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CONGESTION MANAGEMENT SYSTEM STATUS -A NATIONAL OVERVIEW

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Congestion Management System Status--A National Overview

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May 1996

Introduction

One of the most prevalent images regarding congestion management I can recall was developed two years ago, after the publication of the Management Systems Interim Final Rule. Copied widely, it described not what the Congestion Management System (CMS) was intended to be, but what it should not be. Foremost among the factors on this list was the following: "The CMS is not a massive data collection effort." Of course, the implication was that we were in danger of embarking upon another effort to collect information for no purpose.

I am therefore particularly glad to be present at NATDAC 96 to present some of the positive consequences of the management systems in general, and of the congestion management system and its data elements in particular. Rhetorical attempts aside, the management systems--specifically the performance-based systems--share a common characteristic with data; they cut across the milieu of strategic, systems, project, and operational planning activities. Ultimately, they provide the basis for more informed, and hopefully better, decision-making. This session is intended to demonstrate this relationship and highlight the resultant benefits.

The Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 legislated the development and use of congestion management systems for all States and metropolitan planning organizations (MPO) to gather information, analyze, and report on operating conditions of the transportation system. As part of the National Highway System Designation Act of 1995, these requirements were scaled back. Congestion management systems are now essentially optional at the statewide level and for urban areas below 200,000 in population. Transportation management areas (TMAs) must still comply with the CMS mandate.

Despite this relaxation of requirements, most transportation agencies at the statewide and small urban level are continuing with the development and implementation of congestion management activities at the same rate as their TMA counterparts. A recent survey by FHWA indicated that about seventy percent of all state transportation departments plan to remain actively engaged in CMS activities.

This finding **is** largely attributable to a widely expressed sentiment that congestion management activities simply make good planning sense. But their continuation can also **be** ascribed to the institutional improvements they have fostered. Of these improvements, data collection and sharing is one of the activities most often cited by agencies asserting their rationaIe for continued congestion management development.

This overview will review the status of congestion management development efforts at a national level, examine the rationale for its continuation, and discuss the overall benefits that have been attributed to the CMS to-date.

Success Stories

There are three basic ways to define success in the cross-cutting context of congestion management activities within the planning process:

Project Level improvements. This area reflects the impacts of congestion management on moving people and goods more efficiently and reliably. It covers visible improvements in the reduction of congestion, or describes the impacts of improved system efficiency through mobility and accessibility enhancements. To-date, success at this level is generally anecdotal since most improvements have not evolved out of the CMS framework and project developers have not had sufficient time to measure project impacts.

Program Level improvements. Many States and MPOs indicate that a wide range of benefits are being realized through the influence of the CMS in the decision making process. By strongly supporting other related initiatives brought to the planning process (such as sustainable development, livable communities, and public-private partnerships), decision makers now consider not only the addition of highway lanes to solve capacity problems, but a broader array of system and demand management alternatives that address transportation deficiencies and support regional growth and development.

Institutional Improvements. Congestion management activities have expanded well beyond the concept of an isolated decision support system focused on how to move more cars on our highways, to become integrated into the complex arena of planning and operational issues being addressed by State and metropolitan planning activities. As a result, many practitioners have found integration and cooperation a keystone to successful program development. Improved ties have been established within large bureaucracies, as well as with new, nontraditional partners.

A prime factor motivating these advancements is the need for better information to support the planning process. A 1995 AASHTO survey showed that nearly 95 percent of the States plan to develop or improve automated tools in response to the implementation of ISTEA management systems. States expect to streamline their overall data collection program while improving the accuracy and timeliness of data processing and providing more reliable information for decision making. Of greatest importance is the ability to coordinate procedures that ensure the comparability of analytic results, to improve the ability to access, transfer, and display data, and to improve the effective and consistent use of management system information.

Some examples of these efforts are summarized below.

+ A technical coordinating committee in the Massachusetts Highway Department has agreed to use coordinated locational reference systems in order to share data between agencies. The department's Bureau of Transportation Planning and Development will provide the base map for GIS data coverage of all the management systems.

+ New Jersey uses a GIS database translatable between Transcad, Intergraph, and MapInfo, providing a common point of departure for screening applicable congestion management strategies.

+ New York State has established data collection programs and software platform for facilities, travel, projects, and growth forecasts. This enables the State to substantiate the need to implement congestion mitigation strategies by estimating congestion costs and identifying expenditure patterns for alternative strategies. New York City credits the CMS with systematizing a somewhat haphazard approach to data collection and performance monitoring.

+ Dallas-Fort Worth have used CMS data to facilitate public and private stakeholder involvement in planning, advocacy, and implementation of mobility enhancement projects.

+ Washington, DC has developed a multi-jurisdictional CMS data clearinghouse for use in performance monitoring, travel forecasting, and other transportation related activities.

+ Michigan has developed an agency-wide information management and decision support system. This system links projects to performance based needs, thus enhancing program accountability. The system extends beyond MDOT's domain. For example, the CMS portion of database will be expanded to cover local roads, transit data, and incident data. Performance measures have been established and can be adjusted by the user. Areawide performance measures will be developed that link performance standards to goals and enable the tracking of system performance over time. Data has been a catalyst for this coordination.

+ Arizona is utilizing HPMS data in developing its CMS database and software system.

+ The Puget Sound Region in Washington State is investigating the use of its advanced travel management center to collect traffic data and make it available through a regional clearinghouse accessible via the intemet.

+ Oregon plans to develop a "ISTEA Shared Information System" (ISIS) to coordinate data resources in the agency. The system will form the basis for a statewide congestion inventory that will be used for project screening and selection.

Impediments to Success

A recent internal FHWA white paper identified the following barriers to improved performance based planning supported by congestion management activities.

+ Awareness and understanding of the scope of opportunities that can be derived from improved attention to transportation operations.

+ Organizational cooperation, including ownership and control of data and resultant analyses.

+ Limited funding to implement a broad range of actions restricts the potential interest of agencies and decision makers.

+ A lack of empirical data at the systemwide level that reveal specific transportation management deficiencies.

Of particular interest to this conference is the ability to use data to leverage progress in these areas. For example, data sharing is the most often cited example of how diverse organizations begin to create institutional ties that advance the scope of regional planning. In addition, savings offered by the coordination of data resources are being used to further program development. Indirectly, management concerns over the burden of data collection and reporting is being allayed.

Data Related Research

In spite of recent successes and in light of the barriers noted above, a great deal of work remains to be done. FHWA research within the congestion management planning arena is expected to address the following data-related areas over the next several years:

+ Procedures for managing non-work and nonrecurring congestion, including data to support methods that estimate the frequency and duration of incidents, as well as the impacts of incidents.

+ Data sources and methods for multimodal performance monitoring that permit a clearer understanding of the relative benefits of competing transportation system improvements.

+ Congestion management strategy effectiveness, including data on the costs, benefits and impacts of congestion management strategies, and traveler responses to advance information on system performance.

+ Advancements in data collection methods for travel time, vehicle occupancy and related performance measurements in real time.

Wrap-Up

This session examines a hodgepodge of CMS data related issues. In order to follow-up and fill out my rather broadly painted national overview, Mike Shamma of the New York State DOT will provide a more focused discussion on why New York embraced the CMS and how it is enhancing their planning, programming and operations activities. Bili Schwartz of Cambridge Systematics will present the results of a recently completed FHWA research project by describing some of the analytic methods (i.e. performance measures) available to support congestion management activities within the statewide and metropolitan planning processes. Robert Benz of the Texas Transportation Institute will then examine one specific class of performance measures -- those based on travel time or speed. Finally, Jeff Jensen of the University of Nevada at Las Vegas will examine some of the ways to evaluate and portray congestion using geographic information systems.

NEW YORK STATE CONGESTION MANAGEMENT SYSTEM

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NEW YORK STATE CONGESTION MANAGEMENT SYSTEM

ABSTRACT=

Congestion is defined as excess delay in the movement of persons and goods beyond a limit that can reasonably be judged to be tolerable. For example, the delay beyond the reasonably tolerable limit of 40 seconds per vehicle at a traffic signal is excess delay.

Excessive congestion in New York State, as in other parts of the nation, is a very serious problem for people and freight. Intolerable levels of congestion waste the time of employees traveling on business and goods being shipped. Steps must be taken to reduce this economic waste and put the wasted resources to productive uses. At current levels, congestion costs users of New York's freeway system more than $1.5 billion annually.

The New York State Congestion Management System (NYS CMS) identifies the locations and magnitudes of present and future congestion problems and provides a means to evaluate alternative solutions to identified congestion problems on an annual cycle. The results of NYS CMS analysis are to be "considered" in the development of metropolitan and statewide plans and programs, according to Federal Regulation. NYS CMS includes analysis methods at the network-system-overview level and the project-corridor-detail level.

The measures of performance for the transportation system and the measures of accomplishment for actions to reduce congestion are excess person-hours of delay, excess vehicle-hours of delay, **and** excess freight ton-hours of delay. Excess delay has monetary costs including the "value of lost time of persons", the "value of lost productivity of freight hauling equipment and drivers", and the "value of fuel used at idling conditions in traffic jams".

NYS CMS will report on the calculated performance measures for past, present, and future years; and for alternative scenarios of growth and programs. The achievements of transportation plans and programs are the changes in performance that occur as a result of implementing congestion reduction actions.

NEW YORK STATE CONGESTION MANAGEMENT SYSTEM

I. INTRODUCTION

Excessive congestion in New York State, as in other parts of the nation, is a very serious problem for people and freight. Intolerable levels of congestion waste the time of employees traveling on business and goods being shipped. Steps must be taken to reduce this economic waste and put the wasted resources to productive uses. The goal of the Congestion Management System (CMS) is to put in place a process that systematically addresses passenger and freight congestion across New York State in a comprehensive, efficient, coordinated and cooperative manner.

Current practices, organizational structures, and skills already devoted to reducing congestion and improving mobility in New York State are the foundation for implementing New York State's CMS. Major actions have been taken to enhance the ongoing CMS activities including implementation of the Department-wide mobility initiative. This initiative was approved during 1990 and is being guided by a work plan that was established in 1991 and is periodically amended. The Department's Goal Oriented Program (GOP) annual update process is the basis for enhancing New York State's CMS. This process is currently being expanded to address local system and transit mobility needs.

CMS enhancement will be staged in terms of both system coverage and scheduled implementation of upgraded technical tools. The strategy will move New York State's CMS from where we are today ("as it is" or "crawl" stage) to the ultimately desired state ("run" stage) in an orderly incremental manner.

Implementation of the tasks identified in the work plan for CMS will assure that broader uniform and structured CMS results will be available to decision makers to assist in: identifying congestion problems; evaluating congestion management alternatives; refining agency, transportation plan, and program goals; and selecting the most cost effective congestion management strategies.

II. EXISTING SYSTEM

CMS is a systematic approach to identify problem areas and assist in selecting effective treatments to reduce congestion. The Department has an existing CMS for the highway facilities it owns and operates. The Department's existing method includes all components required by Federal Regulations published in the Fall of 1993, including: identification of needs, evaluation of alternative strategies, implementation of effective strategies, and monitoring of effectiveness of implemented actions. It does not, however, include coverage of all congested facilities and services, such as fixed guideway mass transit.

New York State Congestion Management System

The Goal Oriented Program (GOP) development and approval process is the framework for the system. Network performance and program accomplishment are estimated using "excess vehicle-hours of delay per weekday" with the Network-Level Delay Model.

"Interim CMS" requirements have been in effect since July 1993 in urban areas with air quality non-attainment status and population greater than 200,000. Federal-aid design approval for adding a general-use lane requires giving consideration to reduction of single occupant vehicle use and making concurrent commitment to facility management, transportation system management actions, and travel demand management actions. Where these requirements are applicable, Final Environmental Impact Statements address them.

Currently, New York State's twelve Metropolitan Planning Organizations (MPOs) have embarked on addressing their congestion reduction needs in a variety of ways. Their procedures are used for evaluating, as candidates for Federal-aid funding, the congestion-relief proposals made by their various member transportation agencies. All twelve are considering mobility improvement needs in their long-range plans, using varying methods and presentation styles.

In urbanized areas with population greater than 200,000, which are defined as Transportation Management Areas (TMAs), MPO's are complying with Federal "phase-in mandates", which took effect in late 1993. These mandates require TMA MPOs to identify the most serious locations of congestion and develop actions to address them.

III. FEDERAL REGULATION HIGHLIGHTS

During 1994 and 1995, Federal Regulation required that each state shall develop, establish, implement and maintain a congestion management system for the purpose of establishing a systematic process for selecting and implementing cost-effective strategies that work to meet the goal of preserving and improving the efficiency of facility operations.
During 1995, title 32 USC 303 was amended to give the states the option not to implement a CMS in whole or in part. New York is however continuing to implement a CMS, using the former Federal mandates as quidelines.

A. General Requirements

The regulation required results of the CMS analyses to be considered in development of metropolitan and Statewide plans and programs. It also required CMS coverage of all areas of the **State** where congestion is occurring or is expected to occur. All transportation corridors or facilities with existing or potential congestion should be identified and an assessment of the level of congestion should be made on a continuing basis. In both metropolitan and nonmetropolitan areas, consideration should be given to strategies that reduce single occupant vehicle (SOV) travel, and improve existing transportation system efficiency. For TMAs in non-attainment status, the CMS should provide an analysis of all reasonable travel demand management (TDM) and operational management strategies for corridors where an increase in capacity of general purpose lanes is proposed. In addition, CMS strategies should be coordinated with the development of transportation control measures of the State's implementation plan (SIP) for air quality.

The Regulation also stated that the CMS must be developed in cooperation with MPOs and other affected organizations. Performance measures to monitor congestion should also be established cooperatively with MPOs or local officials in consultation with the operators of major modes of transportation in the coverage area. Based on this requirement, the Department interpreted that the Federal intent was that CMS should include a transit congestion element for fixed guideway and rubber tire systems.

B. Specific Data Collection and Implementation Requirements

The following specific requirements were stated in the regulation:

- CMS must use a continuous program of data collection to determine congestion duration and magnitude and evaluate the effectiveness of implemented actions. The Department's traffic monitoring system for highways will provide much of the needed highway data. The data needed from transit operators is currently being identified.

- Data collection for dedicated transit rights-of-way shall include, as a minimum, the number of vehicles and ridership data at the maximum load points for the peak period, in the peak direction and for the daily time period.

- Provisions of a feedback mechanism by which treament performance is measured and fed back into the system is also required.

- The State must develop a work plan that identifies major activities and responsibilities.

IV. PROPOSED SYSTEM

The CMS work plan proposes that MPOs would cover congestion in metropolitan areas while the Department would cover congestion throughout the rest of the State. It is important to recognize that the MPOs will not be locked into a "one size fits all" system. The Unified

Planning Work Program (UPWP) of each MPO will specify the roles and responsibilities of MPO member agencies for CMS data collection, congestion reporting, strategy evaluation, and candidate project identification, to consistent statewide administrative and technical guidelines and standards. The results of the CMS will be a uniform core package of information to support transportation planning and programming decisions at all locations within the state, including consistent performance measures and selection criteria. Additionally, appropriate CMS results to support transportation planning and programming decisions by agencies that operate congested facilities and services will be developed and implemented to their specification, as resources allow. The Department will work cooperatively with the MPOs to develop an overall CMS architecture. The Department will also develop technical tools (e.g. transit congestion measures) and provide assistance in automation activities for use by MPOs.

Figure 1 illustrates the framework of the Department's proposed CMS. Each process box is a major component of the system as required by regulation or is an associated activity that must use CMS outputs (e.g. agency goals). The remaining sections of this Chapter describe each process.

A. Congestion Performance Measures

Concensus was built with MPOs and local officials on use of excess delay for vehicles, persons, and goods as performance measures. Excess delay is the delay beyond a reasonable limit that can be tolerated. For example, the delay beyond the tolerable limit of 40 seconds per vehicle at a traffic signal is excess delay. In addition, the Department has formed a transit subcommittee of the CMS technical committee to recommend transit congestion measures. This consensus building effort also reached to defining cooperative CMS responsibilities of the Department and the MPOs.

The measures of performance for the transportation system and measures of accomplishment for actions taken to reduce congestion are excess person-hours of delay, excess ton-hours of delay for freight, and excess vehicle-hours of delay. Excess person-hours of delay are calculated from the share of vehicles that are used for transport of persons and the average occupancy rate of those vehicles. Excess ton-hours of delay are calculated from the share of vehicles that are used to transport goods and the average weight of freight carried per vehicle. Excess delay has monetary costs that incorporate the value of lost time of persons, the value of lost productivity of freight hauling equipment and drivers, and the value of fuel used at idling conditions in traffic jams. At current levels, congestion costs users of New York's freeway system more than $1.5 billion annually.

B. Collect Data and Identify Congestion

A decision has been reached to automate CMS upgrading with Pentium class personal computers, Windows 3.1 for user interface, dBASE 5.5 for Windows for calculation processes and data relationships, ArcView 2.1 for spatial analysis and visualization, and Quattro-Pro 6.0 for result presentation.

All operators of congested facilities and services, including fixed guideway mass transit operators and bus service operators, will need to assure that four major types of data are collected: facility or service inventory, travel traffic inventory, project inventory, and travel forecasts. The Department is now seeking statewide concurrence with Regional Planning and Program Managers (RppMs), MPO central staffs, and operators of transportation facilities and services on congestion identification and reporting. Identification of congestion is proposed to be accomplished annually using data submissions from agencies that operate facilities and services where congestion occurs . Transit bus occupancy data, where required, is to be collected by operators of the bus service.

The fully operational network-level CMS will identify and report congestion as follows:

- The CMS will use input from the Department's Sufficiency Rating File. The input includes data such as number of lanes, length of highway segments, access control, and functional class.
- Traffic volume input includes AADTs as well as hourly directional volumes.
- The speed limit is used as input.
- The CMS will cover three years of analysis: a base year (the most recent year for which traffic counts are available), the year subsequent to program implementation (five to seven years after the base year), and the year subsequent to transportation plan implementation (20 years after the base year).
- Future year CMS results will include two scenarios in a manner similar to state highway system calculations already being used as a part of the GOP process: the null (do nothing) scenario and the implementation scenario (implement program or financially constrained long range plan).
- The CMS will scan applicable agency databases regarding facilities and services, including mass transit, and select for further analysis only those records for which excess delay is forecast to occur in the year subsequent to transportation plan implementation.
- CMS will calculate expected congestion for the selected records resulting from the following four causes: demand exceeds capacity, traffic incidents, scheduled events or facility maintenance, and unscheduled facility or equipment failure. For recurring congestion the model will **use the Bureau of Public Roads Formula (Figure 2). For**

freeway incident related congestion the model will use the shock wave queuing theory (Figure 3).
- CMS will calculate two dollar values of congestion: one for average excess delay and another for the variance of prevailing congestion from day to day. The average dollar value equates to the maximum cost that can be justified for implementation of congestion reduction improvements.

CMS will be implemented in stages. The stages refer to the levels of refinement regarding facilities and services covered, the calculation of congestion, and the quality of the input data used.

Figures 4 **through** 6 **are examples of the kind of output results that may be viewed and used for** decision making.

C. Evaluate Congestion Management Alternatives

Appropriate consideration should be given to twelve strategies specified by Federal Regulation in the process of developing metropolitan and statewide plans and programs and Federal-aid "project selection for implementation" decisions. These strategies include, but are not limited to:

a. Transportation demand management measures such as car pooling, van pooling, alternative work hours, telecommuting, and parking management;

b. Traffic operational improvements such as intersection and roadway widening, channelization, traffic surveillance and control systems, motorist information systems, ramp metering, traffic control centers, and computerized signal systems;

c. Measures to encourage high occupancy vehicle (HOV) use such as HOV lanes, HOV ramp bypass lanes, guaranteed ride home programs, and employer trip reduction ordinances;

d. Public transit capital improvements such as exclusive rights-of-way (rail, busways, bus lanes), bus bypass ramps, park-and-ride and mode change facilities, and paratransit services;

e. Public transit operational improvements such as service enhancement or expansion, traffic signal preemption, fare reductions, and transit information systems;

f Measures to encourage the use of nontraditional modes such as bicycle facilities, pedestrian facilities, and ferry service;

New York State Congestion Management System

g. Congestion pricing;

h. Growth management and activity center strategies;

I. Access management techniques;

j. Incident management;

k. Intelligent vehicle-highway system and advanced public transportation system technology; and

1. The addition of general purpose lanes.

The CMS work plan proposes that the full implementation of the CMS assesses the applicability of each of these strategies at each problem location and identifies a sub-set of strategies that have potential to eliminate the excess delay in a cost-effective manner. It also proposes to use Geographic Information System (GIS) methods and traffic simulation software (e.g. TMODEL 2 , Tranplan, JHK System 2) to estimate mode choice. The effectiveness assumptions for each strategy will be based on existing technical tools. Purchase of software licenses with CMS funds for tools such as the Travel Demand Management Evaluation Model Version 2.2, (which has been developed by COMSIS and is being sold by McTrans) has been accomplished.

Major Metropolitan Transportation Investment Studies, also required by Federal Regulation, are an additional process where the required CMS consideration can be completed and documented. The Corridor Planning function within the Planning Bureau provides guidance, work plans, and **resources** for such studies.

D. Develop and Approve Transportation Plans and Programs

This step describes the processes used to develop and approve metropolitan, regional, and statewide transportation plans and programs. The Federal Regulation required that the results of the CMS and the other Intermodal Surface

Transportation Efficiency Act (ISTEA) transportation management systems be considered by decision makers at this step for five cases;

- Twelve MPO Long-range Plans,
- the Long-range Intermodal Statewide Transportation Plan,
- Twelve MPO Transportation Improvement Programs (TIPs),
- the Statewide Transportation Improvement Program (STlP), and
- Federal-aid “project selection for implementation decisions” within TIPS and the STIP.

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In addition, the Department plans to require consideration of the results of the ISTEA transportation management systems for two additional cases:

- Regional Comprehensive Plans, and
- the Goal Oriented Program (GOP).

The development of transportation programs includes:

- development of congestion/mobility program goals,
- estimation and allocation of funding resources,
- evaluation of candidate congestion/mobility projects,
- application of funding allocations to treating identified problems (bridge, pavement, safety and congestion) in a balanced and efficient manner,
- determination that the proposed statewide program is effective in achieving statewide goals, and
- program approval.

E. Evaluate Accomplishments

The CMS work plan calls for an annual report documenting congestion in NYS and evaluating accomplishments of implementing newly approved congestion reduction actions. The annual report will include a congestion history, forecasts to the capital program completion year and the long-range plan completion year, and the expected relative performance, per dollar invested, of strategies that are included in the metropolitan and statewide plan and program documents. This report would be prepared each Summer by the Department's Planning Bureau and will present the results of the March 3 1 program approvals.

The Department's Planning Bureau will work with its Regions to assure that short traffic counts are taken before and after implementation of selected mobility projects to determine their effects on traffic volumes by time of day. The Planning Bureau will also work with Regions and the Traffic Engineering and Safety Division to consider the results of Intelligent Transportation System actions and data.

In cases where innovative congestion management actions are implemented in a setting where their effectiveness can be determined by means of more extensive before-after studies, the resources for such studies (funding and consultant designations) will be recommended for approval. However, the Planning Bureau does not anticipate widespread before-after studies, because proposed widespread implementation of "priority treatment" strategy combinations is likely to make determinations of effectiveness for any one strategy impossible.

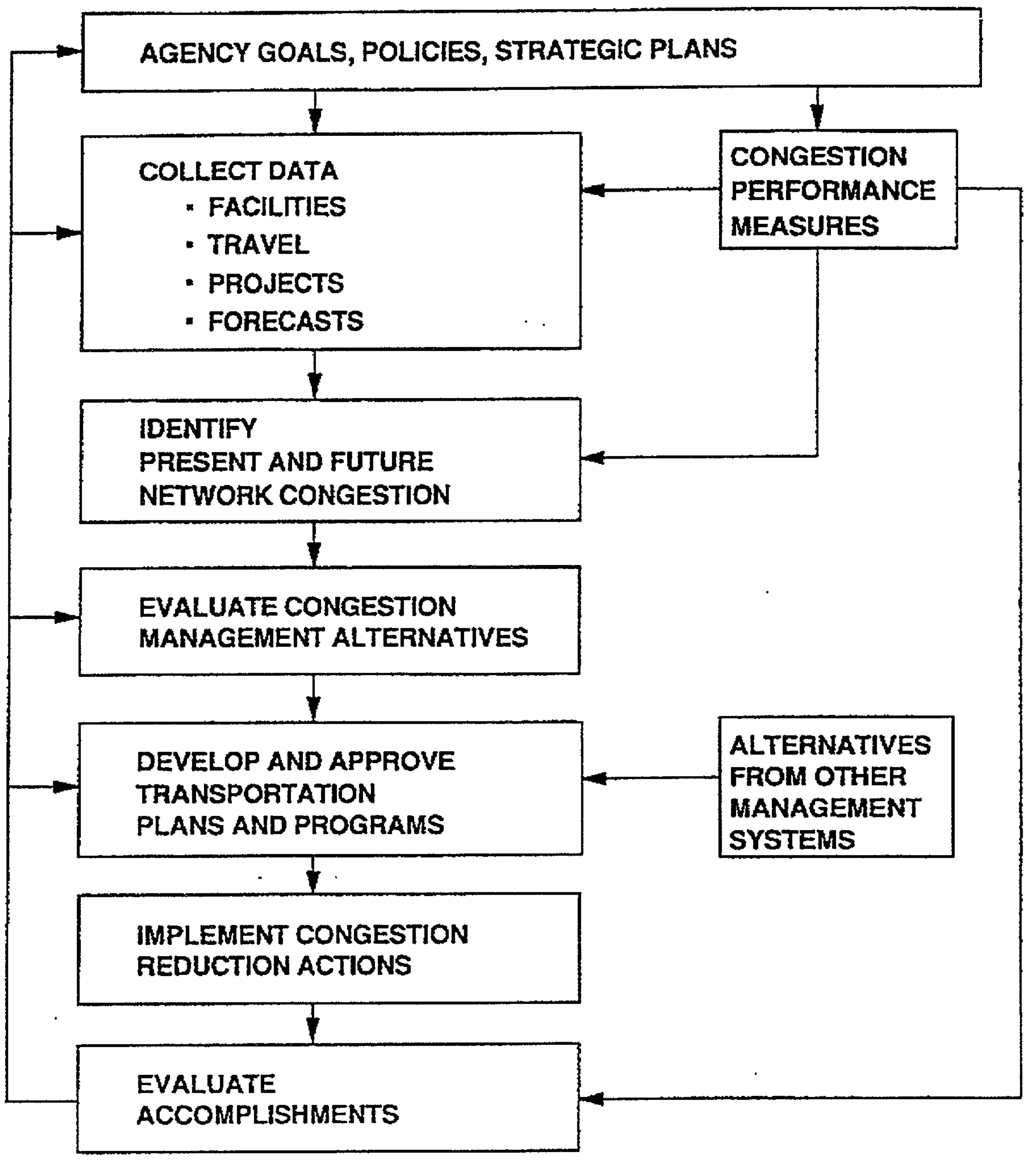
V. SUMMARY

In summary, Congestion Management in New York State has been and will continue to be a decentralized annual process accomplished by planning staff. CMS is a systematic approach to identify problem areas and assist in selecting effective treatments to reduce congestion. New York State has chosen excess delay and it's economic costs as it's performance measures. CMS results will be one consideration whenever transportation plans and programs are being developed.

New York State Congestion Management System

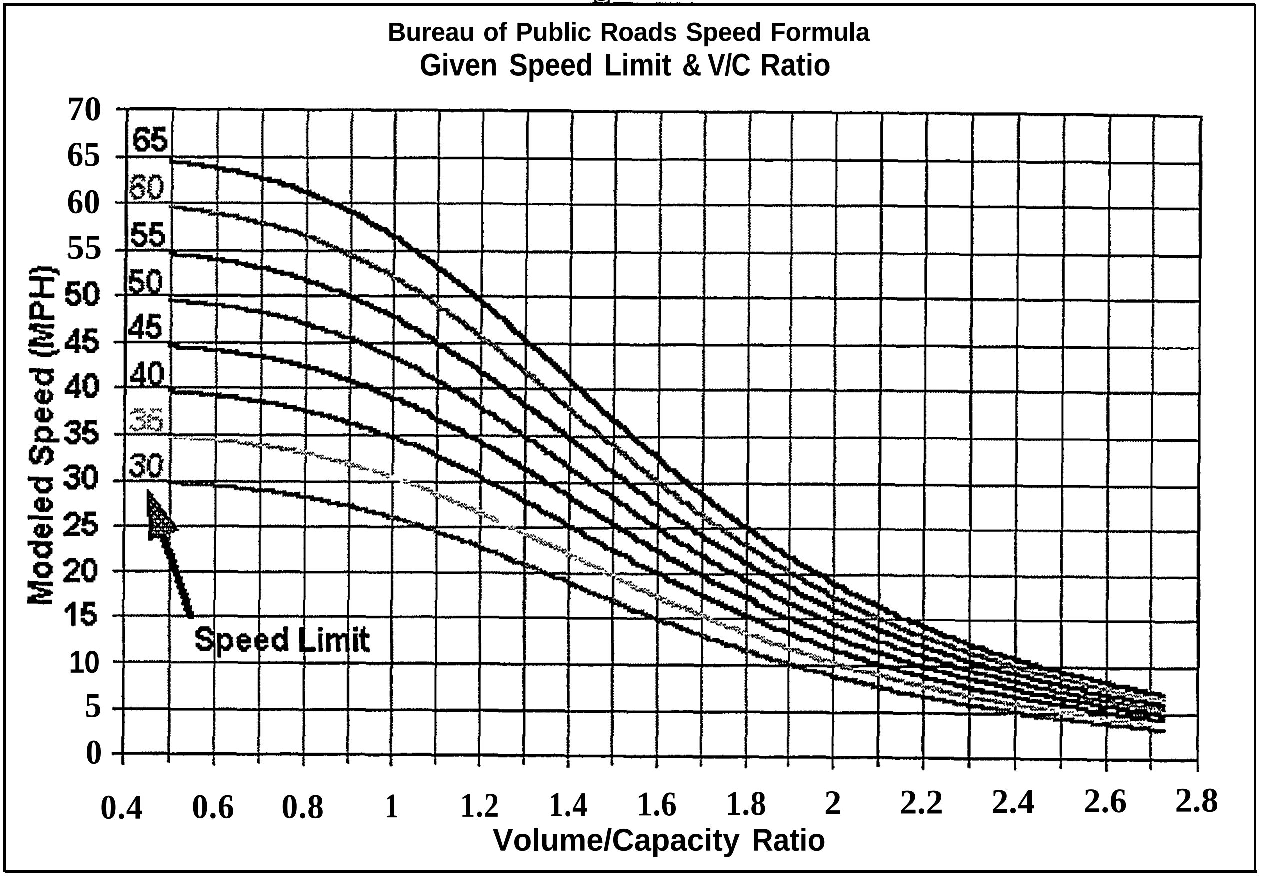
Figure 1

CONGESTION MANAGEMENT PROCESS



New York State Congestion Management System

Figure 2



New York State Congestion Management System

Figure 3

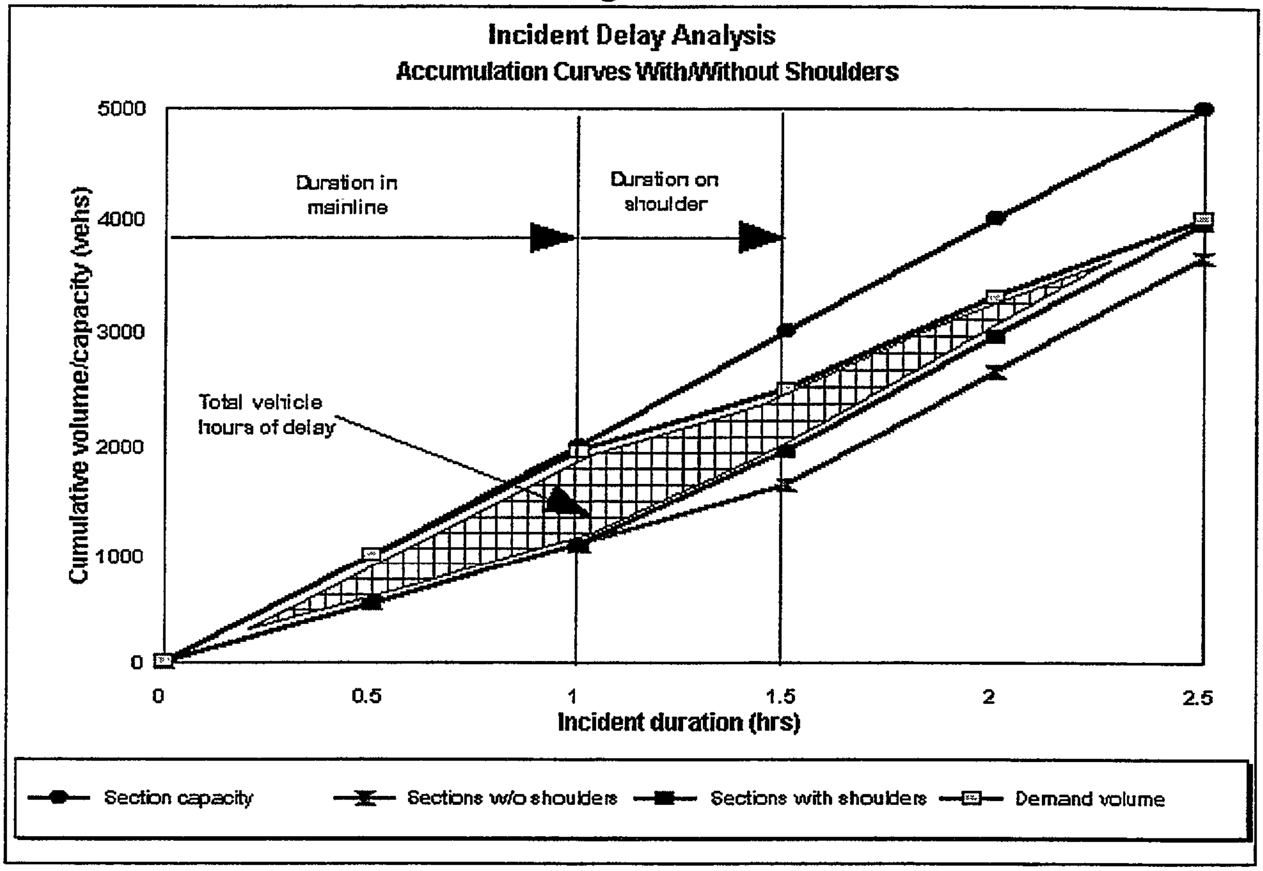


Figure 4

New York State Congestion Management System

PERFORMANCE OF FREEWAYS FOR 1994 WEEKDAYS

(Excluding NYS Thruway)

All Values Are In Millions of Dollars

Area of State	Cost of Wasted Fuel	Value of People's Wasted Time	Added Costs for Moving Freight By Truck	Total Economic Losses Caused By Congestion
Hudson Valley	$4.880	$49.458	$43.743	$98.081
Long Island	$45.069	$470.471	$240.975	$756.515
New York City	$29.314	$339.707	$199.585	$568.606
Upstate	$5.934	$58.865	$66.740	$131.539
Total	$85.197	$918.501	$551.043	$1,554.741

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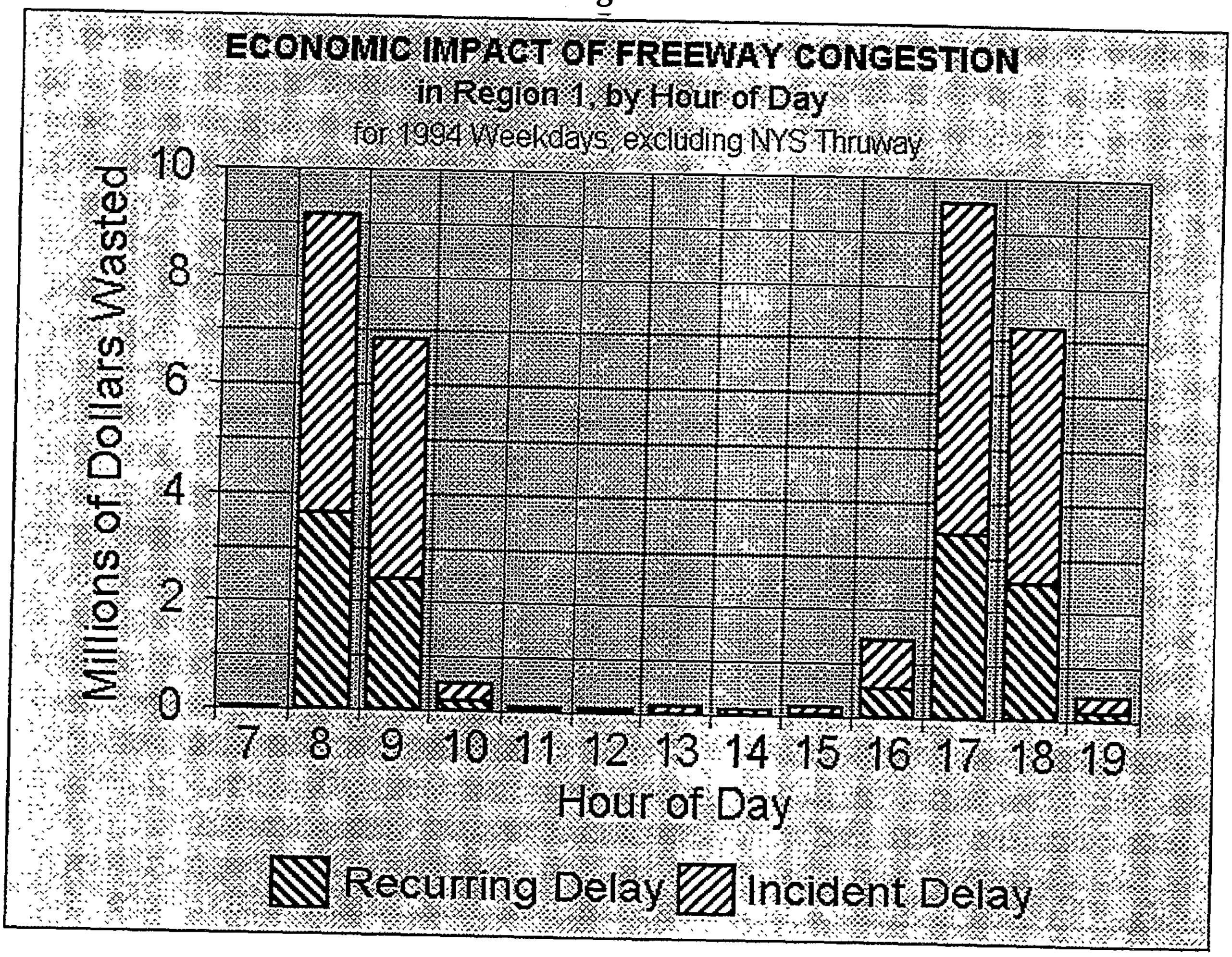
Source: Calculations with Peak Hour Factor of 0.95

New York State Congestion Management System

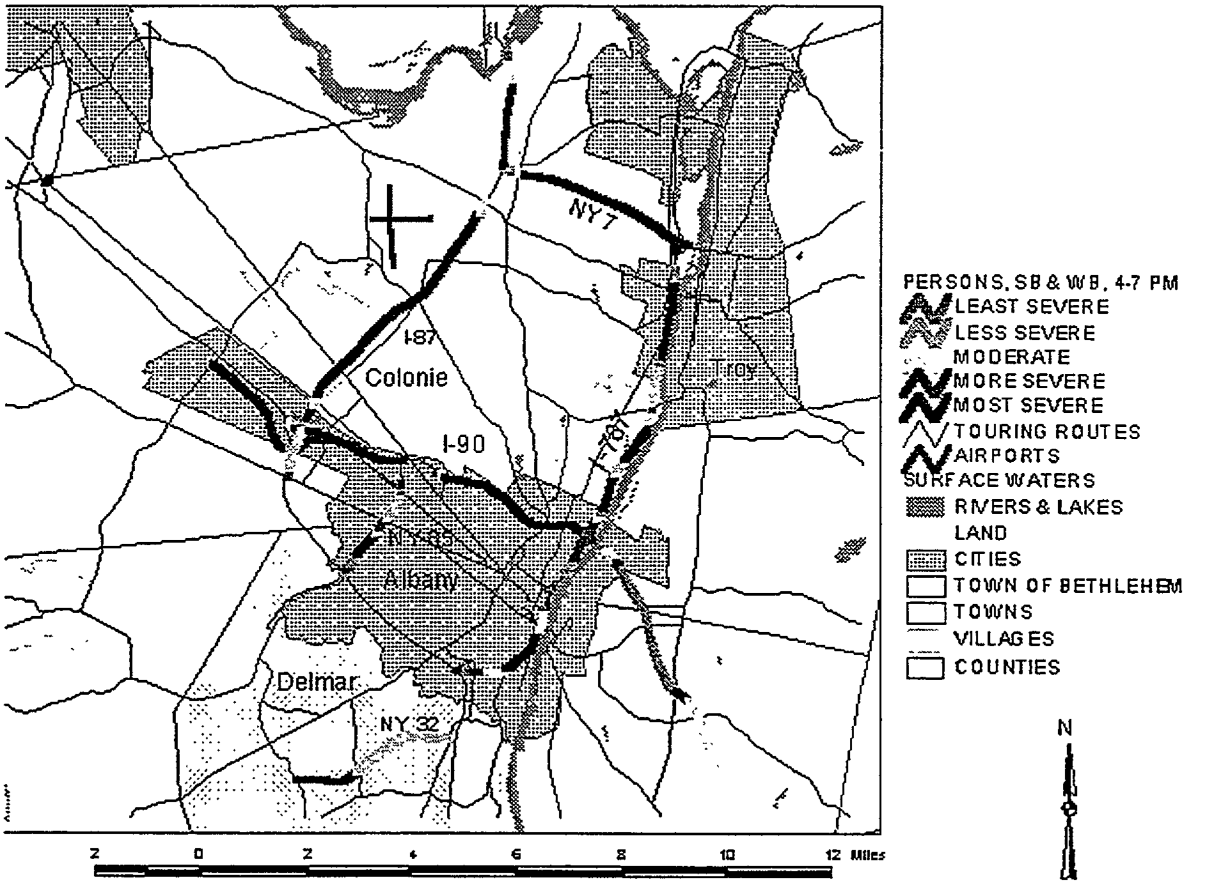
Figure 5



New York State Congestion Management System

Figure 6

NYS CMS FREEWAY INCIDENT EXCESS DELAY COST FOR YEAR 1994 WEEKDAYS



ANALYTICAL APPROACHES TO PERFORMANCE MONITORING

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Presented at
National Traffic Data Acquisition Conference
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ANALYTICAL APPROACHES TO PERFORMANCE MONITORING

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This paper provides guidance regarding sources of transportation data and analytical methods to support congestion-management programs. Included are measures that describe the movement of people and goods or relate to appropriate performance measures. Alternative data sources are described along with a range of available analytical procedures and evaluation techniques. Three case studies demonstrating the use of transportation data in a CMS are discussed. These include the use of the Highway Performance Monitoring System (HPMS) in Montana, the integration of transportation data into a geographic information system (GIS) for Albuquerque, and the multiple transportation data sources used to analyze mobility in Downtown Boston. Also included is a discussion of the data requirements for incident management program activities.

THE DEVELOPMENT, BENEFITS, AND USE OF COMPUTER-AIDED TRANSPORTATION SOFTWARE (CATS) FOR TRAVEL TIME DATA COLLECTION

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Presented at
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ABSTRACT

Link travel times are one of the most widely used and valuable measures of congestion. Travel time measures are compatible with multi-modal analyses and are understood by non-technical audiences, yet are rigorous enough for technical analyses by transportation engineers and planners. The "average" car technique is one of the most widely used travel time based measures. Although there are some cost, safety, and data limitation problems associated with manual travel time data collection techniques, the use of computer aided travel time technology solves most of these problems. Detailed speed, time, and distance information can be safely collected at up to 0.1 second intervals for a reasonable cost. The consistent format of the computer data lends itself to automated analysis. This paper discusses the development and benefits of using computer aided travel time data collection techniques using Distance Measuring Instruments @MI) and laptop computers. Automated analysis techniques and developmental software can produce results such as speed profiles, average speeds, level of service, and vehicle accelerations. Current and future research on emissions modeling, fuel consumption, and additional planning models are also presented.

Kev Words: Data Collection, Travel Time, Average Car, DMI, Speed Profile, Air Quality, Fuel Consumption

INTRODUCTION

Travel time is one of the most useful means of measuring congestion. Several techniques can be utilized to collect travel time information. Each technique has distinct advantages and disadvantages relating to the amount of information, accuracy, and cost of obtaining the data. One of the most widely used techniques for collecting travel time information is the "average" car technique. The "average" car technique involves an observer driving in the traffic stream attempting to judge the average speed of the traffic stream. A similar method, the "floating" car technique, involves an observer "floating" with the traffic stream passing as many vehicles as pass the observer across all lanes of traffic. With both methods the observer travel through a predefined route, recording times at predetermined checkpoints. The average speed can be calculated knowing the distance and times between each of the predefined checkpoints. Both of these techniques usually requires two observers, one to drive and one to record the times at the checkpoints (l). Due to the fact that the travel times are collected during the peak traffic hours, the driver work load is substantial, which makes it infeasible for an operator to drive and record times safely. The level of accuracy obtained by this manual technique varies from driver to driver. Since the distance between realistic/applicable checkpoints is 0.25 to 2.0 miles, only an average speed is known with no detail of conditions between the checkpoints. Another problem associated with the manual technique is that checkpoints can be missed or inaccurately marked. Furthermore, information on traffic queues is limited to the driver's estimation of the length and duration of the queue.

BACKGROUND

A recently completed National Cooperative Highway Research Program (NCHRP) study, "Quantifying Congestion," concluded that travel time-based measures are most useful for the wide range of congestion measurement needs (2). The NCHRP study indicated that travel time measures are compatible with multi-modal analyses and are understood by non-technical audiences, yet are rigorous enough for technical analyses by transportation engineers and planners. Many transportation agencies have already adopted travel time measures for congestion measurement (3). The increasing reliance on travel time information indicates a need to accurately and cost-effectively measure travel times. The traditional method for measuring travel times over the past 40 years has been the test vehicle or "floating car" technique (4). Procedures used in this technique have traditionally been manual recordings of time (stopwatch) while driving through a predetermined route. This is a very labor intensive effort that introduces additional human error possibilities. However, the use of micro-computers and other electronic equipment can elimiite some of these manual disadvantages and increase the amount and accuracy of the information collected.

In 1985, Reid (5) published results of a study conducted to develop a travel time program with the parameters of any selected set of synchronized traffic signals. With a computer input unit mounted in a vehicle and interfaced to some form of distance-measuring equipment, it was thought that it would be possible to calculate various speeds to ensure safe passage through the green phase of successive signals and to optimize these for minimum fuel consumption or transit time. The speed information was successfully collected. However, there were complications with the fuel consumption data in that the fuel measures were not accurately modeled by the program.

A similar study, in 1990, by Prince (6) found that a Toshiba T1000 laptop computer with a remote numeric key pad for input was successful in collecting travel time data. However, the unit could only be used on predetermined routes with the distances manually input into the computer. While the study was somewhat successful, there were limitations on the flexibility of the system and interaction with the driver/operator.

In 1988, Hudson (7) integrated the accuracy of the DMI with the portability of the laptop computer. The results were successful, providing accuracy in a computer format. However, there were still some limitations on the system and significant driver involvement during data collection activities (i.e., the driver had to input all checkpoints, queues, etc.).

The California Department of Transportation (Caltrans) utilizes the DMI technique called "Tach Runs" to monitor congestion on their freeway system (8). The travel time information, that is automatically recorded onto a portable computer in the test vehicle, is later combined with other runs on a central computer to produce travel time and delay summaries. Although Caltrans uses a DMI very effectively, the raw data is not easily obtained for specialized analysis due to the three separate data files that make up the raw data.

Most recently, Young and Taylor (9) and Thurgood (10) published results of studies where DMI's, laptop computers, and experimental software were coordinated to collect travel time data. The Young and Taylor study (9) installed an on-board software system called the Fuel Consumption and Travel Time Data Acquisition System (FCTTDAS) developed by the Australian Road Research Board (ARRB). This system has the capability of collecting distance, speed and fuel consumption data on a second-by-second basis. This results in large data files, even for relatively short data collection runs. Each data file created by the system typically takes 60 to 70 kilobytes of memory.

The Thurgood study (10) utilized the Moving Vehicle Run Analysis Package (MVRAP) developed by the University of Florida (11). The MVRAP software was able to set all the distances between the starting and ending point as well as all link end points. The calibration run must be very precise in locating starting, ending, and link end points, since all subsequent runs will be referenced to the calibration run. MVRAP seems to function well while collecting the information. However, there are problems if the analyst would like to do a different or more detailed analysis. It is difficult to obtain and manipulate the raw data.

These emerging software packages, coupled with the DMI and laptop technologies, offer the flexibility and accuracy that is needed for reliable travel time data. In fact, the more developed these software systems become, the greater ease of operation and safety to the driver. These systems are continuing to improve as technology advances. Likewise, improvements in technology make systems such as these more cost-effective and attractive to local, state and federal agencies. Further developments in this area will only increase the number of software systems utilized in the near future.

SOFTWARE DEVELOPMENT

Several manual (stop watch) and automated (laptop) aids in the Travel Time Run (TTR) data collection process were investigated. All of the techniques have strengths and weaknesses.

The first and most traditional technique is the stop watch method. The manual method is low tech and has low start-up cost (i.e., all that is required is a stop watch and a motor vehicle). Although the start-up costs are low, the manual technique is very labor intensive which results in a high overall cost. Some of the other problems are listed below:

- Labor intensive (a driver and observer)
- Errors in the data collection process (incorrect or missed checkpoints)
- Data entry errors when entering data from the field sheets to the computer for analysis
- Limited data (0.4 to 1.6 kilometer [0.25 to 1 .O mile] checkpoint, estimates of queue length and duration)
- Small sample size due to the labor costs
- Moderate time for data analysis (not in consistent computer format, data entry time)

Crude computer programs were investigated. Such programs use the computer clock to record event times (e.g., checkpoints, queues) and were beneficial in providing information in a computer format, eliminating interpretation and data entry errors. However, there were still problems with missed checkpoints, having to look at the keyboard to enter queue data while driving, and requiring both a driver and observer.The use of a DMI provided the reliable distance element to solve the missed checkpoint problem. Table 1 provides a comparison of the different travel time data collection technologies. Integration of the data storage in the laptop and development of a user-friendly interface solved most of the TTR data collection problems. For these reasons, data collection and analysis software was written.

About the Software

Computer Aided Transportation Software (CATS), an integrated computer program, was developed by the Texas Transportation Institute (TTI) to improve the collection of travel time and speed data for traffic studies. The CATS software currently consists of three modules: DMIREAD, DMIPLOT, and DMISTAT.

The data collection module, DMIREAD, which is used with a laptop computer connected through the serial port to a Distance Measuring Instrument (DMI), collects detailed speed, distance, and clock time data while traveling through a corridor. This DOS based software module is programmed with the computer program language "C". The operator enters information about the run from a menu system, shown in Figure 1, which includes: Roadway Name, Roadway Type, Travel Direction, User Name, Odometer Reading, Weather Conditions, etc. DMIREAD opens the serial port, sets the DMI to the correct mode, places the operators input (run data) in the header, obtains speed and distance information from the DMI, time stamps each data record, formats the data, and writes it to an ASCII file. The information that is provided in the ASCII file are the event number, cumulative and interval distance, speed, a clock time stamp for each reading, and the header (run data) information, as shown in Figure 2. The program typically collects data on a half second interval, but has the capability of collecting the data as frequently as 0.10 of a second.

Two types of data collection can be conducted. First, the simplest (non-redundant) method results when the TTR is then conducted taking care to mark the first checkpoint and all subsequent

Table 1. Comparison of Different Travel Time Data Collection Technologies

Problems	Manual Method	Laptop Variation	Existing DMI Programs	DMI Method
Marking Checkpoints	Stop watch/pen and paper **or** Tape recorder	Mark using a specific key	Mark checkpoints on an initial run these are the checkpoints that are used.	Hit any key on the keyboard **and** Using known distances (before or after) data collection
Accuracy of Data	Limited to hours, minutes, and seconds; mileage from the odometer (potential recording errors)	Time in decimal seconds; mileage from the odometer	Time in decimal seconds; mileage to the thousandths (no recording errors)	Time in decimal seconds; mileage to the thousandths (no recording errors)
Ability to add checkpoints after data collection.	None	None	Takes some doing	Obtain new checkpoint distances
Ability to determine accuracy of checkpoint location	None	None	Not at present	Concurrent "!!!MARKS!!!" can be checked against known distances
Type of data	Times and speeds	Times and speeds	Time, distance, speed, calculated accelerations, and fuel consumption	Time, distance, speed, calculated accelerations, and fuel consumption
Amount of data	0.4 to 1.6 meters [0.25 to 0.5 mile]	0.4 to 1.6 meters [0.25 to 0.5 mile]	Depends on program	Every half second (e.g., every 7.6 m [25 ft] @ 48 kph [30 mph])
Queue Information	Limited	Limited	Estimated from speed profile	Estimated from speed profile
Influence on Driving Task (Safety)	High with one person (Moderate)	Moderate to High with on person (Moderate)	Low with one person (Safer)	Low with one person (Safer)
Efficiency	One or Two people	One or Two people	One person	One person

TRAVEL TIME RUN USING A DMI

MRIN MENU

ITEMS	SELECTIONS
ROADWAY NRME	NORTH FREEWAY
ROADWAY TYPE	MAIN LANES
TRAVEL DIRECTION	NORTH BOUND
SCHEDULED TIME	17:00 (hh:mm)
DRIVER NRME	Robert J. Benz
ODOMETER	43567
WERTHER	CLEAR
LIGHT	NORMAL DAYLIGHT
PRUEMENT	DRY
START DMI	
CANCEL	

Figure 1. Example of DMIREAD Input Screen

```
FREEWAY NAME       :  KATY FREEWAY
FREEWAY TYPE       :  MAIN LANES
FREEWAY DIRECTION  :  IN BOUND
DATE TODAY         :  3/22/1995
WEATHER CONDITION  :  CLEAR
 LIGHT CONDITION    :  NORMAL DAYLIGHT
 PAVEMENT CONDITION :  DRY
 SCHEDULED TIME     :  07:30
 DRIVER             :  Robert J Benz
 MILE START         :  16005
START TIME         :  Wed Mar 22 08:32:46 1995

!!! MARK !!!
 1.    0.002 0.002  61 @ Wed Mar 22 08:32:46 1995
 2.    0.004 0.002  61 @ Wed Mar 22 08:32:46 1995
 3.    0.005 0.002  61 @ Wed Mar 22 08:32:47 1995
 4.    0.009 0.005  61 @ Wed Mar 22 08:32:47 1995
 5.    0.017 0.008  61 @ Wed Mar 22 08:32:48 1995
 6.    0.023 0.007  60 @ Wed Mar 22 08:32:48 1995
 7.    0.029 0.007  60 @ Wed Mar 22 08:32:48 1995
 8.    0.036 0.007  59 @ Wed Mar 22 08:32:49 1995
 9.    0.043 0.007  59 @ Wed Mar 22 08:32:49 1995
10.    0.050 0.007  59 @ Wed Mar 22 08:32:50 1995
11.    0.057 0.007  60 @ Wed Mar 22 08:32:50 1995
12.    0.064 0.007  60 @ Wed Mar 22 08:32:51 1995
13.    0.071 0.007  59 @ Wed Mar 22 08:32:51 1995
14.    0.078 0.007  59 @ Wed Mar 22 08:32:51 1995
15.    0.085 0.008  59 @ Wed Mar 22 08:32:52 1995
16.    0.092 0.008  59 @ Wed Mar 22 08:32:52 1995
17.    0.099 0.007  59 @ Wed Mar 22 08:32:53 1995
18.    0.106 0.007  59 @ Wed Mar 22 08:32:53 1995
19.    0.112 0.007  59 @ Wed Mar 22 08:32:53 1995
20.    0.120 0.008  59 @ Wed Mar 22 08:32:54 1995
21.    0.127 0.007  59 @ Wed Mar 22 08:32:54 1995
 1.    0.004 0.004  59 @ Wed Mar 22 08:32:55 1995   !!! MARK !!!
 2.    0.010 0.007  58 @ Wed Mar 22 08:32:55 1995   !!! MARK !!!
 3.    0.017 0.007  58 @ Wed Mar 22 08:32:56 1995   !!! MARK !!!
 4.    0.024 0.008  58 @ Wed Mar 22 08:32:56 1995
 5.    0.031 0.007  58 @ Wed Mar 22 08:32:56 1995
 6.    0.038 0.007  58 @ Wed Mar 22 08:32:57 1995
 7.    0.045 0.007  58 @ Wed Mar 22 08:32:57 1995
 8.    0.052 0.007  58 @ Wed Mar 22 08:32:58 1995
 9.    0.059 0.007  59 @ Wed Mar 22 08:32:58 1995
10.    0.066 0.007  59 @ Wed Mar 22 08:32:59 1995
11.    0.072 0.007  59 @ Wed Mar 22 08:32:59 1995
12.    0.079 0.008  59 @ Wed Mar 22 08:32:59 1995
13.    0.086 0.007  60 @ Wed Mar 22 08:33:00 1995
14.    0.094 0.008  60 @ Wed Mar 22 08:33:00 1995
15.    0.101 0.008  60 @ Wed Mar 22 08:33:01 1995
16.    0.108 0.007  59 @ Wed Mar 22 08:33:01 1995
17.    0.114 0.007  59 @ Wed Mar 22 08:33:02 1995
18.    0.121 0.007  59 @ Wed Mar 22 08:33:02 1995
19.    0.128 0.008  59 @ Wed Mar 22 08:33:02 1995
20.    0.135 0.007  59 @ Wed Mar 22 08:33:03 1995
21.    0.142 0.007  58 @ Wed Mar 22 08:33:03 1995
22.    0.149 0.007  58 @ Wed Mar 22 08:33:04 1995
23.    0.155 0.007  59 @ Wed Mar 22 08:33:04 1995
24.    0.163 0.008  59 @ Wed Mar 22 08:33:04 1995
25.    0.170 0.007  59 @ Wed Mar 22 08:33:05 1995
```

Figure 2. Example of Output From DMIREAD

checkpoints very accurately by pressing any key on the laptop computer which will write a "!!!MARK!!!" to the ASCII file as shown in Figure 2.

Secondly, reliability (with redundancy) results when the TTR is being made on a predetermined route. Prior to starting the data collection, typically a driver and an observer, will use the DMI to accurately determine the distances between the predetermined checkpoints. The checkpoint distances that are collected are entered into a "yard stick" file which will be used by the DMISTAT analysis module. The TTR is then conducted taking care to mark the first checkpoint and all subsequent checkpoints very accurately by pressing any key on the laptop computer which will write a "!!! MARK !!!" to the ASCII file as shown in Figure 2. The redundancy is introduced with the two methods of marking the checkpoints. As long as the first checkpoint is marked accurately all the following checkpoints can be determined from the "yard stick" file. The redundancy is introduced by the operator concurrently marking the checkpoints as the TTR is being made and comparing this information with the data obtained by using the "yard stick" to determine the checkpoints. The two methods should correspond. If a conflict occurs, typically the problem is that the operator is marking the wrong checkpoint location (i.e., the wrong cross street). Of course, each problem requires a case by case basis investigation.

As stated before the alternative method, the collection personnel drives through the corridor marking the checkpoints. It is imperative that all the checkpoints be marked accurately, since this will be the only checkpoint reference available, unless a yard stick file is collected after the study TTR are collected.

Either method enables the user to post-analyze the microscopic data via the ASCII format as shown in Figure 2. Header information (run data) provided by the operator from a menu format is used to uniquely name each ASCII output data file so that it indicates a roadway name, roadway type, direction of travel, date, and time. This feature eliminates the problem of overwriting previously collected data files.

The other two software modules are Excel macros that are written in Visual Basic. The DMIPLOT module opens the ASCII file, parses the data, plots a speed profile, and uses the header information for title and labeling purposes as shown in Figure 3. The DMISTAT module opens the ASCII file, parses the data, provides interval and cumulative distance and time, calculates average speed, standard deviation, percent time between different speed ranges, and estimates a level of service based on speed as shown in Figure 4.

ADVANTAGES OF DMI DATA COLLECTION

As indicated previously, the different data collection techniques have different advantages and disadvantages. A detailed discussion of the advantages related to the Computer Aided Transportation data collection technique are identified below.

Safety

Manual travel time data collection is very labor intensive. The ITE Manual Of Transportation Studies (1) suggests using two observers, a driver and a recorder. However, using two observers is very costly and there are still limitations to recording times every 0.16 to 0.8 kilometers (0.1 to 0.5 miles). Two options are available where travel time data can be collected

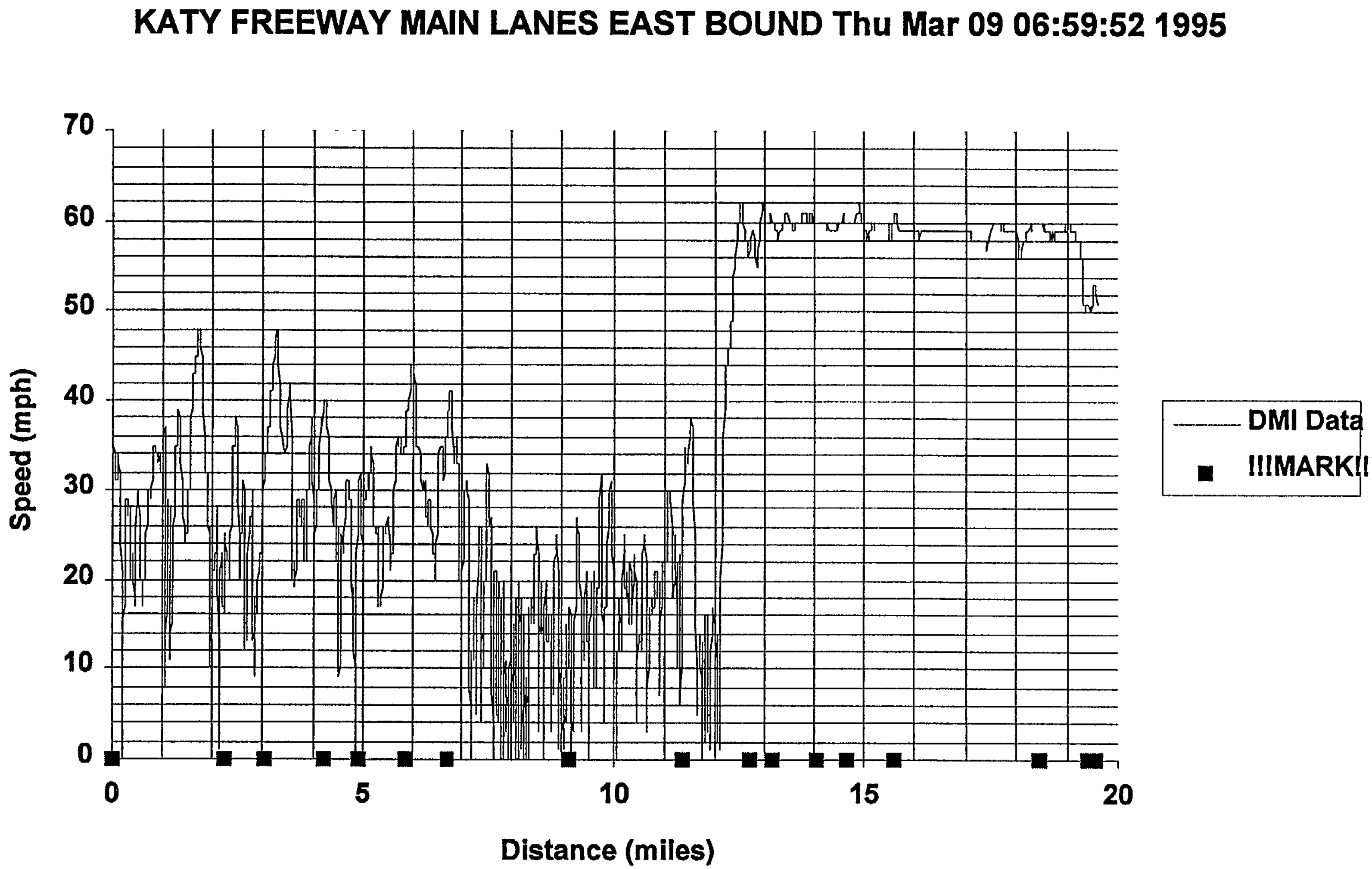

Figure 3. Freeway Mainlane Speed Profile Example

ACTIVITY CENTER: KATY FREEWAY
DIRECTION: EAST BOUND
DATE: Thu Mar 09 05:59:52 1995
WEATHER: CLEAR
PAVEMENT: DRY
LIGHT CONDITION: NORMAL DAYLIGHT

CHECKPOINT	INT DIST	CUMM DIST	INT TIME	CUMM TIME	STDEV SPEED	AVG SPEED	% Time Under 5 mph	% Time Between 5 & 35 mph	% Time Between 35 & 50 mph	% Time Between 50 & 70 mph	Estimated Level of Service
Barker Cypress	0.000	0.000	00:00	00:00	—	—	—	—	—	—	—
West Terminus	2.210	2.210	05:34	05:34	10.35	23.82	4.7%	85.0%	10.3%	0.0%	F
SH 6	0.400	2.610	00:56	06:30	6.23	25.71	0.0%	88.0%	12.0%	0.0%	F
AVL Flyover	0.430	3.040	01:15	07:45	6.76	20.64	0.0%	100.0%	0.0%	0.0%	F
Eldridge	1.190	4.230	02:13	09:58	7.47	32.21	0.0%	60.9%	39.1%	0.0%	E
Dairy Ashford	0.680	4.910	02:01	11:59	10.33	20.23	13.3%	82.8%	3.9%	0.0%	F
Kirkwood	0.970	5.880	02:06	14:05	6.03	27.71	0.0%	90.3%	9.7%	0.0%	F
Wilcrest	0.880	6.760	01:38	15:43	6.28	32.33	0.0%	74.8%	25.2%	0.0%	E
West Belt	0.750	7.510	02:41	18:24	10.33	16.77	11.3%	84.5%	4.2%	0.0%	F
Gessner	1.150	8.660	09:17	27:41	6.91	7.43	46.1%	53.9%	0.0%	0.0%	F
Gessner AVL Exit	0.320	8.980	02:17	29:58	6.96	8.41	40.7%	59.3%	0.0%	0.0%	F
Bunker Hill	0.400	9.380	02:41	32:39	6.51	8.94	36.7%	63.3%	0.0%	0.0%	F
Blalock	0.630	10.010	02:35	35:14	8.12	14.63	16.4%	83.6%	0.0%	0.0%	F
Bingle	1.370	11.380	05:13	40:27	7.02	15.76	9.3%	90.7%	0.0%	0.0%	F
Wirt	0.820	12.200	04:12	44:39	9.56	11.71	25.5%	70.3%	4.2%	0.0%	F
Antoine	0.560	12.760	00:37	45:16	5.58	54.49	0.0%	0.0%	26.4%	73.6%	B
Silber	0.450	13.210	00:27	45:43	1.77	60.00	0.0%	0.0%	0.0%	100.0%	A
AVL Flyover	0.500	13.710	00:30	46:13	0.87	60.00	0.0%	0.0%	0.0%	100.0%	A
West Loop	0.410	14.120	00:25	46:38	0.50	59.04	0.0%	0.0%	0.0%	100.0%	A
East Terminus	0.590	14.710	00:35	47:13	0.52	60.69	0.0%	0.0%	0.0%	100.0%	A
Washington	0.940	15.650	00:57	48:10	0.84	59.37	0.0%	0.0%	0.0%	100.0%	A
SPRR	0.250	15.900	00:15	48:25	0.00	60.00	0.0%	0.0%	0.0%	100.0%	A
Shepherd	0.910	16.810	00:56	49:21	0.12	58.50	0.0%	0.0%	0.0%	100.0%	A
Taylor	1.710	18.520	01:45	51:06	0.92	58.63	0.0%	0.0%	0.0%	100.0%	A
Hogan Street Overpass	1.000	19.520	01:03	52:09	3.43	57.14	0.0%	0.0%	5.3%	94.7%	A
RUN AVERAGES						22.46	17.3%	63.5%	5.3%	14.0%	

Figure 4. Statistical Data from Freeway

using only the driver. First, the driver can use a tape recorder. This provides some safety benefits but requires additional time to reduce the tape recorded data. If the recorder is not on continuously, the reduction time is considerably less. However, there is a greater risk of the driver/observer forgetting to turn on the recorder. There are risks of other sorts of malfunctions as well forgetting to hit the record button, having dead batteries, and running out of tape. It is possible for the driver to record times manually (stop watch), but this method is not recommended due to driver work load during the peak period, higher risk of accidents, higher risk of missing checkpoints, inaccurate readings, and incomplete data. All of the reasons listed above would require the TTR to be re-run during the same time period on a different day.

The Computer Aided Transportation Software (CATS) developed by TTI solves most of these problems by providing an increase in safety while increasing the quality and quantity of data. The ease and consistency of data collection and analysis is an added benefit.

With the DMI and the laptop computer, the distances and times are recorded automatically. Such automation allows the driver to preform the primary and complex task of driving in peak hour traffic, while only occasionally hitting any key or function key to mark the checkpoints, queues and incident locations.

Increase in Quality of Data

There are several redundant operations built into the software system to improve the accuracy and quality of the data being collected. Drivers are still requested to mark checkpoints. However, this function is done with the laptops internal clock by striking any key. Missed checkpoints can be obtained from the ASCII output file if a “yard stick” distance is collected either prior to or after the study data is collected. The accuracy of the driver marked checkpoints, as well as any missed checkpoints, can be verified against or obtained from the output file and the “yard stick” distance data log. The Excel analysis macros DMIPLOT and DMISTAT use the “yard stick” files to locate the checkpoints for analysis. The start of each TTR must be marked accurately, because this marked checkpoint is used as a reference for all of the following checkpoints. There will still be variations between individual drivers but this variation is reduced by having multiple data runs. In addition, some of the variance can be removed if driver profiles are observed (e.g., driver A who is eight percent faster than driver B, driver C who accelerates ten percent harder than driver A). Some of the problems that DMI data collection solves are shown in Table 2. Some of the other quality issues associated with the manual travel time technique are:

- Accuracy of data (missed or incorrect checkpoints)
- Amount of data (0.16 to 3.2 km [0.l to 2.0 mi] depending on skill and number of personnel)
- Variability between drivers

Table 2. Problems and Solutions of Data Reduction and Analysis

Problems	Manual Method	DMI Method
Data Entry	Type information into spreadsheet or input file	None, Data is automatically written to an ASCII text file
Transposition	Read "34" and type "43"	N/A
Readability	Interpretation of numbers	N/A
Time Consuming	Depends on speed and accuracy of personnel	N/A
Quality Control	Reentry and compare or supervisor spot checks	N/A
Average Speed	Must have known distance	Optional but encouraged
Error Checking	Limited	Concurrent "!!!MARKS!!!" and "Yardstick"

Increase in Quantity of Data

The software system provides a vast amount of data for each TTR, as shown in Figure 2. The operator enters information about the TTR such as route name, direction, type, and weather (see Figure l), before the program starts, and writes the header data to the ASCII file. The software system (program and DMI) provide header information which includes:

- Route Name
- Route Direction
- Route Type
- Driver Name
- Run Date
- Start Time (computer generated)
- Weather Conditions
- Light Conditions (daylight, night, fog)
- Pavement Status (we6 dry, etc.)
- Scheduled Start Time

In addition, the program provides an event number, cumulative distance, speed, and computer time stamp at a rate of up to 0.1 seconds. This results in approximately 40 times more data than is collected using the manual method. This level of detail provides some distinct advantages. Fii checkpoints can be determined from the travel time data log even if the observer does not mark the location while **making** the TTR. Quality control checks can be made to determine if the location of the checkpoints are being marked accurately. The greatest benefit from this type of data collection technique is the increased volume of data. Instead of an average speed every 0.4 to 3.2 kilometers (quarter mile to two miles) the data can be recorded every 0.10 second which equates to a data point approximately every three meters (10 feet) (depending on the speed). From these data files a far more detailed analysis can be performed. In addition, the program uses the header data for the automatic file naming system to ensure that no files are overwritten.

Ease and Consistency of Data Collection

The software system provides ease and efficiency of operation, as well as consistency of the data collection process. Once the TTR's are completed, files can be downloaded and the analysis software DMLPLOT and DMISTAT can be used to process the data within minutes per output file. With computer generated files there are no problems with interpretation of the data or data entry errors. More accurate and consistent recording of time that each run was started and when checkpoints are crossed are provided. The consistent data format allows for automated data reduction, which will be discussed later.

Another distinct advantage is that the data is in ASCII format allowing the output files to be viewed or analyzed in almost any software package. Other programs are in various data base formats which are not easily viewed or manipulated.

Automated Analysis Techniques

Two Excel macros have been created to aid in the analysis. Excel's programming language, Visual Basic, provides extreme power and flexibility. The Excel macro DMIPLOT opens a data file, parses data, plots a speed profile, labels the plot and prints the plot. All these functions occur in minutes depending on file size and the speed of the computer. An example of the printed output is shown in Figure 3. The squares along the X-axis represent checkpoints entered by the user.

Another powerful Excel macro, DMISTAT provides statistical information between predetermined checkpoints. The output shown in Figure 4 shows the average speed between checkpoints, standard deviation, and percent time between various speeds, as well as a freeway level of service based on the average speed of the section.

Both macros run in Excel 5.0 in a Windows based environment. These programs provide some of the header data as well as the file name. These programs are just a small example of the potential that can be realized from this large data set.

This vast amount of detail provides the user with ample information on which to conduct a detailed analysis after the data is collected. For instance, in the manual method of data collection, queues were estimated below 48 kph (30 mph). With the automated data collection the analyst could look at the speed profile and determine if the queuing actually starts at 48 kph (30 mph). The analyst can use any speed desirable to determine percent time in queue, percent time stopped (below 8 kph (5 mph)), or free-flow speeds (above 80 kph (50 mph)). A sample of the types and level of detail that can be achieved with DMI data collection is shown in Table 3.

Although Excel was used, the ASCII output file format ensures that almost any spreadsheet, statistical package, or data base program can be used for analysis. The end user may choose to use a program that is more suited for the level of analysis desired.

Table 3. Types of Output and Level of Detail

Type of Output	Manual Method	DMI Method
Overall Detail	Low	High
Average Speed	Yes	Yes
Queue Information	Limited (crude speed profile)	Limited (more detailed speed profile)
Speed Profile	Crude	Detailed
Acceleration Characteristics	None	Calculated
Fuel Consumption	Crude	Detailed
Air Quality	Crude	Crude (potential for future models)

Cost Effectiveness

Using a DMI data collection method to collect travel times is very cost effective. Off the shelf, DMI units can be obtained for approximately $600 dollars. Start up costs are relatively low when combining the DMI units and a standard laptop computer. Some of the savings that are incurred using this technique are the reduction of staffrequirements; only one person is required to collect data instead of two. Checkpoint redundancy reduces the number of makeup runs due to missing data. Detailed information can be collected much more efficiently, possibly allowing the data to be used for future studies along the same corridor. The ease of analysis is greatly simplified with the common format and Excel macros. Other programs can be easily used if their program features are more applicable or if Excel software is not available. A breakdown of the potential cost savings is shown in Table 4. The costs are based on broad assumptions; actual costs will vary.

POTENTIAL LIMITATIONS

As with any type of data collection, there are some draw backs. One of the limitations associated with computer aided data collection is that the number of runs are limited to the number of laptops and the number of DMI units that are installed in available vehicles. Another drawbacks is the size of each data file can get overwhelming and disk storage space can be a potential problem. However, the increased size of and decreased cost of hard disk space, along with the use of compression utilities for long term storage, alleviates this problem. A minor problem is getting power to the laptop computers. Battery life can be as long as 4 hours, but if batteries are not charged fully or if they are altered by constant charging and discharging, problems can develop. A/C adapters are available at a modest cost.

The human factor (e.g., missing checkpoints and failure to or inaccurate calibration) will always be a problem However, these problems can be solved or isolated with proper education and training. These disadvantages can be easily overcome with modest precautions while the benefits far outweigh any disadvantages.

Table 4. Potential Cost Savings Using DMI Data Collection*

Cost	Manual Method	DMI Method (per vehicle)
Start-up	Vehicle and stopwatch ($15)	Vehicle, laptop ($1000), and DMI unit ($600) set-up ($100), Software ($150) all costs in this box are one-time costs.
Labor (data collection)	Two (safety) ($64)	One ($32)
Labor (data reduction)	Data entry time 30 min ($4), error checking ($4), makeup TTR if bad data ($16)	N/A
Analysis	Run analysis program (Software cost $150) and calculations (5 to 20 minutes)($l4)	Use Excel macros (2 minutes per 8 km [5 mi] run) to print average speeds, std deviation, LOS, and speed profiles. Can be run in batch mode to reduce labor cost ($14).
Other projects or other project requirements	May need to make more runs to collect the data at the different checkpoints, or to collect more detailed information (e.g., queue data, stops delay).	Just reanalyze the file using the new checkpoints or calculating the desired output measurements.
Total $ / peak period ($ one time)	$102 ($165)	$46 ($1,850)
Number of peak periods to break even	N/A	31

* Travel Length 8 km (5 mi) TTR
Peak Period 6 to 9 (3 hours) 4 hours total (mobilization/demobilization) set-up @ $8/hr/person
20 minute headways both directions 48 kph (30 mph) 12 runs
Analysis done by technician or engineer $15 to $3 0 say $27.

EVALUATION AND SOFTWARE TESTING

After development of the software, tests were conducted to ensure DMI to laptop computer communication. Several checks were made on the user interface to determine ease of use and quality of information. Once the prototype software was developed, several field tests were conducted. Minor modifications were made and the prototype was ready for full scale field testing. Field tests consisted of freeway and High Occupancy Vehicle Lane (HOVL) travel time runs. Approximately 225 freeway mainlane TTR and 115 HOVL TTR were conducted totaling over 5,950 kilometers (3,700 miles). Quality control was conducted by running Excel macros to print speed profiles and summary averages for each TTR. These quick checks identified problems in the data collection method and gave a preliminary look at the level of congestion. Arterial corridor TTR have also been conducted with great success. Positive responses from the drivers and a thorough analysis process led to some future modifications, which will be discussed later.

The field tests were not without error. Some of the runs needed to be redone due to incorrect calibration numbers in the DMI. Others failures resulted from various user errors. Thorough training and understanding of the system operations solved most of these errors. The remainder of the errors were due to wrong turns or terminating the program prematurely. Some of the problems can be corrected during analysis if caught early enough.

DISCUSSION AND RECOMMENDATIONS

Computer aided Travel Time data collection techniques improve the quantity and quality of data collection efforts. This technique also provides improved and more efficient analysis techniques. The ASCII format provides almost unlimited methods for data analysis. This technique reduces the errors typically associated with manual travel time data analysis. All these advantages at a moderate cost make Computer Aided Travel Time data collection an extremely attractive method for collecting accurate travel time information.

Current and Potential uses for Computer Aided Transportation Data Collection

Analysis is quick and easy using the Excel Macros or other spreadsheet or statistical analysis programs. The ASCII format enables the user to analyze the data with almost any software program. Potential analysis include: speed profiles, progression, fuel consumption, acceleration characteristics, delay, and air quality estimates. Research is currently being conducted to investigate further the potential for fuel consumption and acceleration characteristics. The level of detail provided allows for acceleration and deceleration to be calculated with a high level of accuracy. Using existing and experimental fuel consumption and air quality models, with the high level of detail provided by the computer aided travel time technique, a more microscopic analysis can be investigated where previously only macroscopic insight was available.

Progression on arterial streets can be viewed graphically. Delay information and time spent in queues are easily calculated and shown graphically in the speed profile. The model can be used for freeway applications as well. Information on overall travel time, time and distance spent in queues, and location of bottlenecks can be acquired.

Future Improvements

The use of the program input **and** analysis screens are constantly being improved. One of the major changes that is being planned is a Windows version of the input screen.- This will keep the entire data collection and analysis process on one platform. The Windows version will also provide a slightly more user-friendly interface with wider flexibility. Another feature that is being investigated is collecting the data based on distance rather than time. This will simplify the averaging of several TTR.. Further advancements will include the use of function keys to indicate incidents, stalled cars, and change in conditions. Another improvement will be plotting several TTR on one graph. This graph would vividly show continual problems throughout the day. The new input interface will allow the user to determine the level of detail.

Potential Challenges / Data Collection Tips

Some of the challenges that were described in the paper are summarized here. Some of the pitfalls to watch for are:

- Tire pressure (incorrect tire pressure will provide inaccurate speed and distance readings)
- Calibration Number (incorrect DMI calibration number will provide incorrect but consistent results)
- Calibration of the test vehicles every week during data collection
- Maintenance performed on the vehicles well before data collection starts
- Clock time set on all the laptops and vehicle clocks. This will ensure that the scheduled start times will coincide with the actual start time
- Ensure enough hard disk space on the laptops to store the TTR data
- DMI data should periodically be downloaded, and a speed profile and average summary data printed as a quality control measure
- Insure batteries are fully charged or use DC adaptors

The advantages of the computer aided travel time data collection provides a vast amount of high quality data. Computer format, for quality control and quick analysis. This microscopic level of data also provides some exciting and challenging ways to better analyze and understand the effects of congestion on our environment and natural resources.

Troubleshooting

The DMI method of TTR data collection does have some potential problems. The following is a list of the problems that maybe encountered and some possible solutions which can be used to solve the problem.

Distances appear short/long or speeds seem low/high
- Check calibration number
- Check tire air pressure

Bad calibration number
- Proper training
- Assign a DMI and laptop computer to a specific vehicle or person

Distances recorded in undesired units
- Proper training
- Convert to desired units in spreadsheet

Power failure to the laptop (either batteries are dead or they run out of charge during run)
- Use a power supply that can be hooked up to the vehicle (<$50)
- Be sure that batteries are put on charge at the end of the TTR

Incorrect start time or incorrect time stamp

- Set all laptop computers to the same time
- Set all the vehicle clocks to the same time also

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USING GIS FOR URBAN CONGESTION ANALYSIS

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USING GIS FOR URBAN CONGESTION ANALYSIS

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Urban traflic congestion is a concern of increasing importance. Developing strategies to reduce congestion requires identification and quantification of congestion. These require data acquisition, management, analysis and communication (display). This paper presents an approach to facilitate such efforts so as to measure and monitor traffic congestion in urban areas. The approach uses existing data from ambulance service providers and it is based on the use of a Geographic Information System (GIS) program.

The basic premise of the analytical approach propounded in this paper is that congestion on a roadway could be quantified as the difference between the posted speed limit (in lieu of free flow speed) and actual travel speeds sustained on the roadway. Emergency response vehicles such as ambulances could be considered to be “probes” deployed on the road network Such emergency response providers maintain a computerized database of all responses. The database includes information (data fields) pertaining to the location of the event, time of the call, location of the response units responding to the call, time of dispatch, time of arrival at the event, time of transport (if necessary), time of arrival at the destination (hospital). Also included are attributes identifying whether sirens or flashing lights were turned on or off while the ambulance was in motion. Thus, this database could be used to obtain estimates of travel speeds maintained by the probes on the network In turn, these speeds could be used to quantify the level of congestion.

This paper documents strategies that could be deployed to take advantage of such databases to help measure and monitor congestion and the spatial and temporal distribution of congestion on urban road networks. The paper discusses data capture, management, analysis and display issues required to support such efforts.