IMPLEMENTING A
CONGESTION MANAGEMENT SYSTEM

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Research Report 551-1F
Research Study Number 9-551
Research Study Title: Congestion Management Systems
Process Overview

Sponsored by the
Texas Department of Transportation
In Cooperation with
U. S. Department of Transportation
Federal Highway Administration

January 1995

TEXAS TRANSPORTATION INSTITUTE
The Texas A&M University System
College Station, Texas 77843-3135
IMPLEMENTATION STATEMENT

The materials represented by this report (including visual aids), were used to conduct four one-day short courses for staff of Metropolitan Planning Organizations and district staff of the Texas Department of Transportation. TTI personnel conducted these short courses in Austin, Texas during the months of February and March 1994. The final short course presentation was video-taped for use by interested individuals and agencies.
DISCLAIMER

The contents of this report reflect the views of the authors who are responsible for the facts and the accuracy of the information presented. The contents do not necessarily reflect the official views or policies of the U.S. Department of Transportation or the Texas Department of Transportation. This report does not reflect a standard, specification, or requisition.
ACKNOWLEDGEMENT

The project was funded by the Federal Highway Administration, United States Department of Transportation and administered through the Texas Department of Transportation.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Session</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUMMARY</td>
<td></td>
<td>ix</td>
</tr>
<tr>
<td>SESSION 1</td>
<td>Status of Congestion and the CMS Requirements</td>
<td>1-1</td>
</tr>
<tr>
<td>SESSION 2</td>
<td>Developing, Implementing and Administering a CMS</td>
<td>2-1</td>
</tr>
<tr>
<td>SESSION 3</td>
<td>Measuring Congestion</td>
<td>3-1</td>
</tr>
<tr>
<td>SESSION 4</td>
<td>Defining Congestion</td>
<td>4-1</td>
</tr>
<tr>
<td>SESSION 5</td>
<td>Defining the CMS Network</td>
<td>5-1</td>
</tr>
<tr>
<td>SESSION 6</td>
<td>Monitoring Congestion</td>
<td>6-1</td>
</tr>
<tr>
<td>SESSION 7</td>
<td>CMS Strategies</td>
<td>7-1</td>
</tr>
<tr>
<td>SESSION 8</td>
<td>Getting on with the CMS Task</td>
<td>8-1</td>
</tr>
<tr>
<td>APPENDIX</td>
<td></td>
<td>A-1</td>
</tr>
<tr>
<td></td>
<td>Congestion Management System Brochure</td>
<td></td>
</tr>
</tbody>
</table>
SUMMARY

Congestion on our transportation system has become a critical concern at all levels of public and private travel activities. That concern has manifested itself in congressional requirements as prescribed in the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). This act requires the development of a Congestion Management System (CMS) to identify, quantify, address, and monitor congestion at the state and local government levels.

The Federal Highway Administration (FHWA) is expected to play a significant role in the nationwide development and promotion of CMS as defined in the new legislation. To most effectively fulfill this role, the FHWA needs to provide the technology and the guidance to ensure that congestion management systems are designed, implemented and administered effectively. Major efforts are underway to advance the technology and to provide formal training courses. In most cases, these products were not available until after the interim regulations were issued. In the interim, there was a need to relate what is expected of the various jurisdictions and how those expectations could be met. This required the development of an overview document which explains in detail the components and basic requirements of the regulations.

The objectives of this study were to develop an overview of Congestion Management Systems based on the regulations in ISTEA and a review of the state-of-the-art practice, and to prepare a handbook and a one-day training session which presents the results of the overview. The Texas Transportation Institute conducted a study in which concentrated efforts were made to determine and document the state-of-the practice in congestion management. That study is documented in Congestion Management System State-of-the-Practice Review.

As a part of this study, four training sessions were held in Austin to help responsible agency and jurisdictional representatives to prepare for their congestion management responsibilities. One course each was held for representatives of large-area Metropolitan Planning Organizations (MPOs) in environmental air quality attainment areas, and non-attainment areas; and for state and local representatives in small-area MPOs in attainment and non-attainment areas. The fourth presentation was videotaped so that it could be made available to all interested agencies as an individual or group training activity.

The principal body of this report is a training document that has been prepared to serve primarily as an instructor's or trainer's guide in conducting the training course. However, it may be useful as a supporting document to be used by the trainee using the videotape.

A 24-page brochure, in a 4" x 9" format, was developed as a part of this study. A copy is attached as Appendix A. This brochure presents a concise, effective summary of CMS requirements, and should be widely distributed within all MPOs and state and local agencies with any responsibility in planning, design, operation, or management of transportation systems.
SESSION LENGTH: Approximately 70 Minutes

REFERENCES:

This session correlates to Chapter 1 of Report FHWA/TX-92/563-18, *Congestion Management Systems State-of-the-Practice Review*.


This session will also review the CMS requirements of the Intermodal Surface Transportation Efficiency Act (ISTEA) and explain the importance of implementing CMS programs throughout the United States.
SESSION OBJECTIVES
Upon Completion of this session, participants should:

1. Understand the current status of congestion in the United States and the need for congestion management systems
2. Be familiar with the basic policies, regulations, and requirements of the ISTEA.
3. Understand the difference between policies for TMAs (Transportation Management Areas) and Non-TMAs.
4. Be able to identify the principal consequences of an air quality non-attainment designation.

SESSION OUTLINE
1. The current status of congestion.
2. The need for a CMS in all areas.
3. The policies, requirements and regulations of the ISTEA.
4. The effect of a TMA designation.
5. The effect of an air quality non-attainment designation.
STATUS OF CONGESTION

Measures of congestion:

- Vehicle-hours of delay, wasted fuel, air quality, and user costs.
- Nearly 50% of the nation's urban areas have experienced a 17 to 23% increase in congestion since 1982.
- If not curtailed, congestion is expected to triple by 2005.

In the 1980's there was a rapid increase in user costs associated with congestion. These costs are expected to triple by the year 2005. Nearly half of the nation's urban areas experienced an increase in congestion of 17% to 23% since 1982.

COSTS OF CONGESTION

- Cost of congestion: $43.2 billion in 1990.

Congestion is worse in the larger metropolitan areas, but, as shown in Figure 1-1, congestion levels are increasing at the same rate in every metropolitan area. This fact emphasizes the need for an effective congestion management system in all metropolitan areas, regardless of population size. Note that the trend in the roadway congestion index for all urban areas is increasing over time. The rate of increase is higher in larger metropolitan areas.
CAUSES OF CONGESTION

FREEWAYS

- Demand exceeding capacity.
- Poor lane balance.
- Interchange spacing too short.
- Acceleration and deceleration lanes too short.
- Lack of incident management plan.

Urban freeway congestion is a result of the following root causes: demand exceeding capacity; improper lane balance that increases turbulence and therefore congestion in the interchange area; short interchange spacing, resulting in short weaving sections leading to traffic friction, reduced capacity and traffic accidents.
Spacing interchanges 3 kilometers (2 miles) or longer reduces the number of short trips on the freeway. Longer interchange spacing also provides the distance needed for acceleration and deceleration lanes that allow for smoother entry and exit from the freeway main lanes. Ramp metering has been effective in addressing freeway congestion. It increases traffic flow, reduces fuel consumption and carbon monoxide emissions, and results in improved traffic safety. Accidents and other incidents contribute 60% or more of the delay due to recurring and nonrecurring congestion. As a rule of thumb, 10 minutes are required to re-establish normal traffic flow for each minute of freeway blockage. Thus, substantial congestion will occur unless there is an effective incident management program in an urban area.

### CAUSES OF CONGESTION

**ARTERIAL STREETS**

- Demand exceeding capacity.
- Inadequate spacing of signalized intersections.
- Lack of median access control.
- Inadequate deceleration lanes.
- Poor traffic signal coordination.
- Poor traffic signal timing/phasing.

Demand in excess of capacity is a major cause of congestion on arterial streets as well as freeways. This condition results when the density and pattern of land-use activities produce more trips than can be served by the street and freeway system.

Close and irregularly spaced traffic signals result in poor traffic progression, which in turn causes congestion, as measured by excess travel time, excess delay, and queuing.
Failure to control median and marginal access produces conflicts between through traffic and turning vehicles. Traffic friction resulting from these conflicts reduces capacity and causes congestion.

When deceleration lanes are too short, or are not provided at all, turning vehicles cause very high speed differentials and seriously interfere with through traffic. The absence of left-turn lanes especially contributes to congestion, since a vehicle waiting to make a left turn will block the through traffic in the lane.

Poor traffic signal coordination results in inefficient traffic flow and unnecessary traffic delay. Poor traffic signal timing also produces unnecessary delay. Poor signal timing and coordination, may result from poor planning and design, but also may be due to a lack of qualified signal operation personnel.

CAUSES OF CONGESTION

SOCIAL/ECONOMIC

- Low vehicle occupancy.
- Many trips focused in a narrow time frame.
- Land use patterns.
- Land use is incompatible with the transportation system.

Work trip patterns typically result in high traffic demand and congestion during each weekday morning and evening. Average vehicle occupancy is about 1.1 persons per vehicle during these weekday peaks. Public officials commonly make land use and zoning decisions without adequate consideration of the effect of the resulting trips on the urban street and freeway systems.
California's recent congestion legislation and Washington state's growth management legislation are examples specifically addressing the land use issue.

<table>
<thead>
<tr>
<th>1991 ISTEA</th>
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<tr>
<td>The Intermodal Surface Transportation Efficiency Act of 1991 or ISTEA (pronounced &quot;Ice Tea&quot;) is a six year, $151 billion approach to an innovative, flexible, and balanced transportation program.</td>
</tr>
</tbody>
</table>

The Intermodal Surface Transportation Efficiency Act of 1991 provides greater flexibility in meeting local needs and at the same time focuses greater attention on the environment. It is important to understand what ISTEA does and does not do.
ISTEA ENcourages

- Good planning.
- Coordination of land use and transportation decisions.
- Public involvement.
- Flexibility in meeting transportation needs.
- Sensitivity to the environment.
- Objective decision making for all modes of transport.
- Cooperation between state and metropolitan areas.

ISTAea encourages, through its many sections, the goals shown. These are desirable goals for the transport system decision-making process.

ISTAea Does Not

- Require a reduced commitment to existing transport modes.
- Require state and local governments to abandon existing transportation plans.
ISTEA does not mandate a reduced level of commitment to the traditional transportation modes such as highways and streets. The existing plans of state and local governments will still be in effect as the new ISTEA systems come on line to provide better data for decision making.

<table>
<thead>
<tr>
<th>ISTEA'S SIX MANAGEMENT SYSTEMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bridge Management System (BMS)</td>
</tr>
<tr>
<td>Pavement Management System (PMS)</td>
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<tr>
<td>Traffic Congestion Management System (CMS)</td>
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<td>Highway Safety Management System (SMS)</td>
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<tr>
<td>Intermodal Facilities and Systems Management System (IMS)</td>
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<tr>
<td>Public Transportation Management System (PTMS)</td>
</tr>
</tbody>
</table>

ISTEA created CMS, SMS, IMS, and PTMS to complement the two existing systems, Bridge Management System and the Pavement Management System, with the goal of providing a more flexible method of meeting the needs of the people.
The ISTEA definition of congestion leaves the decision of the defining condition up to the local entity. It will be different for each functional class of the facility.

Each state should develop, establish, and implement, on a continuing basis, a CMS that identifies and assesses transportation system congestion and leads to the implementation of strategies that provide the most efficient use of existing and future transportation facilities.
The state highway agency has the ultimate responsibility for the CMS that must cover the entire state. The state can negotiate with non-MPO areas to develop and maintain their own CMS or the state may include those areas in the statewide CMS. Transportation Management Areas (TMA) are urban areas having a population over 200,000. In a TMA, the MPO is responsible for the CMS. The state highway agency can delegate responsibility for the CMS to MPOs that are not TMAs.
### CMS STRUCTURE

- Select Performance Measure
- ID Areas of Congestion
- Recurring and Non-recurring Congestion Areas
- Select Definition of Congestion.

The CMS structure includes several general requirements. Congested areas must be determined based upon previously determined local performance measures.

### CMS STRUCTURE (Continued)

**IDENTIFY STRATEGIES TO ADDRESS CONGESTION.**

- Demand Management
- Operational Improvements
- High Occupancy Vehicles
- Public Transit Capital Improvements
- Public Transit Operational Improvements
- Use of Nontraditional Modes
- Congestion Pricing
- Access Management
- Incident Management

1-18
Strategies to address the congested conditions include a wide range of alternatives. A mix of strategies to best meet local goals and ISTEA requirements should be used to address the congested operating conditions.

CMS STRUCTURE (Continued)

- Implementation of Strategies.
- Evaluation of Effectiveness.

The implementation phase includes assignment of responsibilities, development of a time frame of implementation, and the identification of probable sources of funding to implement the strategy.
### CMS REQUIREMENTS

**SINGLE OCCUPANT VEHICLE**

- Priority to strategies for reducing SOV travel
- Must address future demand management to integrate general purpose lanes
- Non-attainment areas - No improvements that significantly increase SOV capacity unless approved as part of CMS
ISTEA focuses on reducing single occupant vehicle (SOV) travel in the metropolitan area. Give priority to strategies that have the potential for reducing SOV travel in the planning process, including the CMS. TMAs designated as non-attainment areas for carbon monoxide and/or ozone may not program a highway or transit project that significantly increases SOV travel unless that improvement is a part of an approved CMS.
In anticipation of the formal CMS process, many misconceptions of CMS emerged. These misconceptions are the ones that seem to be the most prevalent. CMS is not a new planning process. Rather, it is an integrated land use transportation infrastructure planning approach that allows greater flexibility in meeting the needs of the community.
The compliance schedule under the ISTEA implementation package calls for all states to have begun the process of implementing the CMS by October 1, 1994. States must complete a plan for the implementation of the CMS program by October 1, 1995.

A traffic monitoring system is required of all states and each metropolitan area with a population over 200,000. The data needed to support the decision making process in the six management systems is the goal. These data also fulfill the reporting requirements of the FHWA. The actual data system is dependent on the performance selected at the MPO and state levels. Indeed, no two metropolitan areas may collect the same data. Some data elements will necessarily be common to all programs.
The traffic monitoring system includes these elements as a minimum. The data retention element deserves greater attention.
SESSION 1
CONGESTION MANAGEMENT
STATUS OF CONGESTION AND THE CMS REQUIREMENTS

**SOURCE DATA RETENTION**

<table>
<thead>
<tr>
<th>FOR EACH DATA COLLECTION SESSION:</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐ Collect each data value</td>
</tr>
<tr>
<td>☐ Date data collection</td>
</tr>
<tr>
<td>☐ Note location of count</td>
</tr>
<tr>
<td>☐ Note hours of counting</td>
</tr>
<tr>
<td>☐ Note type/model of machine used</td>
</tr>
<tr>
<td>☐ Date the last successful test of the machine's accuracy</td>
</tr>
<tr>
<td>☐ Note the names of observers, if done manually</td>
</tr>
<tr>
<td>☐ Retain data for at least 10 years</td>
</tr>
<tr>
<td>☐ Format the data to conform to TMS requirements</td>
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</tbody>
</table>

These are the general requirements of the data in TMS. Each data set must denote the machine serial number or name of the human observer.

Also, the accuracy of the data collection equipment must be verified periodically and recorded with each data set.
ISTEA is a new vision of transportation in America. Transportation agencies will need to adapt to this new vision. Likewise, new opportunities are developing because of the added flexibility in meeting people-moving needs of a modern society. One message in ISTEA is very clear: adding new capacity with each new round of development is no longer acceptable. It is not an economically feasible solution to provide transportation services that damage the environment on which all of us depend. The traveling public will also pay a price for this new direction. Within the personal transportation mode it is no longer practical for drivers to go exactly where they wish and when they wish, particularly as a single occupant in a vehicle. Greater restrictions on land access to arterial streets, and higher design standards for arterial streets will infringe upon the desires of the motoring public.

It is up to the transportation professionals and elected officials of this country to bring this vision to reality and achieve the greatness it deserves.
SESSION 2
CONGESTION MANAGEMENT  DEVELOPING, IMPLEMENTING AND ADMINISTERING A CMS

SESSION LENGTH: Approximately 60 Minutes

REFERENCES:

This session correlates to Appendix K of the "Congestion Management Systems State-of-the-Practice Review." The participant should read this chapter for a better understanding of the CMS implementation process and its limitations.

The process of developing, implementing, and administering the CMS program must allow the maximum opportunity for the CMS initiative to be successful at the local government level. This session reviews the experience nationally with the goal of learning from the experience of others, thus more efficiently implementing workable CMS elements into an area wide CMS program. The CMS programs implemented by metropolitan counties in California in response to state legislation provides valuable experience and guidance in developing an effective CMS.

The Intermodal Surface Transportation Efficiency Act (ISTEA) requires a proactive public involvement process. Additional staff expertise needs to be developed in state highway agencies and MPOs in order to accomplish this requirement effectively. However, many of the principles and techniques for obtaining such involvement are well established, if not widely known. Further, the experience in developing urban comprehensive plans indicates that effective public involvement requires substantial staff resources.
SESSION OBJECTIVES

Upon completion of this session, participants should be able to

1. Build upon the experience of early CMS programs.
2. Appreciate the staffing issues in implementing the CMS.
3. Understand the multi-jurisdictional cooperation required in a CMS.
4. Appreciate the handling of multi-jurisdictional problems.
5. Discuss the methods of handling areas under development as well as those already developed.
6. Evaluate the strengths and weaknesses of the California CMS.

In order for the participant to successfully meet the objective listed above, this session will address the following topics.
<table>
<thead>
<tr>
<th>SESSION TOPICS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The lessons to be learned from the California CMS.</td>
</tr>
<tr>
<td>2. The interaction of air quality guidelines with other community goals.</td>
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<td>3. The use of growth management strategies to reduce congestion.</td>
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<td>4. The relationship of state and MPOs in implementing CMS.</td>
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<tr>
<td>5. The integration of CMS with the planning process.</td>
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<td>6. The keys to rule making for successful CMS implementation.</td>
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</table>
CALIFORNIA CMS SHORTCOMINGS

- Requires that LOS be used.
- Requires annual monitoring for a biannual plan update.
- No definition of primary arterial given.
- Exclusions are permitted.

Specific shortcomings of the California CMS law were identified in interview conducted in that state. Each of these shortcomings has had a negative impact on the successful implementation of CMS by local governments.

MERITS OF THE CALIFORNIA CMS

- Ties land use development approval to CMS.
- Specified target AVO values at work site.
- Provides financial incentive for implementation by local government.

Presented above are the good elements of California's CMS implementation. By "good" the reference is to the concept, and not necessarily the method used to implement the concept. For example, the Average Vehicle Occupancy (AVO) requirements expressed as percentage values, place a heavy burden on suburban business -- a requirement that they can not meet. The fraction of ride sharing at 1.5 or 1.7 is excessively high.
**THE STAFFING ISSUES**

- High level of technical skills required.
- Personnel turnover is likely to be high.
- Higher salaries may be needed to attract and retain qualified personnel.

MPOs and local governments should expect special staffing and funding problems with the implementation of CMS.
The conflict between air quality agency personnel and all other agency personnel was a common topic in the site interviews. The complaint was that air quality personnel tended to focus on specific strategies that had limited impact on air quality while ignoring other strategies that had much higher air pollution reduction potential. Further, they were reported to be close-minded about all air quality matters, frequently changed their rules, and were unresponsive to the needs of local governments. While this issue may be unique to California, it is a common problem when a group is given a charge with no constraints.

The issue of how air quality decisions are to be integrated into the CMS programs must be addressed by the state implementation of the ISTEA requirements. The best practice found to date is to have the air quality agency as a full member of the MPOs' CMS steering committee, with equal voting power to all other members except where the law specifically limits their action. In brief, they have to have something to lose in the negotiation, if they are to negotiate in the best interest of the community as a whole.
For successful implementation of the CMS, the relationship between the state and the MPO must be clearly defined and understood. These are the basic responsibilities of each. The major responsibility for the metropolitan area CMS must be focused in the MPO or TMA. MPOs and TMAs are local agencies and are better equipped to handle problems in the local metropolitan area. Land-use controls are commonly vested in city government. CMS involves the land use/transportation interaction.
The above figure depicts the relationship of the six management systems to the planning process. The traffic monitoring data are inputs to both the six management systems database and to the planning process. The management systems are intended to support the transportation planning process.
Since the designated MPO has the responsibility for the planning process in the metropolitan area and CMS is a part of the planning process, major responsibility for developing, implementing, and administering the CMS in urban areas should be at the MPO level. Moreover, land use decisions, many TSM improvements and ordinances to implement TDM strategies are vested with local units of government. Such decisions and actions will have a significant impact on mitigating existing congestion and/or avoiding future congestion. The local government must play a major role in the implementation of a wide range of CMS actions if the program is to be successful. The MPO is in a position to help ensure that decisions by different local agencies are coordinated as part of a metropolitan CMS. The state role should be to insure compliance with federal law and the resulting rules should provide the technical support needed for the MPOs.

Table 2-1, page 26, of the Congestion Management Systems State-of-the-Practice Review, identifies possible roles for elements of a CMS for state, MPO, city/county, and transit operators.
A general structure for the development of CMS is suggested in the following figures.

1. Organize the CMS Functions
   • Identify Boundaries & Responsibilities

2. Identify Performance Evaluation System
   • Measures
   • Standards

3. Define Network
   • Existing
   • Program Improvements
   • Criteria for Establishing Network

4. Data Collection & Monitoring
   • Baseline Data
   • Forecasts
Note that the Safety Management System as well as Public Transportation and Intermodal Management Systems will have a strong relationship to the CMS.
Flexibility in how to achieve the targets established was a common theme in the site interviews. The California law not only specified what was to be achieved, but also how it was to be done. The result is that the needs of the local areas did not match the solutions specified. Density changes in older neighborhoods often create equal traffic impacts to that of newly developed areas.

Access management has proven to be effective in reducing congestion and improving traffic safety. The state should establish the requirement and provide guidance on the desirable features of a good arterial street access control policy on state highways. The specific ordinances establishing the access control policy for local roadways should be left up to the local unit of government.
Any policy implementing the CMS program must recognize potential future congestion as well as existing or current congested operating conditions.

The past practice of building an arterial street, then waiting until it becomes congested to rebuild it is no longer practical. The most realistic approach is to design the features into the arterial street that will allow it to provide a high level of service in the future. Platoon dispersion results when vehicles delay other vehicles when turning into driveways, and when vehicles enter the arterial from the side streets and driveways following the platoon passage.
SESSION 3
CONGESTION MANAGEMENT

SESSION LENGTH: Approximately 60 Minutes

REFERENCES:
This session correlates to Appendix E and Chapter 3 of Report FHWA/TX-92/563-18, *Congestion Management Systems State-of-the-Practice Review*.

This session considers the measurement of congestion on the CMS network.
SESSION OBJECTIVES

1. Be able to identify the various potential methods of measuring congestion
2. Have a fundamental understanding of the application of each of these measures
3. Have a basic understanding of the "best" measures

Upon completion of this session, participants should 1) be able to identify various methods of measuring congestion; 2) have a better understanding of the various ways that congested operation has been measured; 3) have a basic understanding of the "best" measure(s) for use in a CMS program in order to meet the intent and requirements of the ISTEA.
### SESSION TOPICS

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<table>
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<tbody>
<tr>
<td>1.</td>
<td>Why measure congestion?</td>
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<tr>
<td>2.</td>
<td>Need for a multimodal measure of congestion.</td>
</tr>
<tr>
<td>3.</td>
<td>Need for an area wide measure of congestion.</td>
</tr>
<tr>
<td>4.</td>
<td>Measures of congestion being used.</td>
</tr>
<tr>
<td>5.</td>
<td>Advantages and disadvantages of each.</td>
</tr>
</tbody>
</table>

3–3

The session topics will acquaint the participant with the reasons why congestion needs to be measured quantitatively, the requirements for the measurement, a review of the various measures currently in use and a recommendation as to the best measure(s) to use in a CMS program to meet requirements of the ISTEA.

### WHY MEASURE CONGESTION?

- Better understanding of needs.
- Factual basis for decision making.
- More effective allocation of available funds.
- Required of states and metropolitan areas.

3–4

There are four basic reasons to measure congestion: first, it is important to transportation systems decision-making; second, a better understanding of the congestion in the metropolitan area will lead to a more satisfied customer; third, to more effectively use the limited funding available for transportation improvements; and finally it is required of states and metropolitan areas.
The key question is how to measure congestion to best meet the intermodal and area wide needs of the congestion management program. Unfortunately, most measures of congestion are point oriented and not well suited as either a multimodal or area wide measure of congestion. Many different measures are being used or have been proposed for use.
Any measure of effectiveness selected for use in measuring congestion must be an area wide measure, have reasonable data collection costs, be capable of projecting future congestion and be applicable to all transport modes. It is desirable that the numeric value increase as congestion increases.
<table>
<thead>
<tr>
<th>POTENTIAL MEASURES OF CONGESTION</th>
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<tbody>
<tr>
<td>• Travel time</td>
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<tr>
<td>• Travel rate</td>
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<tr>
<td>• Intersection LOS</td>
</tr>
<tr>
<td>• Arterial LOS</td>
</tr>
<tr>
<td>• V/C ratio-intersection</td>
</tr>
<tr>
<td>• V/C ratio-midblock</td>
</tr>
<tr>
<td>• Vehicle-hours of delay</td>
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<tr>
<td>• Spot speed</td>
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</tbody>
</table>

All of these potential measures of congestion, with the exception of average speed and travel rate, are point oriented and difficult to integrate into an area wide measure of congestion. Appendix B of the "State of the Practice Review" discusses the individual potential measures of congestion. Chapter 2 summarizes the application of these measures to a CMS, and Appendix E discusses potential measures at some length.
This slide and the next slide present some potential measures of congestion. All of these potential measures, with the exception of travel time and rate, are point measures. Appendix B of the "State of the Practice Review" discusses the individual measures.

The running speed decreases as congestion increases. The disadvantage of average running speed is that it is not normally distributed under congested conditions. This makes statistical analysis of the data very difficult.
## TRAVEL RATE

- Average time required to travel a prescribed distance (or minutes/kilometer).
- Measures on both a corridor and area wide level.
- Any method used for collecting travel time data can be used to determine travel rate.
- Can be projected to estimate future conditions.

Average travel rate (minutes/mile or kilometer) can measure congestion on both a corridor and an area wide basis. It can also be projected to estimate future conditions using the computer models that are used in the urban planning process. Travel rate works well as a measure of effectiveness for individual routes or a network of streets. Because travel rate is a function of travel distance, various travel time measurement techniques may be used to determine travel rate. More importantly, travel rate can be applied to conditions where auto and transit are on separate rights-of-way, and HOV lanes are either present, or are to be considered in the future.
Level of Service (LOS) is the most widely used measure of congestion at this time. LOS is commonly used in evaluating traffic operations, and, hence, traffic professionals are familiar with LOS evaluation. California law specified LOS as the measure of congestion. The limitations shown severely limit the application of LOS analysis to the evaluation of area-wide congestion. LOS is clearly not applicable to the transit mode, pedestrian mode, ferry operations, or the evaluation of congestion management decisions.
Average travel speed below a specified value for a given period of time as presented by the operating agency, is used to define congestion on freeways. Average speeds at or near congested flow are constrained, and, therefore, not normally distributed. This fact combined with the trend opposite to the parameter being measured would encourage another measure to be found. Average speed can be converted into travel rate (minutes per mile or minutes per kilometer) by dividing the segment length by the average spot speed. This facilitates automation of the travel rate data collection process on instrumented freeways.

Arterial street measures were predominantly LOS, although a wide range of LOS levels were used as the definition of congested flow. Both intersection and midblock LOS values are being used. Both suffer for a lack of applicability to transit and other modes of operation. For these reasons LOS as a measure of congestion is discouraged.
### POTENTIAL MEASURES OF CONGESTION

<table>
<thead>
<tr>
<th>Measure</th>
<th>Spot</th>
<th>Corridor</th>
<th>Area Wide</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Speed</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spot Speed</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Travel Time</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Travel Rate</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Travel Time Contours</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Delay</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Delay/Veh/Per</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LOS</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Volume</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>V/C Ratio</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Midblock V/C</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R C Index</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Detector Occupancy</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Queue Length</td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The table depicts the area of application of the various potential measures of congestion. Note that only average travel time, travel time contours, and the roadway congestion index are listed as area wide measures. They are also the only ones that lend themselves to all modes of transport.
These are the essential requirements of a good measure of congestion.
To meet the performance measures characteristics previously discussed, travel rate (minutes/mile or minutes/kilometer) and congestion index are the two best measures of congestion. The travel rate data are essentially normal; the area wide constraint is satisfied; future estimates of travel rate are possible; and the data are relatively easy and economical to collect. Moreover, the travel rate is applicable to a multimodal system which is essential in an urban area which has a transit system.

The congestion index (volume/"acceptable flow" rate) is applicable in urban areas where transit is, and will continue to be, an insignificant mode. Hence, it is recommended as an alternative performance measure to travel rate in areas which are not TMAs (population less than 200,000).
SESSION 4
CONGESTION MANAGEMENT
DEFINING CONGESTION

SESSION LENGTH: Approximately 30 Minutes

REFERENCES:
This session correlates to Appendix F and Chapter 3 of Report FHWA/TX-92/563-18, Congestion Management Systems State-of-the-Practice Review.

The definition of congestion is critical for evaluating the defined CMS network. This session addresses the current state-of-the-practice of defining congestion and recommends appropriate definitions based on the measure selected in Session 3.
SESSION OBJECTIVES

A participant should

1. Be familiar with the various definitions of congestion.
2. Have a basic understanding of the practicality of each.
3. Be able to select appropriate performance measures for a metropolitan area.

Upon completion of the session, participants should 1) Be familiar with the various definitions of congestion, 2) Have a basic understanding of the practicality of each potential measure of effectiveness (MOE), and 3) Be able to select a measure of effectiveness appropriate for their metropolitan area.
The basic definition of congestion is the point where "free flow conditions cease to exist." For congestion management purposes, congestion is that condition (or conditions) which the majority of area residents find to be unacceptable. "Acceptable congestion" is all traffic flow conditions between "free flow" and those conditions which are perceived to be "congested."
The FHWA definition of congestion for purposes of congestion management recognizes the need for flexibility in defining congestion to meet the goals and objectives of different areas throughout the United States. A review of current and suggested practices may be helpful in assisting responsible agencies in selecting a definition(s) which is (are) appropriate for their area.
California has more than two years experience in the practice of congestion management. The California law specified LOS as the measure of congestion, but little else. Thus, in application, a wide range of LOS computation procedures are being used and the LOS which is of significance varies from LOS D to LOS F. The California law specifically exempts LOS F operation from the CMS deficiency list. Thus, by defining a roadway section to be operating at LOS F exempted that section from remedial treatments under their CMS program. It is clear that the definition of congestion is very important in implementation of the CMS program.
District four of the California Department of Transportation in the San Francisco Bay Area defines congestion on freeways as the condition when the average speed drops below 55 km/h (35 mph) for more than 15 minutes or longer. The definition of congestion for arterial streets and highways is the condition when the v/c ratio exceeds 1.0 at an intersection.
The Alameda County Congestion Management Agency (CMA) defines freeway congestion as an average speed less than 55 km/h (35 mph) for greater than 15 minutes. Other CMAs in California take the same approach, with the exception of the Santa Clara County CMA which uses a speed of 50 km/h (30 mph). Travel time values are converted to LOS in order to be in compliance with the California legislation. Arterial street congestion is defined using LOS procedures identified in the 1985 Highway Capacity Manual.

The California practice results in inconsistencies in LOS between political subdivisions. One CMA might define congestion at LOS D, while the adjacent CMA uses LOS F. The arterial street sections on opposite sides of the dividing line may be defined as congested or non-congested even though both sections had exactly the same traffic demand and cross section.
For the freeway system, the Chicago Area Transportation System (CATS) uses level of service based on detector occupancy to define congestion. Free flow is below 20% occupancy, capacity is between 20% and 30%, and oversaturated flow occurs beyond 30% occupancy.
Loop occupancy less than 20% is indicative of free flow conditions. The 20% to 30% range maintains high volume but at a reduced speed. Over 30% occupancy, both the speed and throughput are decreased as occupancy increases. While the figure above does not indicate a significant change of speed for occupancy rates below 20%, experience indicates that speed is not uniform (constant) as indicated in the figure. Increasing occupancy by even 2 or 3% in the range between 10% to 20% can significantly change the speed, delay and queue length.
New York State uses excess-hours of delay to quantify the level of congestion on the system. Excess hours of delay is defined as the number of hours of operation at volumes in excess of the specified volume level.

### NY DOT EXCESS HOURS OF DELAY

<table>
<thead>
<tr>
<th>Threshold values for congestion:</th>
</tr>
</thead>
<tbody>
<tr>
<td>□ Arterials:</td>
</tr>
<tr>
<td>1500 veh/hour/lane.</td>
</tr>
<tr>
<td>□ Freeways:</td>
</tr>
<tr>
<td>LOS E 1,000 vph/lane</td>
</tr>
<tr>
<td>LOS F 1,200 vph/lane</td>
</tr>
<tr>
<td>□ Above these values excess-hours of delay are accumulated.</td>
</tr>
</tbody>
</table>

4-10
For each signalized intersection in the Charlotte, North Carolina system, the critical approach V/C ratio is determined each year. The level of congestion is defined as shown. The limitation of using intersection LOS is its lack of application as a system wide measure.

The use of a street AADT, either actual or projected is also a common way to define congestion. This approach also can be used as a system wide measure of surface street congestion. The limitation is the lack of general applicability to other transport modes.
The Capital District Transportation Committee of Albany, New York defines congestion as LOS E. LOS is defined on the basis of demand, as shown above for freeways and below for arterial streets.

### Freeways:
- LOS $E > 1500 \text{ vph/lane}$

### Surface Streets:
- **Two-way, two-lane:**
  - LOS $E > 1500 \text{ vph}$
- **Multi-lane:**
  - LOS $E > 1000 \text{ vph/lane}$
- **Multi-lane limited access:**
  - LOS $E > 1200 \text{ vph/lane}$
SOUTHWEST WASHINGTON RTC
(VANCOUVER/CLARK COUNTY, WA)

- V/C ratio used to define congestion.
- "Acceptable Volumes" used to establish LOS C.
- Horizon year conditions forecast by planning model.

The Southwest Washington Regional Transportation Commission uses the v/c ratio to define congestion. The capacity is determined by the acceptable flow by functional classification. Future conditions are estimated from assigned link flow.
CONGESTION MANAGEMENT

DEFINING CONGESTION

PIMA ASSOCIATION OF GOVERNMENTS (TUCSON, AZ)

ROADWAYS:
☐ LOS at intersections using Florida DOT planning procedure.

TRANSIT:
☐ Travel time, load factor and service frequency.

The Pima Association of Governments (Tucson, Arizona area) congestion management system is well established and probably the best documented of the many CMS programs reviewed. The basic definition of congestion is based on the mode. For transit, travel time, load factor, and service frequency are used to define congestion. The roadway mode uses intersection LOS based on the Florida DOT planning procedure as the basis for defining congestion.

LOS IS THE MOST COMMONLY PROPOSED MEASURE

☐ LOS D, E or F most common.
☐ Not an area wide measure.
☐ Subject to many calculation differences.

LOS is a point measure that is difficult to integrate into an area wide measure of congestion. The descriptors of LOS also are not numeric, making direct conversion to an area wide measure impossible. The fact that LOS does not apply to the transit mode further complicates the use of LOS to measure congestion.
Given the limitations of all the measures of congestion, the most applicable measure to define congestion on a multimodal, system wide basis is travel rate. Travel rate is recommended as the measure of congestion.

The travel rate can be used in multimodal situations and is especially applicable where both auto and significant transit services are provided.
A weighted average travel rate can be developed as illustrated below.

### CALCULATION OF AVERAGE TRAVEL RATE

\[

t_{\text{System Wide Travel Rate}} = \frac{\sum t_i L_i T_i + \sum (t_i - 1) L_i R_i F_i}{\sum L_i T_i + \sum L_i R_i F_i}
\]

Where:
- \( t_i \) = travel rate on section \( i \)
- \( L_i \) = length of section \( i \) (miles or kilometers)
- \( T_i \) = ADT in section \( i \)
- \( R_i \) = ridership on transit vehicle in section \( i \)
- \( F_i \) = frequency of bus service (buses/hour) in \( i \)

4-18

NOTE: The \((t_i+1)L_iR_iF_i\) term can be used for transit or separate right-of-way, if \( t_i \) is the travel rate on the transit section.

This equation calculates the weighted average system-wide travel rate. To evaluate the level of congestion on a system-wide basis, a weighted average travel rate for moderate and heavy congestion is needed.

### WEIGHTED AVERAGE TRAVEL RATE

\[

t_{\text{System - Wide}} = \frac{\sum \frac{t_i T_i}{\sum \frac{1}{T_i}}}{\sum \frac{1}{T_i}}
\]

4-20

The \( t_{\text{System}} \) value can be for either moderate or heavy congestion.
EXEMPLARY

<table>
<thead>
<tr>
<th>Section Number</th>
<th>Posted Speed</th>
<th>Travel Rate Factor</th>
<th>Actual Section Travel Rate, ( t_i )</th>
<th>Section Peak Hour Demand, ( D_i )</th>
<th>Average Section Transit Ridership, ( R_i )</th>
<th>Section Bus Frequency, ( F_i )</th>
</tr>
</thead>
<tbody>
<tr>
<td>105</td>
<td>35</td>
<td>2.4</td>
<td>3.2</td>
<td>1.50</td>
<td>26,000</td>
<td>22</td>
</tr>
<tr>
<td>106</td>
<td>35</td>
<td>2.4</td>
<td>4.1</td>
<td>1.33</td>
<td>27,500</td>
<td>18</td>
</tr>
<tr>
<td>107</td>
<td>35</td>
<td>2.4</td>
<td>2.5</td>
<td>1.14</td>
<td>27,500</td>
<td>17</td>
</tr>
<tr>
<td>108</td>
<td>35</td>
<td>2.4</td>
<td>2</td>
<td>1.53</td>
<td>28,600</td>
<td>20</td>
</tr>
<tr>
<td>109</td>
<td>35</td>
<td>2.4</td>
<td>3.6</td>
<td>2.22</td>
<td>28,600</td>
<td>13</td>
</tr>
<tr>
<td>110</td>
<td>35</td>
<td>2.4</td>
<td>2.7</td>
<td>1.57</td>
<td>28,600</td>
<td>15</td>
</tr>
<tr>
<td>111</td>
<td>35</td>
<td>2.4</td>
<td>4</td>
<td>2.46*</td>
<td>28,600</td>
<td>16</td>
</tr>
<tr>
<td>112</td>
<td>35</td>
<td>2.4</td>
<td>3.2</td>
<td>1.67</td>
<td>28,600</td>
<td>17</td>
</tr>
<tr>
<td>113</td>
<td>40</td>
<td>2.0</td>
<td>2.9</td>
<td>1.55</td>
<td>32,000</td>
<td>17</td>
</tr>
<tr>
<td>114</td>
<td>40</td>
<td>2.0</td>
<td>3.1</td>
<td>1.53</td>
<td>32,000</td>
<td>13</td>
</tr>
<tr>
<td>115</td>
<td>40</td>
<td>2.0</td>
<td>2.8</td>
<td>2.12*</td>
<td>32,000</td>
<td>12</td>
</tr>
<tr>
<td>116</td>
<td>45</td>
<td>1.7</td>
<td>4.1</td>
<td>1.63</td>
<td>34,500</td>
<td>8</td>
</tr>
<tr>
<td>117</td>
<td>45</td>
<td>1.7</td>
<td>4.5</td>
<td>2.22**</td>
<td>34,500</td>
<td>7</td>
</tr>
<tr>
<td>118</td>
<td>45</td>
<td>1.7</td>
<td>4.7</td>
<td>1.84*</td>
<td>37,600</td>
<td>10</td>
</tr>
<tr>
<td>119</td>
<td>45</td>
<td>1.7</td>
<td>3.8</td>
<td>2.33**</td>
<td>37,600</td>
<td>11</td>
</tr>
</tbody>
</table>

* Moderate Congestion; ** Heavy Congestion

System wide travel rate = 2.97 minutes per kilometer (1.84 minutes per mile)

composite average travel rate at moderate congestion = 2.94 minutes per kilometer (1.82 minutes per mile)

The system is therefore, operating at moderately congested conditions on the average. Individual sections of the network are probably operating at an over saturated level. Reviewing the * in column 5, clearly some sections of the network are deficient.
Travel rate (minutes per kilometer or mile) is the recommended definition of congestion where transit or ferry operations are significant. "Significant" transit would include RRT or other transit operating on separate right-of-way, light rail, and HOV lanes. Where little or no trips are made by transit or ferry, use volume divided by the "acceptable flow" rate.

Areawide, subarea and/or corridor congestion can be quantified using a weighted average as indicated in Chapter 3 (pages 3-4) of the State-of-the-Practice Review. The person-miles of travel on each route segment would be used to obtain the weighted average travel rate.
The ratio of volume to "acceptable flow" rate is suggested as the performance measure where transit is not significant, and will not be significant in the future. This performance measure is suggested because it can be calibrated readily for existing and future conditions using the data collection and modeling process commonly used in the urban land use transportation modeling process. The data collected as a part of model validation and update can identify existing congestion. The calibrated model can be applied as currently used to forecast future volumes. The selection of "acceptable flow" rates is similar to that of identifying the link capacities presently used for volume-restraint traffic assignment. In most cases, "revisiting" these link capacities to assume their appropriateness for CMS use is all that should be necessary. In areas that do not have an air quality problem, use 24-hour volumes and "acceptable flow" rates. This will facilitate integration of the CMS into the metropolitan transportation planning process with little or no change in the modeling procedures. Areas which are air quality deficient may wish to use peak-hour directional volumes and "acceptable flow" rates since this would be consistent with the modeling process of such areas.

Outside the MPO areas, the ratio of the volume to "acceptable flow" rate can be used. "Acceptable flow" rates will, of course, need to be established for the route segments where such values have not been chosen. Currently, volume-counting practices will provide all or most of the data needed for identifying existing congestion. Statewide travel modeling (comparable to that used in urban areas) does not seem to be practiced. However, most states have an extensive historical count data that can be used to forecast future volumes with suitable precision by extrapolation or analogy.
SESSION 5
CONGESTION MANAGEMENT

SESSION LENGTH: Approximately 75 Minutes

REFERENCES:

This session correlates to Chapter 5 of Report FHWA/TX-92/563-18, Congestion Management Systems State-of-the-Practice Review.

A functional and economical CMS is key to defining the CMS network. Too large a network will be expensive to monitor, and too small a network will produce meaningless data. This session addresses the definition of the network to ensure that it is objective, functional and economic.
SESSION OBJECTIVES

Participants should be able to:

1. Identify the problems associated with defining a Congestion Management Systems network.

2. Appreciate the need for flexibility in defining the network.

3. Identify the steps in successfully defining a network.

Upon completion of this session, participants should be able to 1) identify the problems associated with defining a network; 2) appreciate the need for flexibility in defining the system; and, 3) identify the steps in defining a CMS network. The following topics will be discussed in order to accomplish these objectives.
**SESSION TOPICS**

2. Providing adequate coverage of the geographic area.
3. The need for continuity within the network.
4. Consideration of monitoring costs.
5. The recommended method for defining the CMS network.
The network definition is important because it forms the basis for the long term measuring and monitoring activities. It is the system on which future strategies will be implemented, and it sets the cost of the monitoring of congestion levels. Thus, a great deal of thought and effort in defining the network will pay large dividends in the future. All segments of the highway system currently congested, and those expected to experience congestion within the next 10 to 20 years, should be included in the network.
STATE-OF-THE-PRACTICE

A variety of approaches are used to identify the CMS network.

- Select the network based on VMT or ADT.
- Select subset of the network used in the transportation planning (modeling) process.
- Select by functional classification.
- Select all interstate highways and the most important state highways and principal arterial streets.

There is no universally accepted method of defining the CMS network. Some agencies simply select the state numbered routes and the streets designated as "Major Arterials" on the urban area long range transportation plan. Others choose to define the network on the basis of VMT or ADT. This tends to provide a more functional definition of the network.

ALAMEDA COUNTY CMS

NETWORK SELECTION:

- Includes 70% of total VMT.
- Includes all links with ADT > 30,000 vpd.

The second approach tends to use criteria such as including in the networks all links with an ADT exceeding some specified value, such as 30,000 vpd.
Continuity is provided between the Alameda County CMS network and the networks of the adjacent counties. For example, IH-880 and IH-680 connect with the Santa Clara County CMS network to the south.
Continuity of CMS network is essential. Leaving out a link may distort the projection of future congestion. Also where it is clear to the planning agency that some future major arterial will be necessary due to development, links that account for that movement need to be included even if they do not meet the criteria for selection. Continuity across political boundaries is especially important.
The networks must be representative of travel patterns and potential areas of congestion. For example, the majority of the Santa Clara County CMS network is concentrated in the metropolitan area where traffic problems exist. The rural portions of the county network are only represented by major highways (numbered routes) and other roadways providing continuity with the adjacent county.
INCLUSION OF RURAL AREAS

The state CMS network must include:

- Interstate highways,
- Other state highways for continuity.

The state CMS network must include all interstate highways and facilities on the National Highway System. The network will normally include state numbered routes.
The size of the CMS network dramatically impacts the cost of monitoring congestion. Data collection should be focused at a representative point on each network segment. Each route segment should be homogeneous in cross section and uniform in traffic demand and may include several signalized intersections or consist of several links in the coded network used in the modeling process. Care at the network definition level will pay large dividends in future years.
Flexibility in defining the CMS network links is essential to adapting to future changes in demand. That flexibility should not be so loose that it allows an agency to redefine its portion of the network at will. The recommended procedure is for the MPO to approve the network as well as any proposed changes in the future.
RECOMMENDED PROCEDURE FOR A METROPOLITAN CMS NETWORK

1. Divide all freeway segments and arterial roadways into segments of similar cross section and traffic flow characteristics (volume and speed).
2. Assemble the traffic volume data for each divided segment.
3. Calculate the VMT on each segment.
4. Array the segments in descending order of VMT.

This visual aid and the next outline the best procedure for defining the CMS network. Following these steps will ensure a workable and economical CMS network.

RECOMMENDED PROCEDURE FOR A METROPOLITAN CMS NETWORK

5. Determine the total VMT on all segments.
6. Sum the VMTs until a selected percentage of the area VMT has been reached.
7. Review the resulting system to insure continuity.
8. For transit routes on separate ROW, use steps 1 through 7 to select the transit network. Use person-miles rather than VMT.
The suggested percentage of VMT used as the criteria in step 6 is 70%; however, a higher or lower percentage may be appropriate in various urban areas. Whatever percentage is used, the process will produce an objective network that includes a substantial proportion of the traffic in the urbanized area. All transit operating on a separate right-of-way will be significant and should be included in the multimodal CMS network. Also where transit is significant, use passenger miles of travel (PMT) rather than VMT for the auto and transit modes.

<table>
<thead>
<tr>
<th>STATE CMS NETWORK</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐ The state CMS network includes all networks defined by MPOs, highways on the National Highway System, and other roads needed for continuity.</td>
</tr>
<tr>
<td>☐ The MPO networks will be monitored by the MPO, but must be included in the state network.</td>
</tr>
<tr>
<td>☐ All network segments not in an MPO will be monitored by the state.</td>
</tr>
</tbody>
</table>

The state CMS network will include all the networks defined by the MPOs within that state, rural interstate highway segments and other highways in the National Highway System, plus selected state numbered routes which are necessary to provide a reasonably direct routing of people movements within the state. It is expected that the congestion in the MPO networks will be monitored by the MPO and the local government units in cooperation with the state. The State will monitor the remainder.
ALTERING THE CMS NETWORK

☐ MPO should formally adopt the CMS network.
☐ Modifications only allowed by MPO vote.

Adoption of, and changes to, the metropolitan CMS network in each MPO area should proceed by majority vote of the MPO policy advisory committee (PAC). The state highway agency will normally participate in this process as a member of the MPO's PAC.

RESULTING NETWORK

☐ Will be objective.
☐ Will be representative of the entire metropolitan area.
☐ Will be less subject to local political pressure.

The resulting network will be objective, representative of the entire metropolitan area, and less subject to local political pressures. Operating at the MPO level also allows all CMS strategies to be evaluated on the basis of the metropolitan area needs, not just the needs of the particular local government units. Where state law requires county congestion management agencies, the metropolitan wide CMS network might be an aggregation of all or part of the local CMS networks.
The cost of travel time studies is about $47 per route kilometer ($75 per route mile).

Point traffic counts are $10 per count based on one count every 4.8 kilometers (3 miles).

Manual intersection turning counts cost about $600 per intersection.

The costs are typical of those reported in the interviews. Obviously the cost will vary substantially by area of the country. Use these values only when locally available cost data are not available. When used consistently, these values can provide an estimate of the total cost of the monitoring effort.
In evaluating congestion, consider point, corridor and area wide congestion. The data needs are different for each.

Local governmental units must be allowed to collect the data that are meaningful to them within a framework compatible with the state and national reporting system needs.

The data to be collected should be kept as flexible as possible while still meeting the needs of the state CMS system and federal reporting requirements. Each local governmental unit may have a different perspective of data needed to plan CMS projects. Also, congestion mitigation actions may be very local in nature (i.e., spot improvements). Some will involve an entire corridor or segment of a corridor, while others will involve a wide area. Different data needs exist for each type of congestion identified above.
SESSION 6
CONGESTION MANAGEMENT

SESSION LENGTH: Approximately 75 Minutes

REFERENCE:
This session correlates to Appendix H of the Congestion Management Systems State-of-the-Practice Review.

The session identifies the monitoring activities necessary as part of a CMS program.
Upon completion of this session, participants should be able to 1) identify the minimum amount of data that must be collected for effective CMS monitoring, 2) identify how the data might be collected, 3) differentiate between recurring and non-recurring congestion, and 4) identify how the data can be used. The topics covered in this session follow.

### SESSION OBJECTIVES

1. Identify the minimum amount of data that must be collected for effective CMS monitoring.

2. Identify how the data might be collected.

3. Differentiate between recurring and non-recurring congestion.

4. Identify how the data can be used.
### SESSION TOPICS

1. The frequency and amount of data collection.
2. The best methods for collecting data.
3. The difference between recurring and non-recurring congestion.
4. The integration of data from other management systems.
5. The method for monitoring transit and ferry congestion.

### RECURRING VS. NON-RECURRING CONGESTION

**Definitions:**

- **Recurring Congestion** - Demand exceeds capacity.
- **Non-Recurring Congestion** - Random event reduces capacity.

Congestion may be recurring or non-recurring in nature. Non-recurring congestion is a random event and is not typically monitored to the same degree as recurring congestion. Recurring congestion is predictable as to time and duration.
To reduce costs and save time, integrate the data collection and processing with the other monitoring systems.
CALTRANS-4 in the San Francisco Bay area monitors freeways by collecting travel time data. The floating car method is used to collect the data. A "full" data collection is used to establish a baseline of average travel speeds. It consists of three computerized vehicles operating as floating cars in the traffic stream. Their operating strategy will include the effects of minimum accidents in the runs, but the runs will be excluded when major accidents occur. The travel time data collected are available to all local agencies which have access to CALTRANS-4 database. After improvements are made to freeway sections, a sufficient number of floating car runs are made to establish a new baseline of average travel speeds. Following establishment of the baseline, one vehicle is used to periodically check travel conditions. If conditions appear to have changed, a full data collection effort is made.
In addition to the travel time studies, the count stations, as indicated in the visual aid, monitor roadway conditions. The peak hour volume counts along with the practical capacity of a particular segment are used to determine the volume-to-capacity (V/C) ratio of the segment.

The Alameda County CMA contracted a private consultant to collect travel time data on the county CMS network on an annual basis. Data collection activities occurred on either Tuesdays, Wednesdays or Thursdays during the evening peak hour. Data was not collected on Mondays or Fridays due to the effects of weekend and vacation traffic. Since the CMP must be updated only biannually, monitoring activities during the off-year appear to serve no purpose.
The city of Charlotte, North Carolina monitors conditions at every signalized intersection within the corporate limits. A monitoring program this large provides plenty of data for evaluating surface street conditions, but is very costly and time consuming to operate.

The frequency of the traffic monitoring process should coincide with the renewal cycle of the Transportation Improvement Program (TIP). The monitoring activities may be most effective when completed during the year in which the TIP or CMP must be updated. However, with a 2-year cycle, collection of data on one-half the CMS system each year may be beneficial for a budgeting starting point.
The costs of monitoring congestion depend on the size of the community, density of the data collection program, the measure of congestion selected, and the frequency of data collection. If collection of data is on an annual basis, costs should be budgeted for each year. However, if data are collected biannually, the budget must include monitoring costs every other year.

Travel time studies for the Alameda County CMA totaled $25,000 for the initial study and $17,000 for the follow-up study the following year. The study was conducted on 735 freeway kilometers (460 freeway miles), so the costs per kilometer were $67.90 ($108.70 per mile) for the initial study and $46.19 per kilometer ($73.91 per mile) for the second year monitoring effort.
Automated data collection systems reduce the manpower necessary to collect the data, but the initial cost is substantial. The estimated costs include hardware at three kilometer (two mile) intervals on the arterial system and eight kilometers (five miles) on the freeways, the control center, and the communications network. Freeway ramp controls bear a large portion of the cost of the system.

The expected cost for turn movement counts would be $250 to $375 per kilometer ($400 to $600 per mile) assuming that data are collected at intersections located one kilometer (mile) apart on the arterial street. The data collected is typically used for calculating volume to "acceptable flow" ratio or a calculated delay.
### MONITORING CONGESTION

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>As identified in Session 4, travel rate is the recommended measure of congestion.</td>
</tr>
<tr>
<td></td>
<td>Collect data annually or biannually according to the TIP or STIP.</td>
</tr>
</tbody>
</table>

Monitoring costs are continuous. Any effort in the planning stages that will save money on data collection will pay off many times in the coming years. The monitoring activities required by the ISTEA are long-term and should be thoroughly planned.
SESSION LENGTH: Approximately 30 Minutes

REFERENCES:

This session correlates to the "Proposed Federal Requirements" and "Toolbox" sections of Chapter 7 in Report FHWA/TX-92/563-18, Congestion Management Systems State-of-the-Practice Review. In addition, Appendix C to that report, "Access Management as a Congestion Management Measure," identifies potential strategies relating to access management. Other references that may be of interest include the following:

1. Implementing Transportation Demand Management Programs, Institute of Transportation Engineers Educational Foundation Seminar Notebook, 1992.


The intent of this session is to introduce various strategies that are available for consideration in a congestion management program. To the degree possible, case studies are used to illustrate how these strategies have been implemented by others. The session objectives are as indicated.

**SESSION OBJECTIVES**

1. Identify potential strategies for use in a CMS to alleviate congestion.
2. Illustrate how these strategies have been used successfully.

Upon completion of this session, participants should be able to identify potential strategies for consideration in a CM program and have a basic understanding of how various strategies have been used successfully. This session will not go into any degree of detail on the various strategies that may be used for congestion relief. Rather, the focus is on expanding the thinking regarding the various alternatives available to address congestion management.
SESSION TOPICS

1. TDM measures.
2. TSM measures.
3. Access management techniques.
4. Growth management programs.
5. Other strategies.

The main strategies addressed in this session are Transportation Demand Management (TDM), access management and growth (development) management.

POSSIBLE STRATEGIES

- Transportation demand management
- Traffic operations improvements
- Measures to increase HOV use
- Congestion pricing
- Growth management strategies
- Access management strategies
- Incident management strategies
- Applications of IVHS technology
- Addition of general purpose lanes
The rules issued by FHWA identify these nine strategies for use in a CMS. The list is intended to broaden the decision-maker's thinking away from the typical response—addition of general purpose lanes. The list is not inclusive of every possible strategy. Different strategies work better in different areas of the country.

### TRANSPORTATION DEMAND MANAGEMENT STRATEGIES

- Incentives and disincentives: 
  - HOV, ride sharing, parking and pricing management, and tolls and congestion pricing.
- Alternative work arrangements: 
  - Variable work hours, compressed work weeks, and telecommuting.
- Improved alternatives: 
  - Transit service improvements, carpools, vanpools, and bicycle/pedestrian facilities.
- Trip reduction requirements.

TDM strategies include a wide variety of strategies that are all designed to manage transportation demand more efficiently. By altering the demand on transportation facilities, the existing capacity can be used more efficiently to help reduce congestion levels (1 and 2).
Strategies such as ramp metering and incident management programs, have been used in many parts of the country for many years. Ramp metering helps to control peak hour freeway demand by restricting access at entrance ramps. Incident management programs strive to remove incidents from the roadway and re-open all lanes to traffic as quickly as possible.
The San Diego TMA identified an upper bound of 30% as the percentage of employees in a firm that will volunteer to participate in a ridesharing program. This suggests that when setting targets for vehicle occupancies for individual employees, the percentage employees that will participate in a ridesharing program should be considered.

**TELECOMMUTING CASE STUDY**

- Puget Sound Regional Council (Seattle).
- Demonstration project proved that telecommuting saves energy over the short-term, particularly gasoline.
- Telecommuting should be voluntary, as it is not for everyone.
- Do not change the conditions of employment for telecommuters, including salary or benefits.
A recently completed telecommuting demonstration project in the Puget Sound area identified the above concerns employers should consider before starting a telecommuting program. In addition, either the employee or the employer should be able to discontinue the telecommuting program (4, 5).

<table>
<thead>
<tr>
<th>ACCESS MANAGEMENT TECHNIQUES</th>
</tr>
</thead>
<tbody>
<tr>
<td>□ Install nontraversable median</td>
</tr>
<tr>
<td>□ Increase medial access spacing</td>
</tr>
<tr>
<td>□ Design median openings for specific movements</td>
</tr>
<tr>
<td>□ Install deceleration lanes</td>
</tr>
<tr>
<td>□ Improve driveway design</td>
</tr>
<tr>
<td>□ Signal spacing</td>
</tr>
</tbody>
</table>

Access management techniques have proven to be very effective in increasing the capacity of major arterials. Access management techniques include more than typical driveway and median controls. By regulating the spacing and addition of signalized intersections, signalized intersection access can be controlled to increase speeds along the roadway.

<table>
<thead>
<tr>
<th>MEDIAL ACCESS</th>
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<tbody>
<tr>
<td>The capacity of a four-lane arterial with an eight-tenths kilometer (half-mile) signal spacing and a nontraversable median is equal to the capacity of a six-lane arterial with a four-tenths kilometer (quarter-mile) signal spacing and medial access.</td>
</tr>
</tbody>
</table>

7-9

7-10
To increase capacity on existing four-lane arterial roadways replace a two-way left-turn lane with a raised non-traversable median. The construction of a raised median is more cost effective than the construction of two additional general purpose lanes. A reduction in the number of medial access points also improves traffic safety.

**ATLANTA PROJECT**

- Replaced TWL TL on six-lane arterial with raised median.
- Total overall accident reduction of 37% over the 7 kilometer (4.5 mile) section.
- Decreased mid-block left-turn accidents by 90%.

A recent safety improvement project in Atlanta, Georgia completed in 1990 on Memorial Drive resulted in a dramatic decrease in the accident rate. The project replaced an existing two-way left-turn lane on the six-lane arterial with a raised median. A "before" and "after" study determined that the total accident rate, including midblock and intersection accidents, decreased by 37%. The injury rate decreased by 48% over the same time period.
The Colorado Demonstration Project used TRANSYT-7F to evaluate the effect of access control. The controlled access condition was with an eight-tenths kilometer (one-half mile) signal spacing and right-turns only midway between the signals. The "uncontrolled" condition was a four-tenths kilometer (quarter-mile) signal spacing and all turn movements permitted at unsignalized access. The controlled access scenario produced a 69% increase in speed, a 42% reduction in total vehicle-hours of travel and a 59% decrease in total vehicle-hours of delay.
By controlling access to major arterials and only permitting signalized intersections at a minimum of half mile intervals, speeds along the arterial significantly improve due to better signal progression. Eight-tenths kilometer (half-mile) signal spacing results in higher speeds along the arterial than .4 or .5 kilometer (1/4 or 1/3 mile) spacings, as shown in the above figure.
GROWTH MANAGEMENT PROGRAMS

- Intended to restrict development only in congested areas.

Growth management programs are in reality development management programs. Their purpose is to control development, not necessarily growth. Growth will still occur, just not in areas that are experiencing excess demand on the transportation system.
## OTHER STRATEGIES

- Transportation Operations Improvements
  - Ramp metering
  - Traffic Signal Coordination

- Incident Management Programs
  - Motorist Assistance Patrols

- Addition of General Purpose Lanes

Other strategies, such as ramp metering and incident management programs, have been in use in many parts of the country for many years. Ramp metering programs help to control peak hour freeway demand by restricting access at entrance ramps. Incident management programs strive to remove incidents from the roadway and re-open all lanes to traffic as quickly as possible.

## IMPLEMENTATION

- Use a combination of strategies.
- Use the strategies that will be the most cost effective, publicly accepted, and will yield the largest benefits.

One single strategy will not greatly affect the current levels of congestion. However, combinations of several strategies will help to effectively reduce congestion. Use the combination of strategies that best fits the local metropolitan area.
SESSION LENGTH: Approximately 30 Minutes

REFERENCES:

This session summarizes the entire Report FHWA/TX-92/563-18, "Congestion Management Systems State-of-the-Practice Review."

This session summarizes the key ideas and concepts from the entire State-of-the-Practice Report. It also sets the direction for moving forward with congestion management in America.
CONGESTION AND THE CMS
SESSION 1

- Congestion is increasing.
- No need for extensive new data collection.
- Consideration of alternatives must precede capacity increases in non-attainment areas.
- State-wide as well as urban area CMS required.
- There are many causes of congestion.

The key points of the first session are summarized here. Recall that control of access is a dominant cause of arterial street congestion. Lane balance and lack of demand control are key congestion causes on freeways. The low vehicle occupancy rate on the street systems in the United States, a result of the economic climate in this country, has a pronounced impact on congestion.
Session 2 addressed the need for flexibility in the rules to allow each metropolitan area to implement a CMS that fits its particular needs with reasonable involvement of air quality personnel. Generally, the MPO will handle the CMS in the larger urban areas. The state develops the CMS for the remainder of the system. The six management systems of ISTEA are a part of the transportation planning process, not separate entities.

The apparent 30% upper bound on voluntary ridesharing needs to be recognized in setting CMS/TDM goals.
Session 3 discusses the many potential measures of congestion. The purpose of measuring congestion is to facilitate more effective transportation decisions. The need for an area wide measure that accommodates all modes was stressed. Travel rate, when significant transit activity exists, and the congestion index when little transit activity exists, appear to satisfy these requirements.
**DEFINING CONGESTION**

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<table>
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<tbody>
<tr>
<td></td>
<td>Measure present congestion.</td>
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<td></td>
<td>Forecast future congestion.</td>
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<tr>
<td></td>
<td>LOS is not an area wide measure.</td>
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<tr>
<td></td>
<td>Detector occupancy is not sensitive to congestion changes.</td>
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<tr>
<td></td>
<td>Average travel rate is the most general measure of congestion.</td>
</tr>
<tr>
<td></td>
<td>Congestion index - volume/&quot;acceptable flow rate,&quot; is OK when transit is not a consideration.</td>
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</tbody>
</table>

Based on the site interviews, the LOS definition of congestion is not desirable. It is a point measure, not a system wide measure. Detector occupancy lacks sensitivity to changes in congestion. Average travel rate (minutes per mile or minutes per kilometer) is the most general measure of system congestion. Use the congestion index where little or no transit trips exist.
DEFINING THE CMS NETWORK
SESSION 5

☐ Detailed enough to provide good insight and broad enough to make monitoring practical.

☐ VMT or PKT/PMT (Person kilometers traveled/person miles traveled) are probably the most objective way. Seventy percent of all VMT or KT/PMT criteria suggested.

☐ Rural network - All major routes.

☐ Need provision to modify network to meet future needs.

☐ COSTS:
  • Travel rate - $50-$60 per route kilometer ($75-$100 per route mile).
  • Point traffic counts - $10 per count.
  • Intersection counts - $400-$600 per intersection.

8-6

Defining the network, selecting the MOE and selecting the data collection cycle determine the cost of monitoring the CMS network. VMT or PKT(PMT) is probably the general approach to defining an objective, functional network. A provision for adopting and modifying the network in the best interest of all affected parties must be a part of the initial discussion on implementation of the CMS program.
The congestion management plan is not a one time exercise. It is a continuing, evolving process over time. Expect to project and monitor congestion. To control costs while providing the necessary data requires very careful planning of the monitoring program. Recall that a measure of vehicle occupancy must be a part of the monitoring program.
The last session reviewed the CMS strategies listed on this visual aid. In non-attainment areas for air quality, these strategies, with all their variations, must be evaluated and then found to not be feasible in solving the congestion problem before a capacity increase alternative can be funded. It may be realistic to structure CMS program to include several TDM strategies and a few "capacity-increase" projects, in order to address and solve a specific congestion problem.
SESSION 8 - GETTING ON WITH THE CMS TASK

- **KEY:**
  
  Six management systems part of the transportation planning process.

- **GOAL:**
  
  Integration of all modes of transport and land use decisions.

So where do we go from here? The immediate objective is to begin the planning for the CMS. The next step is to assemble a working group which includes transit, freight movers, city and county officials, representatives of business, developers, DOT personnel, tribal leaders, military commanders, and literally all affected parties, to select a mutually acceptable measure of congestion. This should be followed by, or concurrently developed with, an objective determination of the CMS network. Finally, the process of traffic monitoring should be carefully thought out and adequate funding obtained to meet both the initial and long term monitoring costs. The MPO and other affected parties should work out these details.
It's up to you. The MPOs and the state must not be reactive on congestion management. Rather, they must be proactive in developing the very best possible CMS for their jurisdiction. Congestion management integrates traffic operations and land use decisions into one planning process. This is as it should have been in the past. Congestion management encourages the most efficient use of the transport system. This is also desirable. Effective congestion management will affect the individual. The access control and land development activities will not permit the individual property owner to "do his own thing" as has occurred in the past. Individual property owners must cooperate with their neighbors in the best interest of the community as a whole.

ISTEA provides a new vision for transportation in America. Bringing this vision to reality is the challenge to transportation professionals and public officials. A high degree of cooperation between the transportation professional and the public official is necessary. The required degree of cooperation insures that there will be both extremely successful CMS implementation programs and also many failures. Let us focus on being among the successes. Concentrate on how to make a CMS successful rather than worrying about failure.

IT'S UP TO YOU!

WHICH WILL IT BE: SUCCESS OR FAILURE?
APPENDIX

CONGESTION MANAGEMENT SYSTEM BROCHURE
DEVELOPING AND IMPLEMENTING A CONGESTION MANAGEMENT SYSTEM

TABLE OF CONTENTS

INTRODUCTION ......................... 2
STATUS OF CONGESTION .......... 2
MEASURING CONGESTION ............ 4
Measuring Congestion on a Multimodal Level ..................... 7
DEFINING THE CMS NETWORK ....... 7
DEFINITION OF CONGESTION ...... 9
Measures Used to Define Congestion .......... 9
The Best Measure of Congestion .... 10
MONITORING THE CMS SYSTEM ..... 11
Data Collection Frequency .......... 13
Monitoring Costs ..................... 13
DEVELOPING AND IMPLEMENTING A CMS ............... 15
Responsibilities ....................... 15
CMS Structure ......................... 17
Organizing the Players ............... 18
CMS STRATEGIES ...................... 22
INTRODUCTION

The Clean Air Act Amendments of 1990 (CAAA) and the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) greatly impacted the nation's transportation programs. State and local officials have been given increased funding, added flexibility to select projects to meet local needs, and enhanced metropolitan and statewide planning requirements. Metropolitan Planning Organizations (MPOs) have been given increased responsibility for planning and implementing projects within their jurisdiction in order to improve mobility.

STATUS OF CONGESTION

Traffic congestion has been a problem in the United States for many years and is growing increasingly worse at an alarming rate. A recent study examined traffic conditions in 50 of the largest cities in the nation. Nearly half of the nation's urban areas have experienced at least a 20 percent increase in congestion since 1982. Since the beginning of the study, only three cities (Detroit, Houston, and Phoenix) have shown a decrease in congestion. Only Houston has shown a continual decrease each year since 1984. The study also estimated the cost of congestion, based on fuel consumption and travel delay, at $43.2 billion in 1990. This figure is a 10% increase from the 1989 cost of $39.2 billion.

Congested conditions in all 50 cities were evaluated using the roadway congestion index. The index is a ratio of urban area daily vehicle-miles of travel (DVMT) per lane for freeways and principal arterial streets to DVMT per lane values identified with congested conditions. An index value greater than 1.0 indicates an undesirable level of area-wide congestion. As expected, congested conditions for the largest metropolitan areas are worse than conditions in smaller areas, as shown in Figure 1. However, congestion levels are growing increasingly worse in all areas at a similar rate regardless of population. This emphasizes the need for congestion management systems in all parts of the country, including both small and large metropolitan areas.

Figure 1. Roadway Congestion Index Values Grouped by Population (millions), 1982 to 1990

MEASURING CONGESTION

Congestion levels must be quantitatively measured if CMS is to be an effective management tool. Monitoring change in congestion and making certain strategic policy transportation decisions require data which will show relative congestion conditions over time. These strategic decisions involve consideration of all travel modes, travel demand management actions (TDM), transportation control measures (TCM) and often complex mobility and air quality issues.

Decisions regarding specific changes to the transportation network, land use patterns and traffic operations require measures of effectiveness which quantify the degree of congestion. Also, a congestion management program involves issues relating to spot locations, corridors, and areawide. In very large urban regions, it will be necessary to analyze congestion by sub-areas. Table 1 presents a list of potential measures of congestion and their application to measurement and monitoring.

The most common measure of congestion currently used involves Level-of-Service (LOS) as defined in the 1985 Highway Capacity Manual (HCM). The HCM bases signalized intersection LOS on calculated average vehicular delay based on turn movement volumes. Arterial LOS, in the 1985 HCM, is based on the average travel speed for the section or the entire arterial being analyzed. For freeways, the 1985 HCM reports that LOS is determined from roadway densities. Other measures which have been suggested or which are currently being used to define congestion along freeways and arterials are average operating speeds, travel times, travel rates, midblock volumes, midblock spot speeds, intersection turning movements, detector occupancy rates, volume to capacity (v/c) ratios, intersection and/or segment delays, travel times generated by a computer model, and vehicle-hours of excessive delay.

It is apparent in Table 1, that most of the potential measures of congestion are applicable to spot locations. Hence, further processing will be necessary to obtain an aggregate of effectiveness (MOE) which can be used to evaluate and monitor areawide congestion and network performance over time.

Those which have the most potential include the following:

- Weighted average travel rate
- Weighted average excess delay per vehicle, or per person
- Weighted average intersection v/c ratios
- Weighted average volume/"acceptable flow" ratio

Weighting should be done on a vehicle-mile, or person-miles, of travel. The weighting and resulting congestion MOE could be for a peak period (am or pm or both), or 24-hour. The use of detector occupancy will be limited to areas having an extensive and sophisticated intelligent highway network.
### Table 1. Potential Measures of Effectiveness

<table>
<thead>
<tr>
<th>Measure of Effectiveness</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average travel speed</td>
<td>X</td>
</tr>
<tr>
<td>Spot speed</td>
<td>X</td>
</tr>
<tr>
<td>Average travel time</td>
<td>X</td>
</tr>
<tr>
<td>Average travel rate</td>
<td>X</td>
</tr>
<tr>
<td>Travel time contours</td>
<td>X(3)</td>
</tr>
<tr>
<td>Total delay</td>
<td>X</td>
</tr>
<tr>
<td>Average delay per vehicle/per person</td>
<td>X</td>
</tr>
<tr>
<td>Minute-miles of delay</td>
<td>X</td>
</tr>
<tr>
<td>Intersection level of service</td>
<td>X</td>
</tr>
<tr>
<td>Arterial/freeway LOS</td>
<td>X</td>
</tr>
<tr>
<td>Volume/&quot;acceptable flow&quot;</td>
<td>X X X</td>
</tr>
<tr>
<td>V/C ratio</td>
<td>X</td>
</tr>
<tr>
<td>Midblock volume/capacity</td>
<td>X</td>
</tr>
<tr>
<td>Roadway congestion index</td>
<td>X X</td>
</tr>
<tr>
<td>Detector occupancy</td>
<td>X X</td>
</tr>
</tbody>
</table>

1. Also applicable to transit.
2. Minutes per mile or minutes per kilometre.
3. Combined volume divided by a flow rate which represents acceptable traffic volume conditions for the type of roadway (i.e. 2-lane, 4-lane undivided, 4-lane divided, etc.), may be vehicles per hour or vehicles/day.
4. Limited application since a travel time contour map relates to a specified origin and there is no procedure for aggregating maps.

Measurement of changes in congestion can also be made by comparing the number, or percentage, of links in the network which are above or below acceptable congestion levels or the number, or percentage of links on which congestion increased or decreased from one year to another. It can also be represented by the number of network segments which are above or below the acceptable levels of congestion.

When selecting a measure of effectiveness, it is important to note that ISTEA requires congestion levels to be forecasted as well as monitored.

**Measuring Congestion on a Multimodal Level**

ISTEA calls for a multimodal approach in managing congestion. This multimodal approach creates problems when trying to determine a single measure which defines congestion. Measures such as level of service or vehicular density are misleading when bus operations are included in the analysis of freeways and arterials.

**DEFINING THE CMS NETWORK**

The CMS network must provide reasonable coverage, yet not be so detailed as to be prohibitively expensive for data collection. The network must include the freeway system and the principle arterial streets yet exclude minor arterials and collector streets. Some agencies may choose to base their CMS network on the network they use for...
transportation planning. One method for selecting a workable network is described below.

1. Array roadway links in descending order based on average daily traffic volume (ADT).
2. Calculate the product of the ADT and the link length.
3. Accumulate the product until a particular percentage of the vehicle-miles of travel (VMT) is exceeded. A suggested figure is 60-70 percent.
4. Review the network for consistency and identify areas of inadequate coverage.

The resulting network will be an unbiased CMS network.

A procedure similar to the above might also be used to identify the state CMS network. An alternative suggested by representatives of some state highway agencies contacted in the State-of-the-Practice Review is to use the National Highway System (NHS) as a base and to supplement it with other important rural and intercity roads.

The identification of the initial CMS network is an important task in the CMS Program. However, changes in the transportation system and urban growth may necessitate modification of the CMS network. Thus, each agency should have a formal procedure for updating the network as changes take place in the land use or transportation system. It is recommended that the metropolitan planning organization formally adopt the CMS network. Changes in the adopted network should then only be permitted by a majority vote of the advisory committee.

**DEFINITION OF CONGESTION**

It is imperative that all agencies involved in developing a CMS use a definition of congestion based on the same measurement parameters. Public officials often have difficulty understanding how congestion measurement techniques, applied along one section of roadway, yield different LOS values. A single definition eliminates these discrepancies in the results, and also facilitates the comparison of congestion on continuous major roadways running through adjacent jurisdictions.

**Measures Used to Define Congestion**

Each MPO should be responsible for selecting the congestion level considered to acceptable for their area. The selected definition of congestion should be comprehensive enough to measure the extent, severity and duration of unacceptable congestion.

Freeway congestion is after being defined by speed and direction. For example, unacceptable congestion may be a speed of less than 35 mph for a period longer than 15 minutes. The comparable travel rate is 1.71 minutes per mile (per kilometre). The ratio of volume to "acceptable flow rate" is greater than 1.0 (where, for example, "acceptable flow rate" is 1500 vph/ lane).
Definitions of congestion being used for arterial streets include the following: intersection v/c ratio ≥ 0.85; LOS based on calculated intersection delay; observed volume greater than some "acceptable" flow rate where the acceptable flow rate depends upon cross-section, traffic control, intersection design, access, etc. (for example > 1,000 vph/lane).

While most agencies are currently using LOS to measure congestion, the Congestion Management State-of-the-Practice Review and Quantifying Congestion found that agencies familiar with LOS, have decided that it is inappropriate because, among other areas, it is not applicable in multimodal situations, it can produce confusing results, and is difficult to apply on an areawide basis.

The Best Measures of Congestion

Of the various possible measures of congestion, travel rate (minutes per mile or minutes per kilometre) is probably the most universal. It applies equally to transit, ferries and auto modes, if the one accounts properly for the access times for each mode. Also, the characteristics of travel rate (normal distribution) allow it to be easily evaluated statistically and travel rates can be added (averaged) to develop a subarea wide measure of congestion. The skewed distribution (speeds are not distributed equally about the average speed) of speeds make the application of statistical measures complicated. Further as the travel rate increase, the system is becoming more congested. For these reasons travel rate is the recommended multimodal measure of congestion. Where transit is not significant, the congestion index (volume divided by acceptable flow rate) is a suitable and readily obtainable measure of congestion.

The urban transportation planning modeling process is capable of providing the information so that these measures of congestion can be used for forecasts as well as monitoring as required by the ISTEA. To fully define congestion, the network should be analyzed on three levels: spot or intersection, corridor, and subarea or areawide. Calculated delay or v/c ratios can be used to define congestion at intersections or spot locations. The best indicator of congestion along corridors is travel rate (travel time per unit of distance, i.e. minutes per mile). A weighted average of travel rate will work well on the subarea/areawide level. A subarea/areawide measure of congestion of volume divided by acceptable flow rate can be obtained by weighting the individual ratios by the VMT on each link.

MONITORING THE CMS SYSTEM

The ISTEA clearly states that long term monitoring of the congestion on the designated CMS network is expected. The monitoring of congestion must be integrated with the other management systems for efficient data collection and processing. This suggests that to the degree possible, the system definitions for the four interrelated systems should have common boundaries.
A relatively large CMS network may require that data be sampled at representative points. To control data collection cost, the number of sample points should be as small as practical and still be representative of the CMS network. The following guidelines are suggested:

1. Freeways - Segments which are consistent in cross-section and traffic volume but not exceeding five miles in length.
2. Arterial Streets - Ten percent of the links or nodes including those in proximity to major traffic generators. Street segments should be no more than three to five miles in length and representative of all arterial streets in the network.

Since long term monitoring of the congestion on the CMS system is required, great care must be used in the selection of the data collection locations. The data collection cost will be incurred every one to two years for the indefinite future. A heavy emphasis on the selection of the CMS network and the data collection system in the first year will pay big dividends in future years.

The CMS network is the backbone of the congestion management system data collection and analysis process. Monitoring should be coordinated with the other five management systems (safety, intermodal, public transportation, pavements, and bridges). Before any decisions are made on the network or the data collection system, serious questions must be asked regarding the use of the data that are to be collected. Failure to plan the monitoring component of the CMS carefully will result in added cost and delays in the future.

Data Collection Frequency

Depending upon the measure of congestion selected and the renewal cycle of the TIP, the frequency of the traffic monitoring activity will vary. For a one year renewal cycle of the TIP, annual monitoring studies will be needed. If a two year renewal cycle is used on the TIP, then traffic monitoring studies on a biannual basis will be sufficient to track the changes in congestion on the designated CMS network.

Monitoring Costs

The cost of monitoring congestion depends upon the measure of congestion selected for use. Travel time related measures typically involve test vehicles driven through the system periodically. Travel time studies on the freeway of a moderate size community would involve the commitment of about $20,000 per year, based on the limited amount of information available.

Travel time studies on arterial streets appear to be somewhat less costly. The limited data available suggest that a cost in the range of $500 per mile should be expected for each data collection period.
Automated data collection systems reduce the man power necessary to collect the data. The initial cost of the automated system is substantial. Typical costs for automated data collection are about $120,000 per mile initial cost and $10,000 to $12,000 per mile annual cost should be expected. This system includes the field hardware at two mile intervals on the arterial system and five miles on freeways; the control center and the communications network to transmit the data to the control center. This cost structure assumes that freeway ramp control facilities are in place or will come on line with the automated data collection system and bear a large portion of the total cost of the system.

Data to evaluate the level-of-service for an intersection costs $400 to $600. Assuming that data are collected at 3 mile intervals on arterial streets, the expected cost per mile would be $130 to $200 per mile for each data collection period. Volume/capacity ratio analysis requires the same data.

The reader is reminded that monitoring costs are continuous. Any effort in the planning stages that will save money on the data collection will pay off many times in the coming years. It is also critical to remember that future congestion levels must be forecast.

Thus, the ease and cost of projecting the variable used in the measure of congestion should be a major consideration in its selection.

DEVELOPING AND IMPLEMENTING A CMS

While CMS is a specific requirement, it relates directly to a variety of statutory and regulatory requirements as well as the other five management systems required by ISTEA legislation. Other factors, such as growth management and concurrency requirements, will influence the structure and implementation of a CMS in some states.

The primary purpose of CMS is to provide additional information needed to make effective decisions on the use of limited resources to protect the investment in and improve the effectiveness of the existing and future street and highway network. The CMS must provide overall measurement and monitoring of mobility - not just roadway performance. This approach is necessary because many of the decisions relative to the roadway system will directly affect bus transit operators and goods movement by truck.

Responsibilities

ISTEA requires that states institute a statewide planning process, develop a statewide transportation plan and prepare a statewide transportation improvement plan. It also makes each Metropolitan Planning Organization (MPO) responsible for developing, in cooperation with the state and transit operators, a long range transportation improvement plan for its area.
ISTEA also makes the state responsible for the development and implementation of the six management systems. In metropolitan areas, the systems must be developed and implemented in cooperation with the MPO. In addition, MPO’s with a population greater than 200,000 are Transportation Management Areas (TMA’s). Each TMA must develop and implement a congestion management system for their area in conjunction with the state congestion management system. While the CMS, and other management systems, must be implemented on a statewide basis, the state may define subsystems within the state and delegate responsibility for development and implementation of the CMS to local agencies.

If the management systems are to result in better decisions relative to the used and improvement of streets and highways, they will need to be integral to the planning process, as illustrated in Figure 2. This is a specific requirement for areas designated as TMA’s. Integration into the planning process is equally applicable for MPO’s which are not in a designated TMA. This is because the MPO has the primary responsibility for the metropolitan transportation planning process and development of the long range transportation plan. Also, the urban transportation modeling process will be the basis for the forecasts of the location and severity of future congestion required by the ISTE A. However, the ISTE A specifies that the state highway agency (SHA) has the ultimate responsibility for the CMS, as well as the other management systems. Close effective cooperation between the state DOT and the MPO must also continue through integration of the metropolitan TIP into the STIP. The local governmental jurisdictions will also need to be fully integrated into the CMS, the transportation planning process and development of the TIP since these municipalities and counties will be primarily responsible for implementing the TCM and land use controls.

CMS Structure

The general steps in developing and implementing a CMS is given in Figure 3. Once the boundaries of the local congestion management areas have been established, the responsibilities of the various agencies (state, TMA/MPO cities, counties, and transit operators) must be agreed upon. The DOT rules allow considerable flexibility in this regard. Agency roles for implementing a CMS in metropolitan areas are suggested in Table 2.
Results from the previous meeting(s) need to be distributed in advance of subsequent meetings in order to help gain consensus.

CMS STRATEGIES

CMSs are developed to maintain or improve mobility and air quality through the development of a CMP. Each CMS will develop a CMP consisting of strategies aimed at relieving existing and anticipated traffic congestion. The CMS directors must be adequately informed on the strategies in order to make decisions on the selection and implementation of regional policies, programs, and projects which make efficient use of the existing transportation infrastructure.

CMS strategies are comprised of both TDM and TSM strategies. TSM strategies reduce congestion by utilizing the existing transportation infrastructure to provide efficient and effective traffic flow. TDM strategies reduce congestion and improve air quality by reducing single occupant vehicle (SOV) travel.

Congestion is obviously worst during the morning and afternoon peak periods. There are currently two fundamental methodologies aimed at improving traffic flow during these congested periods. The first calls for an increase in roadway capacities along congested roadways. The second methodology attempts to shift trips out of the peak periods and into off-peak periods. Compared to increasing capacity, through either the addition of general purpose lanes or the use of TSM strategies, shifting trips into off-peak periods is often more desirable due to it's lower cost and ease of implementation.

The strategy of shifting trips is successful at diverting up to approximately 30% of work generated trips out of the peak periods. Trying to shift more than 30% of the trips requires a substantial rise in costs with only limited results.

There are literally hundreds of congestion management strategies, however the majority of them can be categorized into the following areas:

- TDM measures
- Traffic Operations Improvements (traffic surveillance and control, improved signal systems, motorist information systems and intersection improvements).
- HOV measures (public transit improvements, HOV lane provisions, guaranteed ride home programs, and employer trip reduction ordinances).
- Congestion Pricing
- Land use management and activity strategies.
- Access management techniques.
- Incident management strategies.
- IVHS applications.
- Additional general purpose lanes.

TMA's are designated as either nonattainment or attainment areas depending on whether the
area meets National Ambient Air Quality Standards (NAAQS) for either carbon monoxide or ozone. In addition to reducing VMT, nonattainment areas are required to improve air quality by lowering vehicle emissions.

TDM strategies to reduce VMT and reduce emissions in nonattainment areas can be grouped into the following categories:

- Improved alternatives to SOV travel (transit, car and vanpooling, park and ride lots, walking and bicycling provisions).
- Incentives for alternative mode use (ramp priority, preferential parking, financial incentives, reduced parking rates for non-SOV, trip reduction ordinances).
- Disincentives for SOV travel (increased parking rates, limited parking, SOV tolls, trip reduction ordinances).
- Work hours management (flexible work hours, staggered work hours, telecommuting, 4-day work week).

TSM strategies are specifically designed to improve the traffic operations of the existing roadway infrastructure without the addition of general purpose lanes. This is achieved through improved management of the supply and use of transportation facilities. TSM strategies can be implemented as spot, corridor, and areawide measures.
Organizing the Players

As illustrated in Figure 4, several governmental and stakeholder organizations will have an interest in the development and implementation and administration of the congestion management program. It is important to develop an understanding of the objectives of and commitment to the congestion management system to be implemented. In order to achieve this it is suggested that in addition to the MPO Policy Committee, the three following groups be organized.

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Table 2. Possible Roles for Elements of a Congestion Management System

<table>
<thead>
<tr>
<th>CMS Activity</th>
<th>State DOT</th>
<th>MPO</th>
<th>TMA</th>
<th>City</th>
<th>Transit Operator</th>
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<td>Identify Performance Evaluation Standards</td>
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<td>Provide Forum &amp; Conflict Resolution</td>
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<td>Select Measure</td>
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<td>Select Standards</td>
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<td>Define the CMS Network</td>
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<td>Identify Data Needs</td>
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<td>Develop Definitions &amp; Submission Protocol</td>
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<td>Define Methodology</td>
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<td>Provide Traffic Counts</td>
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<td>Provide Transit Data</td>
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<td>Perform Baseline Evaluation</td>
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<td>Identify Baseline Deficiencies</td>
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<td>Performing Forecasts</td>
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<td>Identify Future Deficiencies</td>
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<td>Data Dissemination</td>
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<td>Maintain Database</td>
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<td>Identify and Evaluate Improvement Strategies</td>
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<td>Identify Candidate Strategies</td>
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<td>Evaluate Strategies</td>
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<td>Evaluate Implmnt Strategies</td>
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C: Coordinate - Combine information and data collection, perform analysis or provide central focus

P: Participate - Coordinate information, data, or analysis or performing specific implementation actions

- Lead - Initiate action or have primary role in achieving results

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A-12
The stakeholders group consists of a wide range of diverse interests which are users of the roadway system or are impacted by congestion management strategies. Real estate developers, large employers, trucking companies and shippers are among those directly affected.

Experience has shown that in order to obtain careful consideration in the initial stages of developing a CMS, meetings with the MPO Policy Committee should be scheduled with the CMS as the only agenda item, or as the main item on a very limited agenda.

Experience has also shown that the following guidelines be followed in order to obtain effective participation from the decision makers and stakeholders groups.

- Use direct personal contact followed by a mailed invitation.
- Clearly state the objectives, clearly identify what is expected of the individual and the group, and the expected results of their participation.
- Meeting dates need to be established several weeks in advance to give individuals schedule flexibility.
- For each meeting a specific, well defined agenda needs to be distributed in advance together with any information with which participants should become familiar. Agenda and schedules need to be rigorously followed.
- At least two meetings of the group are needed to obtain meaningful input.