, including all techniques as potential treatments.

Surface transportation system management strategies are intended to affect either the demand for transportation or the supply of transportation services. These strategies are generally organized along traditional service delivery programs, which historically have been driven by the federal-aid program. These categories of strategies and tools are:

- traditional transportation system management,
- incident management strategies,
- information systems,
- access management,
- parking management,
- travel demand management, and
- intelligent transportation systems.

These categories are not unique and some approaches are found in more than one category. In order to have an integrated approach to surface transportation system management, the strategies must be considered as part of an overall management process.

EVALUATION OF STRATEGIES

Current practice in multimodal evaluation in passenger transportation is presented in *NCHRP Synthesis 201* (*21*). The study concluded there was a need for measures of multimodal mobility. It suggested that a mobility measure might include the following dimensions:

- Access—average of the time by mode necessary to travel to all zones in an area
- Demand—the amount of travel between zones
- Means—a measure of the ability of people to travel
- Choice—a determination of whether or not alternatives exist.

The study also concluded that traditional systems analysis is not always followed, a clear statement of goals and objectives is not always present, the definition of alternatives does not encompass a broad enough range, and methods to measure and model impacts of alternatives are, in some cases, inadequate. The study concluded that new comprehensive guidance is needed and a multimodal measure of mobility should be developed.

PRIORITIZATION

A variety of means can be used for prioritizing projects, including many traditional economic analysis tools, such as benefit/cost ratio. Categories of funding are often created to address specific problems, such as safety and capacity. Others use rankings based on weighted evaluation criteria. The criteria could represent the goals and objectives of the local area,

TABLE 2
USER SERVICES

Bundle	Service
Travel and Traffic Management	En-Route Driver Information Route Guidance Traveler Services Information Traffic Control Incident Management Emissions Testing and Mitigation Highway-Rail Intersection
Travel Demand Management	Demand Management and Operations Pre-trip Travel Information
Public Transportation Management	Public Transportation Managment En-route Transit Information Personalized Public Transit Public Travel Security
Electronic Payment Services	Electronic Payment Services
Commercial Vehicle Operations	Commercial Vehicle Electronic Clearance Automated Roadside Safety Inspection On-board Safety Monitoring Commercial Vehicle Administrative Processes Hazardous Material Incident Response Freight Mobility
Emergency Management	Emergency Notification and Personal Safety Emergency Vehicle Management
Advanced Vehicle Safety Systems	Longitudinal Collision Avoidance Lateral Collision Avoidance Intersection Collision Avoidance Vision Enhancement for Crash Avoidance Safety Readiness Pre-crash Restraint Deployment Automated Highway Systems

with relative importance being reflected in the weights. Criteria could include, for example, improve accessibility, improve economic vitality, improve mobility, improve system performance, reduce single-occupant vehicles, or improve air quality.

PROGRAMMING/FUNDING

The metropolitan planning provisions of ISTEA feature an enhanced role for local governments. The metropolitan planning organization (MPO) is responsible for developing, in cooperation with the state and affected transit operators, a long-range transportation plan and a transportation improvement program (TIP) for the area. The TIP must be consistent with this plan and must include all projects in the metropolitan area that are proposed for funding with either Title 23 or Federal Transit Act monies. ISTEA requires MPOs to consider 15 factors in developing transportation plans and programs, including land use, intermodal connectivity, methods to enhance transit service, and needs identified through the management systems. *NCHRP Synthesis 217: Consideration of the 15 Factors in the Metropolitan Planning Process* (*22*) covers the process and issues in detail.

Programming and funding must be undertaken in methods consistent with federal requirements and local considerations. These steps determine when and how the project is funded within the various programs available to the participating agencies. As seen in the case studies, projects are being funded in more creative ways to take advantage of the benefits of multiple funding partners. In some cases, public agencies are partnering with private entities to bring additional funds to projects that may have been funded exclusively by the public sector in the past.

IMPLEMENTATION

As seen in some of the examples of current practice, successful projects result from agency champions. Projects are implemented because someone with the appropriate authority and resources (staff and funding) believes in them. The problem is more difficult with multiple agency projects because there has to be a champion in each organization.

Because comprehensive projects involve multiple agencies and jurisdictions, a carefully crafted plan is also important. Key aspects of a successful implementation are *(22):*

- Clear responsibilities,
- Useful results,
- High level of coordination and cooperation,

- Full participation by all jurisdictions,
- Timely arrival of accurate data,
- Implementation is a priority,
- Integration with planning and programming, and
- Coordination with statewide plans and management systems.

In any process, it is important to realize that continuing success requires perseverance. Primary factors in sustaining the process are clear lines of accountability/responsibility, coordination, and cooperation among all involved agencies.

Institutional considerations are fundamental to the practical application of comprehensive management of the surface transportation system. Typically, agencies respond to problems in their jurisdiction or operating environment. These types of projects are easiest to implement if they do not require multiple agencies. Particular strategies to meet an individual agency's needs that have a neutral effect on other agencies are easiest to implement because they generally do not generate resistance. Strategies that are potentially competitive for customers or resources, or that affect another transportation agency's jurisdiction can create resistance. Therefore, details of a particular strategy may have profound effects on how a project is ultimately viewed by other than the lead agency.

OPERATIONS

The traditional view of surface transportation has been largely one of building the system. When it did not operate well, the system was expanded through additional capacity. Operating the system involves a more proactive approach to surface transportation system management. One of the most basic examples of proactive management concerns minimizing the congestion that results from incidents. This approach involves rapid detection and removal of incidents to return the facility to its full non-incident capacity as quickly as possible.

Intelligent transportation systems are the application of technology to enhance performance of the surface transportation system through more proactive management, such as the coordination of traffic signals across jurisdictions. It is also the use of information technology to reduce traffic demand on the system so that it operates better.

MAINTENANCE

Maintenance has often been the weak link in managing the surface transportation system. A recent General Accounting Office report (*23*) indicated that nearly 90 percent of traffic signal systems were not functioning to minimum standards of performance because of inadequate maintenance. Without adequate consideration of maintenance, inefficiency will begin to develop shortly after implementation of a project. Maintenance costs should be factored into every management project.

THE OVERALL PROCESS

The overall process was presented earlier in Figure 7. The process is drawn as a continuous circle. As the system is being operated and maintained, it must be continually monitored. The monitoring process sets in motion another cycle of performance evaluation, identification of improvement strategies, evaluation, prioritization, programming/funding, implementation, operations, maintenance, and so on. Without such a process, the surface transportation system will fail to perform at optimum effectiveness and efficiency.

CHAPTER THREE

CURRENT PRACTICE

This chapter presents selected cases of current practice relative to management of the surface transportation system. These examples illustrate some of the various approaches taken to date to enhance the overall management of the surface transportation system. The examples of current practice were selected based on available information, which, in some cases, is limited. The intent is to show the variety of approaches that have been taken to meet the needs of the specific local area. The examples cited are: Houston, Texas; Seattle, Washington; Metropolitan New York, New Jersey, and Connecticut; Los Angeles and San Francisco, California; and Minneapolis/St. Paul, Minnesota.

HOUSTON, TEXAS

Houston, Texas provides a well-documented example of multimodal, multi-agency cooperation, and presents one approach to comprehensive management of the surface transportation system based on its unique institutional structure. The other cases present different approaches based on different institutional considerations.

It is useful in understanding the development of multimodal institutional arrangements in Houston to go back at least to the early 1960s. Although the early Houston experiments with ramp metering were technically a successful example of freeway traffic management, the Texas Highway Department, now Texas Department of Transportation (TxDOT), was more engrossed in the design, construction, and maintenance of the highway system, which was their principal role; they left the operation of urban freeways to those organizations responsible for enforcement (*24,25*).

By 1970, peak-period congestion on Houston freeways had worsened to a point of public concern. By 1975, Houston had received approval from the Federal Transit Administration (FTA) for a Service and Methods Demonstration to investigate further the feasibility of contraflow lanes (CFL) on the North Freeway in Houston. After considerable effort, a formal agreement was reached between the city and the state, and construction began in 1978. The project included CFL, associated park-and-ride lots, freeway ramp metering, and contracted bus service (*26*).

Funding for CFL came from local sources, state sources, Federal-Aid Urban System, Federal-Aid Primary, FTA Section 6, Federal-Aid Interstate, and FTA Section 9 Programs. The unusual mixture of funding sources demonstrated the degree of state and local inventiveness. It also showed federal, state, and local cooperation. Traditional highway related funding helped support a public transportation improvement while transit related funding helped to further the highway aspects of the overall project.

The City of Houston's Office of Public Transportation, now Metropolitan Transit Authority of Harris County (Metro) and TxDOT not only joined forces to obtain funding for the group of CFL projects, they also worked together on the several construction contracts involved. The state handled construction management, engineering, and inspection, while Metro administered funds for contractor payment and reimbursement of TxDOT expenses.

Although CFL were highly successful, they were never intended to be a permanent facility. In 1981, it was concluded that CFL should not operate past 1985. Metro and TxDOT again combined forces to modify a previously authorized project to upgrade and expand Interstate 45. In 1983, construction began on a barrier-protected median, reversible HOV lane following similar arrangements to the CFL project. Again, innovation was brought to the project through the use of an incentive construction clause that allowed the HOV project to be completed in a record 269 days.

In the late 1970s, TxDOT identified the need to repair and overlay a 10-mile portion of the Katy Freeway (I-10). In addition, Metro HOV staff realized that timely commencement of the Katy HOV lane was unlikely because of the lengthy delay attendant with including the HOV lane construction in the long-term reconstruction project (to follow the pavement rehabilitation project) or the difficulties of building the HOV lane as a separate project. Sensing an opportunity to expedite the Katy HOV lane, the team members suggested that TxDOT delay the pavement repair project and that Metro accelerate the Katy HOV lane planning schedule so that the HOV lane could be constructed as a part of the pavement repair contract. Although initially reluctant to delay the pavement repair project, the TxDOT District Engineer approved combining the two projects because it would reduce disruption to freeway drivers.

Once again, a joint team of Metro and TxDOT worked on the difficult task of combining projects. The challenge turned into a beneficial solution because the HOV lane construction allowed the median area to be reconstructed first as part of the ultimate HOV lane, providing the necessary space for traffic handling during the pavement repair. The project was implemented in just 30 months (*27*). TxDOT and Metro have continued to build HOV lanes jointly in Houston. They are currently developing a system of 110 miles.

In January 1981, Houston took the Traffic Management Team concept first developed in San Antonio, Texas in 1975 and applied it to multiple jurisdictional coordination. In addition to TxDOT and Metro, who had an established relationship, several additional agencies were brought into an "interagency team." The additional agencies included the Houston Department of Traffic and Transportation, the Houston Police Department, the Houston Fire Department, the Texas Department of Public Safety, the Harris County Sheriff's Department, and the Harris County Engineer's Office. Other agencies, such as the Houston Chamber of Commerce, railroad companies, the Texas Transportation Institute, and the Federal Highway Administration have participated on an as-needed basis. The Team has successfully dealt with many operational problems on the existing transportation facilities (*28*).

One unique public/private partnership that came out of the process involves the Houston Motorists Assistance Patrol (MAP) program initiated in 1989 to aid stranded motorists along the major freeways within an approximate 15-mile radius of the Central Business District. Metro, TxDOT, the Harris County Sheriff's Department (HCSD), the Houston Automobile Dealers Association, and Houston Cellular Telephone Company provide funding for the MAP program. MAP currently patrols 150 miles of freeway with nine mini-vans continuously between the hours of 6:00 a.m. and 10:00 p.m. The vans are driven by HCSD deputies and are dispatched by TxDOT.

In early 1991, TxDOT, Metro, and the Texas Transportation Institute developed the concept of the Houston Intelligent Transportation System (HITS) as a strategy to implement an accelerated program using advanced technologies to improve the mobility of people and goods on the transportation infrastructure in nontraditional ways and to reduce the environmental impacts of the transportation system. HITS was intended to capitalize on the growing interest in ITS and to help define ITS projects, such as the Houston Smart Commuter Project and the Real-Time Transportation information project, which were under way were but early examples of a broader vision. HITS was a coordinated effort of public agencies and the private sector to improve the overall efficiency and effectiveness of the movement of people and goods in Houston (*29*).

HITS now includes the Transtar transportation and emergency management center. The 52,000 square foot facility controls every aspect of traffic and emergency management within metropolitan Houston. The multi-agency center is responsible for many freeway and street systems, including:

- The Computerized Transportation Management System in freeway corridors,
- The Regional Computerized Traffic Signal System,
- The Motorist Assistance Program,
- ITS Projects including Smart Commuter,
- The HOV lane network, and
- Emergency and disaster assistance.

The center's construction and operation costs are borne by HITS' four member agencies. The center combines personnel and operations under one management structure.

Houston TranStar is truly integrated in terms of both systems and daily management of personnel and work functions across jurisdictional boundaries. The unique feature of TranStar is its integration of agency personnel and responsibilities into a single unit that creates a seamless implementation effort. Unlike other transportation management centers, Houston TranStar has combined transportation and emergency management personnel. This integrated structure creates an effective environment in terms of responsiveness, elimination of administrative and boundary constraints, and pooling of financial, personnel, and equipment resources. For each participating agency, TranStar provides the opportunity to aggressively focus on implementing transportation and emergency management functions.

SEATTLE, WASHINGTON

The Policy Framework for the Puget Sound Regional Transportation Improvement Program Process provides direct policy support for implementation of the 1995 adopted regional (Metropolitan Transportation Plan) and local comprehensive (Growth Management Act) plans. The Policy Framework provides regional guidelines and policy intent for how the region will manage, administer, and approve projects to be programmed and selected under the three regionally managed federal funding programs referred to as the Surface Transportation Program, the Congestion Management and Air Quality Program, and the Federal Transit Administration Program. The Transportation Improvement Program must also contain all projects that are approved for "state managed" and "regionally managed" federal transportation funding programs.

The Puget Sound area uses four broad transportation policy framework categories as part of the Metropolitan Transportation Plan (MTP) development process for solicitation and consideration of potential projects for regional level project funding. These categories are multimodal and acknowledge the importance of both preservation and expansion. Priority consideration is given to any projects proposed within these four categories that most directly support any or several of the following emphasis areas:

- Improved mobility within the hierarchy of designated centers (including commercial and industrial centers) or along major corridors connecting such centers.
- Projects that can demonstrate that they contribute to sustaining or encouraging continued economic vitality for the region.
- Projects that mitigate the impacts of essential public facilities.

The four broad MTP policy categories and examples of generic types of projects the region should encourage within each area are as follows:

- Critical projects that optimize or manage use of existing facilities/services:
  - Major bridge rehabilitation safety/seismic retrofit projects.
  - Major multi-jurisdictional signal interconnect projects to improve overall traffic flow (perhaps with priority transit treatments).
- Travel demand management/system management projects that address congestion and environmental objectives:
  - Innovative study project(s) leading to a demonstration of ways to shift travel behavior for more efficient

transportation system performance or a "transportation pricing" concept that might offer long-range opportunities to develop major new regional transportation projects and program financing.

Freight and goods corridor or intermodal terminal access studies leading to specific projects for improving port access and improved corridor movements.

Major pedestrian projects (bridges, trails, etc.) that remove major barriers and link activity to or within centers.

- Projects that focus transportation on investments that support transit and pedestrian-oriented land use patterns:

A major regional center or urban corridor development/redevelopment study to improve pedestrian accessibility.

Transit/pedestrian transportation project components to a major innovative redevelopment project.

Pedestrian bridge projects that effectively "link" activity areas and create new economic vitality, especially within centers.

- Transportation capacity expansion projects offering greater mobility options:

Planning/design/construction of major regional multimodal transportation center/terminal projects.

Passenger ferries linking or connecting to regional centers.

Design/development of important new highways or arterials as "missing links" or system completion projects.

Advanced land acquisition to preserve major regional development opportunities, including nonmotorized facility preservation.

Design/construction of HOV lane projects.

Freight and goods special access projects supporting improved intermodal transportation and economic development.

Venture Washington represents the program that will implement the Washington State ITS Strategic Plan. The approach is problem based, looking at particular transportation corridors, and recommending specific solutions to the identified problems. The Seattle to Portland ITS Corridor Plan is the first such study. The solutions are being programmed into the state's budgeting process for eventual construction and deployment. The approach recognizes that no single strategy will solve the complex set of transportation problems facing both the nation and Washington state. The program has efforts in several areas including: comprehensive traffic management, coordinated communications, extensive traveler information systems, roadway performance monitoring, efficient traffic control systems, alternatives to single-occupancy vehicles, improved safety, and enhanced commercial vehicle operations (*30*).

The comprehensive traffic management element of the Venture Washington Plan focuses on completing and extending their surveillance, control, and driver information systems. It includes improved congestion prediction to improve ramp control, improved incident detection, automatic vehicle location systems for improved traveler information using Metro transit bus data, the use of Geographic Information Systems and Geographic Positioning Systems for improved real-time traffic monitoring, and integrated traffic signal control between city and state systems.

Coordinated communications will allow communications between multiple cities to provide corridorwide surveillance, control and driver information. The cities of Tacoma, Spokane, and Vancouver, B.C. will be tied to Seattle.

Traveler information systems include Seattle Wide-area Information for Travelers (SWIFT), which will deliver information into vehicles and to portable wireless devices including watches and subnotebook computers. Other systems will provide information to users in homes, offices, shopping areas, and recreational sites. Delivery systems include telephone, television, radio, computer, and in-vehicle devices.

Efficient traffic control systems coordinate across jurisdictional boundaries and with freeway traffic management systems. Systems will be able to share video and data. The first project in Seattle is the North Seattle Advanced Traffic Management System (ATMS), which will provide a central database to share both freeway and arterial traffic control data among jurisdictions in the Seattle to Everett corridor.

The North Seattle ATMS project got its start as a research effort to determine the best approach for traffic control in the Seattle region. The objective was to develop a multi-jurisdictional integrated traffic control system. Four steps were planned to implement the objective (*31*):

1. Needs identification and consensus building
2. Develop a project to demonstrate the concepts of an integrated system
3. Build traffic management teams
4. Develop and implement a multi-jurisdiction integrated system.

The key to its success is ensuring that all groups involved support the concept by participating in the team.

To foster use of alternatives to single-occupancy vehicles, Seattle is applying advanced technology to encourage transit use, provide ride-sharing incentives, and facilitate the use of alternative modes. Techniques include transit traffic signal priority, real-time transit, and ride-sharing information at home, at transit centers, and en-route.

Improved safety is being provided through a statewide emergency Mayday system, improved incident detection and response, and the promotion of in-vehicle technology to reduce rear-end, sideswipe, and run-off-the-road accidents. The Puget Sound Help Me (PuSHMe) project consists of emergency notification devices, a cellular communication network, and response centers. The response centers will be able to identify the vehicle's location within approximately 10 meters. The response center will receive the request for assistance, prioritize it, and dispatch the appropriate services.

In order to increase the efficiency of commercial goods movements throughout Washington, various efforts are underway to develop paperless and automated systems for permitting, weighing, and safety inspections. These automated systems are also being coordinated with other states.

The Seattle area continues to develop its comprehensive approach to system management with an FHWA-supported

ITS model deployment initiative called Seattle Smart Trek. A group of 25 Northwest public agencies and private companies are working together to improve the Seattle region's transportation management and information systems as part of the U.S. Department of Transportation's Intelligent Transportation Systems Model Deployment Initiative (MDI).

The Smart Trek project continues to build on existing ITS infrastructure and institutional relationships in the central Puget Sound region to showcase a fully integrated Intelligent Transportation Infrastructure (ITI). Seattle was chosen through a national competitive process as one of four sites for the MDI, along with Phoenix, San Antonio, and New York. The projects at each of these sites will provide the United States Department of Transportation, state, and local governments, and the private sector with a model for deploying integrated ITS in urban areas throughout the nation.

The project will integrate existing and new data sources; establish a transportation information network that is integrated, regional, and multimodal; and greatly expand the distribution of traveler information. Information distribution will be spearheaded by private corporations with support from telecommunications firms. The program is being led by the Washington State Department of Transportation, in cooperation with FHWA and Federal Transit Administration, and includes public and private agencies committed to providing a range of services and products.

The project builds on established public and private institutional relationships and establishes a model for ITI coordination among federal, state, regional, and local governments, the private sector, and the public. The project is designed to showcase ITS results and benefits directly to users.

The project's fundamental goal is to improve transportation for the region's travelers by providing the following benefits:

- Reduce travel time by 15 percent,
- Increase system efficiency,
- Increase acceptance and awareness of ITS by 25 percent,
- Increase safety by 10 percent,
- Improve traveler information distribution by 25 percent, and
- Decrease emissions and energy consumption.

The Seattle area MDI is meant to address real and obvious transportation problems. The Smart Trek project will result in transportation management systems that will integrate freeway and arterial control, as well as give priority to transit and emergency vehicles at signalized intersections and improve the safety of traffic movement through rail-street grade crossings.

These same systems will provide much of the data and communications infrastructure necessary to deliver regional, multimodal traveler information. This information will be available pre-trip or en-route; at home or in the office; in a car or on a bus. Agencies will provide a basic level of free information to all travelers. Independent service providers will create value-added applications and more advanced systems as consumer demand warrants. At the same time, the systems will allow regional and multimodal transportation management to appear seamless to the traveler across jurisdictional boundaries and will also respect agency desires to maintain local control when necessary.

METROPOLITAN NEW YORK, NEW JERSEY, AND CONNECTICUT

In 1984, TRANSCOM was conceived as a coalition of traffic and transit agencies in the New York, New Jersey, and Connecticut metropolitan region. TRANSCOM's mission is to bring about cooperation among dozens of agencies on incident notification, regional incident management, and construction coordination. Its role has expanded to include a multi-agency test-bed for implementing ITS technologies. Although TRANSCOM has no authority as an operating agency, it has been very effective in carrying out its mission (*33*).

Located in Jersey City, New Jersey, TRANSCOM is administratively and legally a unit of its host agency, the Port Authority of New York and New Jersey. However, TRANSCOM is governed, funded, and staffed by all its member agencies, which include ConnDOT, NJDOT, NJ Transit, New York State Thruway Authority, New York State Police, NYCDOT, Palisades Interstate Park Commission, NJ Turnpike Authority, Metropolitan Transportation Authority, NJ Highway Authority, MTA Bridges and Tunnels, Port Authority of NY and NJ, and Port Authority Trans Hudson Corporation (PATH). TRANSCOM's Operations Information Center (OIC) is open 24 hours a day, seven days a week. It shares incident, construction, and special event information simultaneously and selectively among more than 100 highway, transit, police agencies, and media traffic services, by phone, fax, and alpha numeric pager. It maintains a shared data base of its member agencies' construction projects. When necessary, it brings specific agencies together when conflicts, such as parallel closings between projects, are likely to result without cooperative intervention and mitigation.

Just how TRANSCOM serves as a necessary means for helping its member agencies, and dozens of affiliated local agencies, to serve the traveling public, is best illustrated through examining a major incident. One of the best examples of a severe incident is the complete closure of Interstate 287, the Cross Westchester Expressway, for almost 24 hours. Not only did this incident affect travelers in all three states in the metropolitan area, it affected travelers in other parts of the Northeast Corridor. I-287 is an integral part of one of the two main corridors for people and freight through the New York metropolitan area. This incident was caused when a propane truck went out of control and hit a bridge abutment early one weekday morning. The resulting explosion took the life of the driver and caused structural damage to an overpass.

In the case of this incident, the three TRANSCOM member agencies responsible for the operations and maintenance of I-287 (the New York State Thruway Authority, the New York State Police, and the New York State Department of Transportation) had their hands full dealing with the problem on site. They focused on public safety, structural integrity, and on moving traffic on and off the Interstate, in cooperation with local authorities. A number of regional issues had to be dealt with and this is where TRANSCOM assumed a significant role. TRANSCOM took on the regional responsibility to notify dozens of local agencies in three states. Then, traveler information was provided through the combined infrastructure of the cooperating agencies, an impossibility for any one of the individual agencies to provide.

TRANSCOM activities continue to expand. TRANSMIT project looks at the integrated application of electronic toll collection (ETC) equipment for both automated toll collection and incident detection through the use of tag-equipped vehicles as traffic monitoring vehicles. The Service Area Travelers Interactive Network (SATIN) is a partnership to provide kiosks at major highway service areas and transit facilities to provide the traveling public information about traffic conditions and delays, transit schedules and delays, services available, and emergency information. The Alternate Bus Routing System (ABRS) is a public/private partnership project to use ETC technology to provide bus drivers with an audible message concerning the best route from the Garden State Parkway to the New Jersey Turnpike (*34*).

The region has also become part of the I-95 Corridor Coalition (*35*), a partnership of the major public and private transportation agencies serving the Northeast Corridor of the United States from Maine to Virginia. Built on a foundation of cooperation and coordination, the Coalition serves as a unifying force for members to use technology to provide seamless transportation services in the corridor. The Coalition seeks to establish an economically beneficial, multimodal framework for early implementation of appropriate ITS technology.

The mission reflects the Coalition's underlying purpose to improve mobility, safety, environmental quality, and efficiency of interregional travel in the Northeast. Through cooperative efforts to implement real-time communication and operational management of the transportation system, members hope to link transportation providers and users beyond their usual political and geographical boundaries. In doing so, the Coalition seeks to establish an economically beneficial, multimodal framework for early implementation of appropriate ITS technology. Accomplishments of the Coalition include an Information Exchange Network, Commercial Vehicle Operations (CVO) Program, Electronic Toll and Traffic Management (ETTM), and being a ready source of traveler information.

The Information Exchange Network (IEN) allows any member to communicate quickly and efficiently with other Coalition members during emergencies and to coordinate transportation management and traveler information on a regional and corridorwide basis. The IEN provides the points of entry and access to transportation agency data bases throughout the Corridor, and also functions as the communications backbone for exchanging this interagency information. Installed first in highway operations centers, it is being expanded to metropolitan transit operations.

The Coalition has developed a CVO program for the Corridor that enhances the productivity of the goods-movement industry. The program improves safety and enforcement through automated credentialing processes, and information-sharing partnerships. For example, the Coalition is implementing a system that will provide commercial vehicle dispatchers and drivers with information on congestion, incidents, weather, and routing that is necessary to meet the demands of shippers and receivers in the Corridor for timely and reliable delivery of goods and services.

All members of the Coalition have adopted an ETTM vision and strategy to achieve compatibility in the Northeast Corridor. Once this compatibility is achieved, users will need only one tag per vehicle, one account per customer, and one set of credentials per commercial vehicle to permit seamless travel through toll facilities.

The Coalition provides travelers with information in a variety of ways. A Northeast Travelers Alert map, which identifies major construction activities, upcoming events, and typical holiday weekend bottlenecks, is updated twice each year and is made available at Welcome Centers and rest areas along the major interstates in the corridor, at some truck stops, and regional American Automobile Association (AAA) offices. This map is also available on the Coalition's World Wide Web home page. The home page includes information on the Coalition and its member agencies and was developed to facilitate the distribution of Coalition products and services between member agencies and the traveling public. Information shared by other agencies about impacts on regional travel is provided to travelers by the Coalition's member agencies through the use of variable message signs, highway advisory radio, and traffic reports.

LOS ANGELES

Los Angeles was also involved in freeway traffic management in the 1960s and 1970s. By the early 1970s, it was one of the first areas in the country to implement HOV facilities. This began as bypass lanes for carpools with two or more occupants at metered entrance ramps. Although these projects represented a move away from a focus on single-occupancy vehicles, they still represented an approach by a single agency, Caltrans.

Several line-haul concepts for bus only use on reserved freeway lanes were studied in the early 1970s. These included a contraflow bus lane on the Hollywood Freeway, concurrent flow HOV lanes in the medians of the San Diego, Long Beach, and Artesia Freeways, concurrent flow lanes by taking away a lane on the Santa Monica Freeway, and a barrier and buffer-separated HOV facility on the San Bernadino Freeway.

The first joint project involved the Southern California Rapid Transit District (SCRTD) and Caltrans to implement the San Bernadino Busway in 1970. Caltrans and SCRTD shared project sponsorship, which involved Federal Transit Administration and Federal Highway Administration funding. As one of the outcomes of a bus strike in 1975, the facility was opened to carpools.

In 1974, as a result of the 1970 Clean Air Act, Caltrans responded with a proposal for a widespread implementation of HOV lanes. The previously proposed demonstrations became the backbone of a regional HOV program. Due to Clean Air Act deadlines, the next project to be implemented was the Santa Monica diamond lanes in 1974.

The Santa Monica diamond lanes only required the restriping and signing of an existing freeway lane for carpools of three or more persons. This project removed 25 percent of the general purpose capacity and caused significant traffic congestion on the remaining lanes. Perceptions of HOV lane underutilization, reaction to increased local traffic, public outcry, and negative media coverage resulted. Despite technical success in moving more people, the project was halted under court order after 21 weeks. The results of the Santa Monica diamond lane project appear to have had a major impact in stalling the development of HOV projects throughout California well into the 1980s.

Although the Santa Monica diamond lane project was a setback, it ultimately lead to a different approach to HOV. The Route 91 (Artesia Freeway) HOV demonstration was proposed as an added capacity project for carpools only. The Deputy Director of Traffic Operations for Caltrans District 7 became the project "crusader" who was willing to take the project to local representatives to "buy into" the concept. The success of this project set the stage for several hundred miles of other HOV projects in the region.

The 1984 Olympics, held in Los Angeles, gave dramatic proof that management of the surface transportation system can work. The feared gridlock never occurred because of the coordinated planning and management by a host of agencies: traffic, transportation planning, police, public transportation, and the Olympic Committee. The approach merged plans for each segment of the system—freeways, streets, buses, parking, etc.—into an overall approach for the games, which was then implemented by the appropriate agencies (*36*). The Olympics effort appears to have resulted in other collaborative activities, as will be discussed later in this section.

One key aspect of the City of Los Angeles' Olympics Transportation Plan was the Automated Traffic Surveillance and Control (ATSAC) System. The benefits of this system lead the City of Los Angeles to expand the system over a period of about 10 years to include 11 areas and 1170 traffic signals. The most recent expansion of the system includes the Smart Corridor (*37*).

In response to increasing congestion and improved technologies, various agencies jointly initiated the Smart Corridor Demonstration Project to implement "smart" technologies within the Santa Monica Freeway corridor, one of the most heavily traveled and congested in Los Angeles and the world. This project built on the various programs of the individual agencies and the success with the 1984 Olympics (*38*).

The primary agencies involved in the Smart Corridor cooperative effort are: the City of Los Angeles Department of Transportation; the California Department of Transportation (Caltrans); the California Highway Patrol (CHP); and the Los Angeles County Transportation Commission. Other agencies and organizations involved in the project include: The City of Los Angeles Police Department; the City of Los Angeles Bureau of Street Lighting; the City of Culver City; the Southern California Rapid Transit District; the Southern California Association of Governments; the Automobile Club of Southern California; and FHWA (*33*).

The Smart Corridor Demonstration is investigating the physical, operational, institutional, and political feasibility and potential effectiveness of managing the individual facilities within the corridor at maximum efficiency, balancing traffic flow between alternative routes, and dissemination of traveler information using advanced technologies to achieve the operational goals. Methods to achieve maximum efficiency include computer control of traffic signals and ramp meters, incident detection and confirmation on the freeway and arterials, coordinated incident response, and coordinated enforcement and accident investigation measures (*33*). Implementation of the Smart Corridor operations by the City of Los Angeles, Caltrans, and the CHP has necessitated the development of a detailed operations policy statement (*39*). Likewise, a cooperative agreement has been drafted (*40*) for the operation of Smart Corridor traffic signals in Culver City by the City of Los Angeles, subject to agreed upon strategies and the ability of the City of Culver City to have monitoring capability. These various agreements demonstrate that it is possible to overcome various institutional considerations in a complex operating environment.

Success in the Smart Corridor is partly dependent on flexibility among and within agencies, and in some cases, contractors. That is to say, it is often difficult to anticipate all the issues or problems that may be encountered when a project is undertaken. If the parties pursue a project based on strict contractual terms, it may be difficult to obtain the desired result. The process is one of confidence building among the various partners. Regular communication among working staff is also an important ingredient in success.

A unique congestion pricing project in the Los Angeles area is the State Route 91 Variable-Toll Express Lanes, the first fully automated toll road in the world. It opened for revenue service on December 27, 1995. The four-lane toll facility is located in the median of the existing eight-lane Riverside Freeway in Orange County, California, between the City of Anaheim and the Riverside County line. Unlike variable-toll roads in Singapore, Scandinavia, France, and elsewhere, the SR91 project is a single highway section serving an urban commute corridor, where a free, although congested, alternative route is readily available (*41*).

The privately built and operated facility charges tolls that vary with the time of day, reflecting the travel time saved by toll lane customers compared with users of the adjacent public freeway. The longer the traffic delays on the adjacent freeway lanes, the higher the toll. Currently tolls follow a published schedule, although the technology would permit the toll levels to vary dynamically.

All tolls are collected by automatic vehicle identification (AVI), in part because there is not enough space in the freeway median for conventional toll booths. Vehicles not equipped with AVI are prohibited from the facility. The system on State Route 91 is interoperable with lanes on the other publicly operated toll roads in Orange County, where conventional toll booths are also provided.

Rideshare groups with three or more persons (HOV-3+) currently travel toll-free, although they may be charged a discounted toll sometime in the future. A special lane is provided for HOV-3+ vehicles to bypass the electronic toll-taking, which occurs about halfway along the length of the facility. Proper use of the automated toll lanes is enforced by the CHP, under contract to the California Private Transportation Company (CPT), and through the use of video surveillance equipment.

The CPT operates the toll lanes on land leased from the state of California. The CPT has 35 years to return a profit to its investors, after which time the toll lanes revert to full state control.

SAN FRANCISCO BAY AREA

The San Francisco Bay Area has developed a Metropolitan Transportation System (MTS). The MTS is the Bay Area's multimodal network of highways, major arterials, transit services, rail lines, seaports, airports, and transfer hubs critical to the region's movement of people and goods (*Internal memos and personal communication, MTC staff*).

ISTEA put considerable emphasis on managing the system. At the urging of the Metropolitan Transportation Commission (MTC), the various agencies involved in regional transportation planning began the task of developing a management strategy for the MTS. A consensus evolved that the MTS needed to be managed as though it were one system, irrespective of mode or ownership. Beyond that, however, there remained varying opinions about what a management strategy should encompass and its relationship to other regional planning and decision-making activities.

The conceptual model developed by MTC is a series of three concentric circles, the management strategies in the center, surrounded by the regional transportation plan, which is surrounded by the broad community goals. Depending on the strategy, it may or may not require trade-offs between these various levels. For example, Freeway Service Patrols are generally acceptable and noncontroversial. On the other hand, adding capacity, changes in pricing, or changes in land use involve broader community goals. The dilemma is how far up the continuum does the management strategy go before it must be reconciled with other objectives and how does this reconciliation take place?

The management strategy first seeks to identify effective tools that tend to be at the center or neutral end of the planning and community goals spectrum. Promising strategies that tend to threaten other objectives must be reconciled in the larger context of the Regional Transportation Plan or even in the context of broad community goals.

Effective management strategies will require tradeoffs between jurisdictions and modes. This requires the building of partnerships. For example, one management strategy is management of traffic signals. One signal, on its merits, is relatively benign. When several are strung together across jurisdictional boundaries and involve state highways and local roads, then the potential for conflict climbs higher on the scale. Another example is the Caltrans Freeway Operations System (FOS). It is viewed as potentially giving priority to freeways, dumping traffic on local streets, and taking money that could go to local projects. To be successful, the FOS must be defined in a way that benefits all parties. Therefore, an important objective of the management strategy is to put forward agreed upon ground rules that will enable partners to resolve potential conflicts as strategies are put forth.

Capital projects lie in the center of the continuum and for the most part are reconciled in the Regional Transportation Plan process. However, if the interaction between management strategies and capital improvement strategies is not considered, poor management strategies and poor capital decisions will result.

The process to date in the Bay Area has lead to a goal to demonstrate that an interagency management strategy can be effective in improving regional mobility. The strategy

- Focuses on the MTS,
- Provides a system context for interagency decisions,
- Provides a multimodal context for management decisions by unimodal operators,
- Builds on the management initiatives that are underway,
- Provides a regionwide commitment to develop and implement ISTEA's six management systems, integrated to the extent feasible as the elements of the management strategy, and
- Is seen as a continuing, vital endeavor essential to support the region's transportation investment.

To foster interagency cooperation, a Bay Area Partnership was formed. The Bay Area Partnership Board (*42*) consists of the top managers from 31 agencies responsible for moving people and goods in the San Francisco Bay Area, as well as agencies responsible for protecting the region's environmental quality. These experienced professionals have come together to improve regional mobility by sharing ideas, working on issues of mutual concern, and cutting through the process that blocks innovative solutions to the twin problems of traffic congestion and smog. A key issue is commitment to enhancing the Bay Area's economic vitality, preserving the features that make the region a special place to live and work, and conserving resources. From the outset, The Partnership was developed as a nonhierarchical institution without walls, thriving on mutual interest and cooperation.

The Bay Area's numerous natural barriers and rich mix of urban, suburban and rural settings and subeconomies have resulted in a multiplicity of transportation system owners, operators and regulators. This institutional framework is responsive to varying local needs, but also requires coordination where their systems intersect or overlap.

The complex Bay Area environment depends on connections that are as much financial, institutional, and informational as they are physical for integration of individual components into the larger picture of a system. The Bay Area Partnership is a forum for communication, much of it face-to-face. The dialogue occurs at many levels, including bimonthly meetings of the full board and a smaller steering committee, and at numerous subcommittee and task force meetings that occur in between. The chairmanship and location of the regular meetings of the full board are passed from agency to agency to further foster the relationships.

While joining the partnership initially required a leap of faith, over time, the Partners have found good reasons to commit their time to these multiple-agency sessions. They develop a mutual understanding of the budgets that must be shared, and how best to invest in improving overall system performance, even when some of their own favored projects had to be deferred. A guiding principle is that decisions jointly made will more readily lead to action and a commitment to overcoming obstacles. With maturity, The Bay Area Partnership has developed a common vision of a single transportation system, supported by pooled resources.

The Bay Area Partnership has spotlighted a select group of interagency projects for some special attention. The program is known as JUMP Start, which stands for the Joint Urban Mobility Program. JUMP Start is designed to expedite delivery of relatively short-term, low-cost, projects with high-payoff projects. The projects focus on smoothing traffic flows, making public transit and carpooling more attractive, enhancing system safety, reducing polluting emissions, and streamlining the planning process.

JUMP Start projects require the joint efforts of two or more agencies or involve multiple modes. In fact, where it can take a decade for a transportation project to leap the various financial and bureaucratic hurdles, JUMP Start addresses institutional issues that previously would stall promising concepts. The time elapsed between project conception and delivery of benefits has been reduced to weeks and months.

The following are a few examples of the early successes. With the help of a federal grant, MTC, Caltrans, and the region's public transit operators set up a clearinghouse—known as TravInfo—to provide travelers with real-time data on traffic conditions, parking availability, and public transit, and carpooling options. The Bay Area's high-tech private sector also has been an important player in the development process.

MTC also teamed up with the region's public transit operators to test the concept of a Bay Area-wide "superpass" among three interconnecting systems: BART, County Connection buses in Contra Costa County, and BART Express buses. The Partners are exploring adaptation of the TransLink universal ticket to other rail, bus, and ferry systems in the Bay Area based on the lesson learned.

To benefit from the flexible federal funding flowing to the Bay Area from ISTEA in 1992, a partnership task force spent countless hours developing an equitable process for screening and ranking projects. By the fall of 1994, MTC had used this pioneering "multimodal priority-setting process" to allocate more than a half-billion ISTEA dollars to some 500 projects.

In March of 1995, the Bay Area Partnership formally adopted their strategy for managing the Metropolitan Transportation System (*43*). The strategy has two defining elements: 1) a set of five core principles, and 2) a commitment to cooperative planning at the corridor level. The core principles outline a multimodal approach to system management that gives appropriate emphasis to people movement during commute hours and correspondingly appropriate emphasis to traffic flow during off-peak hours. The emphasis on corridor planning ensures that the management strategy can be tailored to fit local conditions. It also ensures local governments a real opportunity to participate in the process of system management.

The five core principles that define the Partnership's strategy can be summarized as follows:

- Streets, highways, and transit services should be planned, operated, and priced as if they were integral parts of a single system;
- Transportation and land use should be better coordinated to enhance accessibility while reducing the need for travel;
- The transportation system should be designed to provide convenient access to jobs and services, to move goods efficiently and reliably, to facilitate the interregional movement of people and goods, and to shelter the region's communities and its natural environment from traffic overload;
- Despite limited resources, the region can effectively resolve the conflict between these goals if it adopts a system management strategy that is tailored by corridor and time of day; and
- Operational improvement alone will not be sufficient to maintain mobility. Continuing investment—coupled with innovations in pricing and technology—will be required to meet the needs of a growing population and economy. Thus, it is essential to coordinate the planning for management and investment.

MINNEAPOLIS/ST. PAUL, MINNESOTA

Traffic management efforts in the Twin Cities Metro Area started in 1970 with the implementation of isolated ramp metering on a 6-mile section of I-35E. The system has since expanded to include an extensive system of ramp meters, closed circuit television cameras, and changeable message signs. The goal of Mn/DOT's strategic plan for freeway traffic management is optimizing traffic flow, including the following specific objectives:

- Minimizing the magnitude and duration of congestion,
- Reducing the accident rate,
- Minimizing the impact of accidents,
- Providing support for special events, construction, and maintenance activities, and
- Promoting HOV facilities, a voluntary truck management program, and other demand management activities.

In 1990, the development of Mn/DOT's ITS program, called Guidestar, further expanded traffic management activities (*44*).

Minnesota Guidestar is a statewide intelligent transportation system program and is dedicated to the goal of better transportation. Minnesota Guidestar's mission is to transform the current transportation system into one with increased accessibility, greater productivity, enhanced safety, reduced environmental impacts, and broader private sector investments. This transformation will be accomplished by incorporating existing and developing technologies into the Minnesota transportation system. This will be accomplished through government, private sector, and academia working together in modified organizational relationships, processes and approaches (*45*).

One example of the Minnesota Guidestar program is St. Paul Advanced Parking Information System operational test (*46*). The focus of the project is to demonstrate a real-time, event-based, downtown parking information system for the first time in the United States. The goals of the project included having a positive impact on the surface transportation system in downtown St. Paul. This innovative project demonstrates the potential benefits of managing the surface transportation system.

Minnesota Guidestar is seeking to develop a truly statewide intelligent transportation system. Mn/DOT and its partners have realized the importance of a management framework. An organizational structure has been developed that provides each participant in the program access to management decisions. Public and private sector partners are encouraged to be proactive in such decisions. The result is that Minnesota is building multimodal solutions, creating a consensus throughout public agencies in the state, developing systems for urban and rural needs, fostering partnerships, and utilizing existing transportation strengths in Minnesota (*47*).

Minnesota's vision is that its citizens, businesses, and visitors will benefit from the application of ITS to the state's transportation system. ITS will be fully integrated into transportation strategies for the enhancement of safety, mobility, and economic vitality, for the protection of the natural environment, and for the development of sustainable communities. The following goals have been established to achieve the vision:

- Statewide Approach—Implement an ongoing, integrated and responsive statewide program for ITS research, testing, and deployment.
- Safety/Security—Improve the safety and security of the users of the transportation system.
- Mobility/Convenience/Comfort—Enhance personal mobility and accessibility to services; enhance the convenience and comfort of all (including unfamiliar) users of the transportation system.
- Efficiency—Increase operational efficiency and productivity of the transportation system.
- Economic Vitality/Productivity—Enhance productivity of individuals, businesses and organizations.
- Sustainability—Provide transportation services that support sustainable communities including improved accessibility, environmental protection, and local planning.

Based on the vision and the goals, Minnesota's transportation system will achieve a new level of safety and effectiveness:

- In-vehicle technology will automatically and instantaneously communicate the location of a vehicle involved in a crash, as well as the severity, for rapid emergency response. When motorists are lost, in-vehicle navigation systems will guide them back on course. When roads are icy, fog is heavy, or road conditions are otherwise dangerous, travelers will be notified prior to their trip and advised while they travel.
- Collision-avoidance sensors in their vehicles will warn travelers when they are too close to other vehicles or objects. Vision enhancement systems in vehicles will allow travelers to see better at night and in poor weather. New detection and warning systems at railroad grade crossings will help prevent crashes between trains and vehicles, including school buses. Electronic message signs in advance of construction work zones will advise of actual speeds or accidents in the work zone. Other technologies will detect motorists who drive dangerously and violate motor vehicle laws.
- Travelers will receive real-time traffic and road condition information in their vehicles on electronic displays, advanced radios and cellular phones. Interactive television, pagers, fax machines, telephones, electronic kiosks, personal computers, personal digital assistants and other devices will be used to obtain this information elsewhere. The information will be available in customized form for individual travelers. Comprehensive information on tourist attractions, food and lodging, and on a wide variety of other services and facilities will also be easily accessible.
- Advanced technologies installed on all major roadways will speed the detection of traffic accidents and incidents. Integrated communications systems (exchanging voice, data, and video) will assist transportation and emergency response organizations. Travelers, especially the injured, will receive help more quickly and in a coordinated fashion. Traffic delays will be shortened.
- A statewide network of transportation management centers will facilitate travel across Minnesota. Real-time information and shared facilities will ease transfers between modes (highway, bus, rail, and air). Detectors installed above, adjacent to, and on all major roadways will monitor road surface conditions, traffic levels, and vehicle type and weight. The data generated will benefit travelers, shippers, transportation engineers and planners, and enforcement agencies.
- State-of-the-art traffic signal systems will smooth traffic flow by responding and adapting to current conditions, including incidents, poor weather, and special events. To further speed travel, signal systems will be coordinated between arterial roads, freeways, and ramp meters.
- Travelers will be presented with information and options that help reduce reliance on the single-occupant automobile. Real-time ridesharing and door-to-door transit service will be feasible through computerized call-taking, ride matching, and dispatching systems. Telework centers, home telecommuting, and teleconferencing will be commonplace. The quality of transit and paratransit services will be enhanced through automated scheduling and fleet management systems, including automatic vehicle location.
- Commercial vehicle operations will be enhanced through consolidated weighing, inspection and credentialing systems. The systems will be coordinated within Minnesota and integrated with other states. Electronic payment technologies, such as smart cards, will eliminate the need for cash at parking meters and on buses.
- Agencies operating fleets, including public safety, transit and maintenance, will consolidate dispatch centers in their geographic areas, thereby reducing the costs of new infrastructure. Information will be shared with local agencies and directly with users of the transportation system.
- Partnerships with public, private, non-profit and academic organizations will result in increased coordination, greater funding levels, and flexibility for transportation infrastructure and services. Private firms will profit from the provision of products and services and will provide much of the

capital needed for deployment of ITS in return for user fees. Businesses in Minnesota will benefit from improved access by customers, through reduced shipping costs, and easier commutes for employees. Finally, Minnesota will be integrated with the national and international ITS network to allow seamless travel anywhere and at anytime, safely and efficiently.

CHAPTER FOUR

CONCLUSIONS

The Intermodal Transportation Efficiency Act of 1991 is the most recent effort by policy makers to articulate a user perspective on management of the surface transportation system. The goal is improved mobility and accessibility for surface transportation system users through improved management of the system. The principles on which to develop a holistic view of the system, with some notable exceptions, largely exist and are relatively straightforward in concept. However, there are serious practical barriers to achieving a system that operates seamlessly. This synthesis summarizes the problem, the process, the successes to date, and the challenges that must be overcome to achieve the vision of a surface transportation system operating as if under single ownership and management.

The surface transportation system is fragmented due to multiple jurisdictions (federal, state, and local), functions (police, fire, traffic, etc.), modes (highway, bus, rail, bike, and pedestrian), and even disciplines within a single organization (planning, design, operations), being responsible for only a portion of the system. The streets, highways, mass transit facilities, railroads, trucking companies, port terminals, airport terminals, and trucking terminal facilities are operated by separate managements. Managerial independence is a jealously guarded prerogative. Each organizational unit has its own mission, funding, and support group. Furthermore, there is little agreement on measures of effectiveness and efficiency that reflect consumer needs or overall social and environmental cost. This institutional complexity results in a system that is difficult to manage in a practical sense.

Effective management of the surface transportation system, therefore, requires a process for resource allocation, investment decisions, and other actions in order to maximize the performance of the system. The process should include monitoring, performance evaluation, identification of improvement strategies, evaluation of strategies, prioritization, programming/funding, implementation of appropriate actions, operations, and maintenance of the surface transportation system. A formal process is needed to address the fragmented nature of the existing institutional structure of transportation service providers.

However, it is also necessary to recognize that demands on the transportation system are a by-product of local land-use decisions and location choices made by households and firms. Transportation providers have virtually no influence over these choices, nor efficient and effective ways to steer growth and development. Therefore, there are likely to always be events beyond the control of managers of the transportation system.

Experience to date would suggest that effective management of the surface transportation system is still in its early stages of development. Although many tools exist to assist in the process of managing the surface transportation system, there are weaknesses. Key needs include better institutional collaboration, better measures of system effectiveness, better evaluation methodologies, and better system monitoring.

Progress toward effective management of the transportation system has generally evolved by building on the success of previous projects. Management of the surface transportation system will continue to evolve as a natural progression from a construction-oriented paradigm to a management focus as the transportation system matures. The speed of evolution, however, will be partly determined by institutional considerations. Additional incentives may be required to expedite the evolution to a truly integrated transportation system.

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