UC Berkeley
Working Papers

Title
Traffic Management Systems Performance Measurement: Working Paper #2

Permalink
https://escholarship.org/uc/item/8dx3z7dd

Authors
Banks, James H.
Kelly, Gregory

Publication Date
1997-11-01

eScholarship.org Powered by the California Digital Library
University of California

This paper has been mechanically scanned. Some errors may have been inadvertently introduced.

CALIFORNIA **PATH PROGRAM**
INSTITUTE **OF TRANSPORTATIONSTUDIES**
UNIVERSITY OF CALIFORNIA, BERKELEY

Traffic Management Systems Performance Measurement: Working Paper #2

James H. Banks, Gregory Kelly
San Diego State University

California PATH Working Paper
UCB-ITS-PWP-97-28

This work was performed as part of the California PATH Program of the University of California, in cooperation with the State of California Business, Transportation, and Housing Agency, Department of Transportation; and the United States Department Transportation, Federal Highway Administration.

The contents of this report reflect the views of the authors who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the State of California. This report does not constitute a standard, specification, or regulation.

November 1997

ISSN 1055-1417

TRAFFIC MANAGEMENT SYSTEMS PERFORMANCE MEASUREMENT

WORKING PAPER #2

DATA SYSTEM IMPROVEMENT PLANS

by

James H. Banks
Gregory Kelly

Department of Civil and Environmental Engineering
San Diego State University
San Diego, CA 92182-1324

November 14,1997

ABSTRACT

Traffic Data System Improvement Plans were prepared for Caltrans Districts 11 (San Diego) and 12 (Orange County) as part of a research project on performance measurement for traffic management systems. The plans document data system objectives, data requirements, and existing data collection and management systems; evaluate the adequacy of existing systems; identify improvements and resource requirements; and document the districts' priorities for action. Both districts have similar data systems, although Orange County's is better developed. Both systems rely heavily on single-loop detectors for traffic surveillance. Both either have or plan to have current-generation data display and management software, complete coverage of urban freeways by loop-detector systems, extensive video surveillance systems, and fiber-optic communication systems. In addition, both provide or will provide computerized incident and equipment-status logging, adequate accident and traffic volume data bases, and automatic data screening capability. Traffic data systems in the two districts appear to be generally adequate to support major performance measures identified in a previous phase of the project. Despite their commitment to providing sophisticated traffic data collection and data management systems, however, the two districts do not necessarily have a clear vision of how to use the data to monitor performance, and lack the organizational structure and staffing to carry out evaluation studies, performance monitoring, and data quality control.

Key words: Performance measurement, traffic data collection, traffic data management, transportation management centers, traffic systems management

EXECUTIVE SUMMARY

Traffic Data System Improvement Plans were prepared for Caltrans Districts 11 (San Diego) and 12 (Orange County) as part of a research project related to performance measurement for Caltrans transportation management centers (TMCs) and other units involved in traffic system management. The preparation of the data system improvement plans was the second phase of the project. One objective in preparing the plans was to verify the practicality of performance measures proposed in the first phase of the project. **A** second objective was to provide the two Caltrans districts with recommendations for improving their traffic data systems' ability to support performance measurement. The San Diego and Orange County districts were chosen because of their well-developed traffic data systems, their past involvement in supplying data for intelligent transportation systems (ITS) research, and their proximity to the researchers' home base.

For both districts, the data system improvement plans:

- Set forth data system objectives related to performance measurement and identify data required to meet these objectives
- Document existing traffic data collection and management systems, including traffic surveillance systems, traffic data management and display systems, traffic data bases, and the personnel required to manage, operate, and maintain the system
- Evaluate the ability of the existing system to support traffic data system objectives
- Identify potential improvements to the traffic data system
- Identify resource requirements for implementing potential improvements, and
- State the districts' priorities for actions to improve their traffic data systems.

The two districts proved to have similar approaches to traffic data collection and management, similar existing systems (although the one in Orange County is more fully developed than that in San Diego), and similar plans for system improvements.

Both existing systems rely heavily on single-loop detectors to provide traffic surveillance. Most of the existing detectors in both districts were originally installed as part of ramp metering systems, but are also used to provide real-time surveillance in support of incident management (for instance, to assess speeds and the extent of queuing). In both districts, there are also some detector stations intended for surveillance only. Some double-loop stations exist, but are not used as such due to a lack of adequate controllers. The Orange County district also has a fairly extensive video surveillance system, which it plans to expand; San Diego does not have video surveillance at present, but plans an

extensive system. Both districts also plan to install fiber-optic communications systems as a part of the deployment of their video surveillance systems.

The Orange County district has recently installed a current-generation data display and management system developed by the district and the National Electronic Technologies (NET) Corporation; the San Diego district is in the process of installing a similar system. The NET software provides incident and equipment-status logging capabilities. It also provides data screening and repair algorithms for loop detector data. Both districts also have access to adequate accident and traffic volume data bases.

Traffic data systems in the two districts appear to be generally adequate to support the major performance measures identified in the first phase of the project. These performance measures include 1) travel time and related measures, 2) ramp delay, **3)** traffic volumes, 4) accident rates, *5)* traffic information accuracy, ***6)*** incident clearance times, and 7) equipment status. Reservations about the ability of the traffic data systems to support performance measurement include concern about 1) the questionable accuracy of travel time estimates derived from loop detector data (especially single loop installations that do not measure speed directly), 2) inadequate staffing to support labor-intensive data collection activities such as the manual queue counts needed to estimate ramp delays, 3) and lack of staffing and institutional infrastructure to support evaluation studies, performance monitoring, and data quality control.

The first phase of the project also involved identification of actions by Caltrans or PATH to facilitate performance measurement. The experience of developing the traffic data system improvement plans confirmed most of these action proposals. In a few cases, it turned out that the suggested action had already been taken as part of the development of the Orange County-NET software package. Also, the process of preparing the plans showed that the ability of the districts to implement actions such as performance monitoring, evaluation studies, and data quality control had been overestimated in the first phase of the study. In these cases, it had been recognized all along that the first step was to develop plans and policies; the experience of working with the districts showed that the process of developing these plans and policies is likely to be more difficult and time-consuming than had originally been expected.

In general, the two Caltrans districts studied are committed to the provision of sophisticated traffic data collection and data management systems. At the same time, however, they do not necessarily have a clear vision of how to use the data to monitor performance, and they lack the organizational structure and staffing to carry out activities such as evaluation studies, performance monitoring, and data quality control. **As** a consequence, future work on performance measurement for Caltrans traffic management systems should focus on organization and staffing rather than measurement techniques.

ACKNOWLEDGEMENTS

We wish to thank Caltrans Districts 11 and 12 for their cooperation in this research. We especially wish to thank Ross Cather, Don Day, and Ed Khosravi for their patience and help in preparing the Traffic Data System Improvement Plans.

TABLE OF CONTENTS

INTRODUCTION

This report presents traffic data system improvement plans for California Department of Transportation (Caltrans) Districts 11 (San Diego) and 12 (Orange County). The report itself summarizes the plans and discusses lessons learned in preparing them; the plans are included as appendices. The plans were prepared as a part of a research project entitled "Traffic Management Systems Performance Measurement," which was sponsored by the California Partners for Advanced Highways and Transit (PATH) Program. The focus of the overall project is on performance measurement for Caltrans Transportation Management Centers (TMCs); consequently, it is primarily concerned with the urban freeway system, although some findings may be applicable to non-Caltrans efforts such as local TMCs.

Project objectives are to 1) analyze performance measurement requirements associated with Caltrans TMCs, 2) identify and assess the feasibility of data collection and management activities required to support TMC performance measurement; and **3)** recommend specific actions by Caltrans and PATH that will facilitate performance measurement.

The first phase of the project involved a number of research tasks. These included discussions with PATH and Caltrans representatives that were intended to refine the objectives and priorities of the project, a literature survey, an analysis of proposed measures of effectiveness (MOEs) for traffic system and TMC performance, and identification and prioritization of specific actions intended to improve performance measurement. Results of these activities were documented in a previous Working Paper (*1*).

The data system improvement plans were intended both as a check on the practicality of implementing specific performance measures identified in the first phase of the project and as a basis for implementation of improved performance measurement systems by Caltrans. The San Diego and Orange County districts were selected as sites for this activity for a number of reasons:

- The San Diego district has been a leader in developing ITS systems in California, particularly the automatic data-collection and management systems associated with traffic-responsive ramp meters.

- The Orange County district has taken the lead in developing and implementing the most recent generation of automatic data collection and display software, in collaboration with the National Electronic Technologies (NET) Corporation.

- Both districts have been the source of automatically-collected data that have been used in ITS research. Data from the San Diego district have been used in past research by San Diego State University on performance measurement and control

strategies for ramp metering systems as well as research and development by Ball Aerospace and Technologies Corporation related to incident detection, freeway flow modeling, and traffic data collection and display systems. Orange County is the site of the Orange County Test Bed, and has been the site of a large amount of ATMIS research carried out by the University of California, Irvine and others, much of it under the auspices of PATH.

- Both districts are located close to San Diego State University, and the research team was already somewhat familiar with their data collection systems, particularly that of the San Diego district.

For both districts, the data system improvement plans:

- Set forth data system objectives related to performance measurement and identify data required to meet these objectives.

- Document existing traffic data collection and management systems, including traffic surveillance systems; traffic data management and display systems; traffic data bases; and the personnel required to manage, operate, and maintain the system.

- Evaluate the ability of the existing system to support the traffic data system objectives.

- Identify potential improvements to the traffic data system.

- Identify resource requirements for implementing potential improvements.

- State the districts' priorities for actions to improve their traffic data systems.

SUMMARY OF PLANS

A comparison of the two data system improvement plans shows that both districts have similar approaches to traffic data collection and management. The goals of the two systems are similar, as are most of the types of data collected. There are significant differences, however, in the degree to which the two systems are developed. These include differences in the degree of geographical coverage, differences in approaches to the overall task of traffic surveillance, and differences in the sophistication of data collection and display software.

Existing Systems

Both data collection systems are oriented toward real-time monitoring of traffic conditions, although both also have the capability of producing reports summarizing historical data. In both cases, traffic surveillance systems rely heavily on single loop

detectors; the majority of these single-loop detector stations are used primarily for ramp meter control. In addition, a number of surveillance stations (some involving double loops) have been installed in both districts, but controllers adapted to double loops are lacking. The Orange County system also includes a fairly extensive video surveillance system; to date, San Diego does not employ video surveillance, although an extensive system is planned.

Both districts maintain computerized loop-detector data bases and computerized incident logs, although the accessibility of data in the existing log in the San Diego district is limited by the difficulty of searching and sorting it. Both districts have access to an adequate accident data base through the statewide Traffic Accident Surveillance and Analysis System (TASAS).

Both districts have some current capability to provide for access to traffic data bases by external users.

At present, the traffic data system in Orange County is more fully developed than that in San Diego. First, Orange County's loop detector system provides nearly complete coverage of its freeway system. San Diego's system is much less complete, and a number of freeway segments that are believed to experience recurring congestion are not covered. Second, Orange County has recently installed state-of-the-art data management and display software that it developed in conjunction with NET Corporation. San Diego's current data management and display software is obsolete and is being replaced by a system similar to that in Orange County. Finally, San Diego has installed a number of surveillance detector stations that are not currently useful because they lack counter and communications systems. When fully operational, these will provide spacings of 0.33 to 0.5 mile on several freeways; these compare with current spacings of 0.5 to nearly 2.0 miles in San Diego and 0.6 to 1.0 mile in Orange County.

Overall resource allocation to traffic data collection appears to be somewhat more generous in Orange County than in San Diego. In addition to the investment in a more extensive surveillance system and more up-to-date data management and display software, Orange County has been able to maintain long-standing data collection activities such as ramp queue counts, which San Diego has dropped due to resource constraints.

Planned Improvements

Table 1 summarizes and compares planned traffic data system improvements in the two districts. Proposed improvements were identified in consultation with representatives of the traffic management units of the two districts and were prioritized by the districts. The overall priority classification scheme had six levels. These were:

Table 1. Planned Data System Improvement Actions

Action	Status	
	San Diego	Orange County
Install NET Software	Level 1 (underway)	Completed
Install controllers and communications for existing loops	Planned as part of communications system deployment	N/A
Improve data access for external users	No specific plans	Level 1
Phase in 2070 controllers at double loop sites	Planned as part of communications system deployment	Level 2
Complete deployment of loop surveillance system	Level 2	Level 3
Deploy or extend CCTV system	Level 2	Level 2
Deploy fiber-optics communications system	Level 2	Level 2
Complete deployment of ramp metering system	Level 2	Level 2
Provide staffing for evaluation studies	Level 3	Level 2
Institute traffic data monitoring program	Level 3	Level 2
Institute traffic data quality control program	Level 3	Level 2
Restore or expand ramp queue counting program	Level 3	Level 3

Level 1: District is already committed to this action; resources are available or action is already underway.

Level 2: District is committed to this action, but resources are not yet available.

Level **3:** High priority, but district is not yet committed to this action.

Level 4: Medium priority.

Level 5: Low priority.

Level ***6:*** The district does not want to pursue this action.

In actually rating proposed actions, however, the districts used only the first three levels.

As can be seen from the table, the planned systems will be very similar at full deployment. Many of the differences in the improvement plans result from differences in the degree to which the existing systems are developed. Both districts plan to provide complete coverage of their urban freeway systems for both ramp metering and detector surveillance systems. In addition, both districts plan extensive video surveillance systems and fiber-optics communications systems to support them. On the other hand, neither district has specific plans for conducting evaluation studies or providing performance monitoring, although both consider these activities to be important.

The data system improvement plans also include estimates of resources required to implement particular actions, where these were available. These are omitted from Table 1 because the way actions were grouped together in projects was not consistent between the two districts. Overall the San Diego district expects to spend about **$83** million on deployment or expansion of the loop detector surveillance system, the video surveillance system, the ramp metering system, and the fiber-optics communications system. The Orange County district expects to spend about **$34** million on similar improvements. See Appendices A and B for details.

EVALUATION OF PROPOSED PERFORMANCE MEASURES

Development of the Traffic Data System Improvement Plans provided an opportunity to evaluate the practicality of the performance measures identified in the first phase of the project. Results of this evaluation are as follows:

- *Travel time and related measures.* Neither district is pursuing anything other than loop-detector-based methods for measuring travel times, speeds, delays, or similar quantities. At present, neither district is capable of measuring speeds directly by means of double loops. Both have installed some double loop stations, but currently use only one loop at these stations due to lack of adequate controllers. Full use of

double-loop stations requires installation of Model 2070 controllers. Installation of these is on hold, pending resolution of software and incident detection issues and allocation of resources. Meanwhile, research related to the accuracy of loop-based methods for estimating speeds and travel times remains a priority. Specific objectives of this research should be to 1) determine the most accurate methods for estimating speeds and travel times from loop detector data (especially single-loop data) and 2) quantify the errors resulting from the use of different methods.

- *Ramp delay.* Manual queue counts remain the only practical way to estimate ramp delay. Because this activity is labor intensive, it tends to be given low priority. The San Diego district has discontinued ramp queue counts due to resource constraints. The Orange County district continues to conduct routine ramp queue counts, but the number and frequency of counts is considerably less than that recommended in the previous Working Paper *(1)*.

- *Traffic Volumes.* Traffic volumes are available on a comprehensive basis in both districts through the Traffic Census program. In Orange County, where the coverage of the detector surveillance system is virtually complete, much of the traffic census data is supplied by the traffic data system. Also, because of the virtually complete coverage, traffic volumes may be obtained at many more locations, and at much higher frequencies than is common in the Traffic Census program. In the San Diego district, detector coverage is not complete. Consequently, the spacing and frequency with which traffic volumes are available vary a great deal, depending on whether a given roadway segment is covered by the detector surveillance system.

- *Accident rates.* In both districts, very complete accident rate information is available through the TASAS program. There is a time lag in the availability of accident rate data, however, and its comprehensiveness may be limited due to non-reporting of accidents. Non-reporting is a less serious problem on freeways than elsewhere because of the high visibility of accidents and the high probability of response by the CHP, but presumably it does occur to some extent.

- *Traffic information accuracy.* Both districts have, or will soon have, the capability of automatically detecting and recording certain types of loop-detector data errors. Verification of the accuracy of other types of data commonly disseminated will require manual checking. The costs of doing this appear to be modest (from 0.5 to 1.0 PY/year of technician time), but the requirement for additional staffing runs counter to the trend in Caltrans of reducing staffing.

- *Incident clearance times.* Both districts keep computerized incident logs. Those produced with the NET software (currently installed in Orange County and under development in San Diego) should be adequate for establishing incident clearance times (provided the necessary data are recorded in the log) and are recorded in a data base format that allows convenient sorting, searching, and other types of analysis.

Actual calculation of clearance times from the incident logs will require some additional staffing, and so far, neither district is committed to this.

- *Equipment status.* The NET software currently installed in Orange County and under development in San Diego provides for equipment status logs. Certain types of failures for the loop detector system will be recorded automatically. Other equipment status information may have to be entered manually. To date, neither district is committed to producing equipment status reports or providing the staffing to do manual data entry.

EVALUATION OF PROPOSED ACTION PRIORITIES

The traffic data system improvement plans also provided an opportunity to reconsider the action priorities identified in the first phase of the project. Evaluation of these action priorities is as follows:

Possible Immediate Actions

- *Develop a policy for evaluation of investments in TMC functionality.* A recommended policy has been developed and reviewed as part of the process of developing the data system improvement plans. Based on input from the San Diego and Orange County districts, Caltrans will probably not be able to staff evaluation studies internally. One possible model for staffing evaluation studies is for Caltrans Headquarters to enter into a multi-year statewide contract with either a consulting firm with local offices throughout the state, or with PATH, which would subcontract with local universities. In the event of such an arrangement, local districts would issue task orders against the statewide agreement for individual evaluation studies. In the absence of a statewide contract, individual districts may need to enter into contracts with local consulting firms or universities.

- *Conduct research to compare loop-detector-based travel time estimates with actual travel times.* Existing traffic surveillance systems and plans for improving traffic surveillance were documented for both districts. This documentation confirmed that loop-detector-based systems are the only existing source of automatically-collected data about travel times and speeds, and that there are no plans at this time to replace them with non-loop-based systems. Furthermore, although both districts have installed double-loop detector stations, they are not currently operational. Consequently, research related to the accuracy of loop-detector-based travel time estimates remains a priority. Objectives of this research should be to 1) determine the best methods for estimating travel times from single-loop detector data and **2)** quantify the probable errors resulting from different estimation techniques.

- *Develop quality control system for traffic information disseminated to the public.* The data system improvement plans document the fact that neither district currently

has an organized program to assess the quality of data that is disseminated to the public or to other agencies. Some data quality assessment capability is provided by the NET software package. The software screens detector data using occupancy thresholds, lane-by-lane comparisons, volume state changes, etc. as screening criteria. Raw and processed data are entered into the permanent data base, and possible data errors are indicated by flags. Data quality control beyond that provided automatically by the software will require manual checking of information. Staffing needs for this activity appear to be modest, but so far neither district is committed to providing the resources.

- *Develop a monitoring plan for traffic system performance.* Discussions with district personnel in San Diego and Orange County showed that they did not have a clear concept of how traffic data could be used to monitor long-run system performance. One barrier to the exploitation of traffic data bases for monitoring is that most monitoring activities are viewed as the responsibility of planning units, and there is inadequate communication between the planning units and the traffic operations units concerning data needs and data availability. Also, there is an ongoing effort to collect data on performance indicators on a statewide basis and the districts appear to be reluctant to develop their own monitoring programs prior to the adoption of statewide standards. Before formal monitoring plans can be developed, further discussion will be required to outline statewide standards, clarify the traffic data needs of outside agencies (for instance, MPOs) and Caltrans units not directly involved in traffic operations (for instance, Planning), and determine the proper relationships among the Caltrans units using and supplying the data.

- *Conduct research on the feasibility of relating incident and accident data.* The NET software package provides for improved incident logging. Research to determine how well incident log data can be related to the accident data in the TASAS data base remains an important priority, as does research to determine the feasibility of identifying secondary accidents resulting from incidents.

- *Develop an equipment status logging system.* This has already been done as a part of the development of the NET software package.

- *Develop an improved incident logging system.* This has already been done as a part of the development of the NET software package.

Possible Future Actions

- *Conduct research on non-loop-based measures of travel time.* Research is going forward under the auspices of PATH. Given the existing investment in loop-based traffic surveillance, however, only methods which can be easily integrated with the existing system are likely to be adopted in the districts.

- *Extend loop detector coverage.* Expansions of the existing system continue to take place as ramp meter and traffic surveillance systems are expanded. Both districts are already planning expansions of their ramp metering and real-time surveillance systems that will provide virtually complete detector coverage for their urban freeway systems. Implementation of these plans depends on resource availability; consequently, it is not certain how soon complete coverage will be available, especially in San Diego. These planned installations are not intended solely (or even primarily) for monitoring traffic system performance. **As** previously recommended *(I),* expansion of the loop detector system for the sole purpose of monitoring system performance should be undertaken only after research comparing actual travel times with loop-detector-based estimates is completed and performance monitoring plans are developed.

- *Develop data reduction and display software for the performance monitoring system.* This should also be deferred until performance monitoring plans are developed. In light of the two districts' responses to the concept of performance monitoring, an extended period of negotiation and planning may be required. Issues that should be addressed before any software development effort is undertaken include data requirements, monitoring standards, and institutional arrangements.

CONCLUSIONS

Major lessons learned from preparation of the traffic data system improvement plans include the following:

1. The two Caltrans districts studied have similar traffic data systems, although the Orange County system is better developed than that of the San Diego system. Both systems rely heavily on single-loop detectors. Both either provide, or plan to provide, complete coverage of their urban freeway systems with loop-detector surveillance systems.

2. So far as actual data collection capabilities are concerned, the existing and planned traffic data systems of the two districts are reasonably adequate to support the performance measures recommended by this study. The accuracy of travel time estimates derived from loop detector data remains a concern, however, but there are no current plans to make use of non-loop-based techniques. Otherwise, the main issues related to the practicality of the performance measures have to do whether the data will actually be collected, not whether their collection is within the capabilities of the system.

3. Although plans for traffic data collection and management systems are well advanced in the both districts, the primary purpose of these systems is not to produce data for performance measurement. Rather, the real focus of the districts' traffic management is on ramp metering and incident management; the collection of traffic data is mostly

a byproduct of these activities. For instance, existing loop detectors are primarily intended to provide input to traffic-responsive metering algorithms. They are also used to generate real-time visual displays of estimated speeds that are used to evaluate traffic conditions for incident management. In developing the plans, it was difficult to separate actions intended to improve data system capabilities from those intended to improve traffic management. It appears, however, that the primary motive for most of the major actions listed in the plans is improvement of the traffic management system, not collection of data to measure its performance.

4. Despite a commitment to providing sophisticated data collection and management systems, neither district appears to have a clear vision of how to use the data to monitor performance. The development of exact procedures for performance monitoring is likely to require considerable discussion, both within the district staffs and between the districts and Caltrans headquarters. It also appears that at least some of the discussion needs to take place between Caltrans units that are not accustomed to working closely with each other. In particular, effective performance monitoring will require communication between units involved in traffic operations and transportation planning.

5. The districts studied lack the organizational structure and staffing to carry out monitoring and evaluation activities. Also, they lack the staffing to undertake labor-intensive data collection, even if it is necessary to give a balanced and accurate picture of system performance. Caltrans' allocation of resources between equipment and staffing seems to be distorted by management decisions to limit staffing, and by an inability to resolve legal and political issues related to use of consultants. Since Caltrans appears to lack the in-house staff to conduct evaluation studies and produce performance monitoring reports, it makes sense to contract for these services. Staff time will still be required, however, to manage the contracting process and utilize the results of the studies and reports.

REFERENCE

1. J. H. Banks and G. Kelly. *Traffic Management Systems Performance Measurement: Study Directions and Scope, Proposed Measures of Effectiveness, and Proposed Action Priorities.* California PATH Program Research Report UCB-ITS-PRR-97-13, 1997.

APPENDIX A

TRAFFIC DATA SYSTEM IMPROVEMENT PLAN

CALTRANS DISTRICT 11 (SAN DIEGO)

SYSTEM DESCRIPTION

The District 11 Traffic Data System consists of traffic surveillance systems, traffic data management and display systems, traffic data bases, and the personnel required to supervise, monitor, operate, and maintain these. Most, but not all, of the traffic data system is provided as a part of the District Transportation Management Center (TMC).

Traffic surveillance systems include loop detectors and voice radio and telephone communications systems used to report traffic conditions to the TMC. In the near future, video surveillance capability will be added.

Traffic data management and display systems include the hardware and software required to collect and record data, provide access to data, and display it. In addition, traffic data management systems may include pre-processors to screen data, traffic models, and post-processors to aggregate or analyze data.

Traffic data bases exist in both paper and electronic form. They include data on traffic volumes, occupancies, and speeds; incidents and accidents; information disseminated to the public (such as changeable message sign (CMS) messages); and equipment status and operational logs.

Personnel required to operate the traffic data system include supervisory personnel, TMC operators, computer programmers, hardware and software maintenance personnel, various other technicians, and data gatherers.

DATA SYSTEM OBJECTIVES

Objectives of the District 11 traffic data system are to support the following:

1. Evaluation of expansions or improvements to ramp metering systems and changes in ramp metering strategies.

2. Evaluation of incident management system improvements.

3. Evaluation of motorist assistance services such as freeway service patrols **(FSPs).**

4. Congestion monitoring efforts.

5. Long- and short-range planning and management of the freeway system.

6. Quality control for traffic information disseminated to the public, other Caltrans units, and other public agencies.

7. Evaluation of TMC equipment availability.

In addition to these activities related to performance measurement, the traffic data system is also intended to generate information for private information service providers.

DATA REQUIREMENTS

To achieve the above objectives, the following data are required:

1. Traffic volumes.

2. Estimated average speeds and/or travel times.

3. Ramp queue counts or other measures of ramp meter delay.

4. Incident types, times, locations, and durations (including accidents).

5. Accident report narratives.

6. Accident and incident rates.

7. Changeable message sign (CMS) and highway advisory radio (HAR) message logs.

8. FSP logs.

9. TMC equipment status logs.

If information service providers expect to provide information about alternative routes, they will also require data on arterial travel times. Since most arterials are not Caltrans facilities, this will require integration of data from local agencies into the Caltrans traffic data system.

EXISTING SYSTEM

Traffic Surveillance System

The existing traffic surveillance system consists of loop detector stations. In addition, some information entered in the incident data bases is relayed to the TMC via voice communications systems.

Detector stations are primarily single-loop installations associated with the ramp metering system. There are currently 95 of these. In addition, 170 detector stations intended primarily for surveillance have been installed on I-8,I-SO5 and 1-5, but most of these have not yet been hooked up to controllers or communications systems due to resource shortfalls. These detector stations provide only partial coverage of the freeway system. Table 1 lists the number of detectors and their average spacing for freeway segments currently monitored. Detector spacings for the existing ramp metering system range from about one-third of a mile to nearly two miles; average spacing for most of the longer segments is around one mile. Spacing for the combined ramp metering and surveillance systems, when fully deployed and operational, will be from about a third- to a half-mile. Most locations employ double loops, but the district plans to use them as single-loop installations in the near term, due to the limitations of the Model 170 controllers that are used as traffic counters.

Table 1. Loop Detector Spacings for San Diego Area Freeways

		Ramp Meter Sta.		Surveillance Sta.		Total Stations	
Segment	Length	Number	Spacing	Number	Spacing	Number	Spacing
I-5N, PM 14.55-20.39	5.84	0	--	12	0.49	12	0.49
I-5N, PM 33.00-38.68	5.68	3	1.89	0	--	3	1.89
I-5S, PM 14.55-20.39	5.84	0	--	12	0.49	12	0.49
I-5S, PM 28.04-41.39	13.35	11	1.21	0	--	11	1.21
I-8E, PM 0.21-4.03	3.81	0	--	7	0.54	7	0.54
I-8E, PM 4.03-11.60	7.56	4	1.89	8	0.95	12	0.63
I-8E, PM 11.60-21.89	10.29	0	--	21	0.49	21	0.49
I-8W, PM 0.21-7.06	6.85	0	--	15	0.46	15	0.46
I-8W, PM 7.06-21.89	14.83	18	0.82	16	0.93	34	0.44
I-15N, PM 9.03-15.89	6.86	4	1.72	0	--	4	1.72
I-15S, PM 14.37-32.70	18.33	18	1.02	0	--	18	1.02
SR-94E, PM 1.94-9.38	7.44	6	1.24	0	--	6	1.24
SR-94W, PM 2.28-10.04	7.76	15	0.52	0	--	15	0.52
SR-125N, PM 13.42	--	1	--	0	--	1	--
SR-125S, PM 13.46-15.25	1.79	4	0.45	0	--	4	0.45
SR-163S, PM 7.83-8.83	1.00	3	0.33	0	--	3	0.33
I-805N, PM 9.25-16.80	7.55	8	0.94	16	0.47	24	0.31
I-805N, PM 16.80-27.87	11.07	0	--	23	0.48	23	0.48
I-805S, PM 9.25-18.60	9.35	0	--	19	0.49	19	0.49
I-805S, PM 18.60-27.87	9.27	7	1.32	20	0.46	27	0.34

Table 2 shows freeway segments in urbanized portions of the San Diego area that are not covered by either set of detectors. These segments include several areas that are subject to recurring congestion.

Table 2. Urbanized Area Freeway Segments Not Covered by Loop Detector System.

Route	Direction	Segment
1-5	Both	Mexican border to just south of San Diego CBD
1-5	Both	Just north of 1-8 to 1-805
1-5	NB	North of Del Mar to Camp Pendleton
1-5	SB	Camp Pendleton to Encinitas
I-15	Both	1-5 to I-805
1-15	NB	I-8 to Balboa Ave.
I-15	NB	Mira Mesa Blvd. to north of Escondido
SR-52	Both	All
SR-54	Both	All
SR-56	Both	All
SR-67	Both	All
SR- 78	Both	All
SR -94	EB	32nd Street to Kelton Rd.
SR-94	EB	Kelton Rd. to Massachusetts Ave.
SR-94	Both	SR-125 to SR-54
SR-125	NB	Campo Rd. to 1-8
SR-163	Both	1-5 to Washington St.
SR-163	Both	Washington St. to I-805
SR-163	NB	I-805 to 1-15
1-805	Both	1-5 just north of Mexican Border to Sweetwater Rd.
1-905	Both	All

Model 170 traffic controllers are installed at existing detector sites. The district plans to install Model 2070 controllers at the new surveillance stations, but only after software and incident detection issues are resolved.

Voice communications monitored by the TMC include call box and cellular 911 communications. These are provided through colocation with the California Highway Patrol (CHP).

District 11 formerly conducted manual ramp queue counts, but has discontinued this practice due to a lack of resources.

Data Communications Systems

Loop detector data are transmitted to the TMC by means of leased conventional telephone lines. The district is in the process of deploying fiber optic cable in central urban areas, and will expand the fiber system as required to support CCTV installations. Data are transmitted from the TMC to external data users by means of conventional leased telephone lines. Existing external data links include links to local radio stations, Maxwell Labs (which provides traffic data via a World Wide Web page), and Ball Aerospace and Technologies Corporation.

Data Management and Display Systems

The existing data management and display system consists of a network of servers, work stations, display monitors and CRT projectors for large screen displays, running the SDRMS software package. SDRMS was developed internally by District 11, but is now considered to be obsolete. The district is in the process of replacing this system with a modified version of the National Electronic Technologies (NET) Corporation software package currently implemented in District 12. System functions include polling detector stations and recording data, data screening, a data display system, incident logging, and preparation of data reports. CMS control is provided by means of the Signview software package, which runs independently of SDRMS. The permanent data base contains raw data, with flags indicating potential data errors.

Data Bases

The detector data base provides detector status flags, traffic volume, occupancy, and estimated speed (calculated from volume and occupancy) for each lane at each detector station, as well as ramp counts (where available), and metering cycles. The minimum time resolution of recorded data is 30 seconds. The district's primary data base records data for peak periods only (four hours in the morning and evening); also, data are normally recorded only for the peak direction of travel. Data are also distributed (but not recorded) by means of a background process. Data are available on a 24 hour per day basis for all detector stations by means of this process. This method is used to distribute data to Maxwell Labs and Ball Aerospace and Technologies Corporation.

The Traffic Accident Surveillance and Analysis System (TASAS) data base may be accessed via Caltrans' statewide computer network. In addition, copies of accident reports are on file.

Personnel

Table 3 gives a breakdown of personnel employed in the operation of the existing District 11 traffic data system.

Table 3. Personnel Employed in the Operation of the Traffic Data System.

Unit	Classification	No.	%Time	PYs
Electrical Maintenance	Electrician Leadworker	4	15%	0.60
	Electrician	17	<15%	<2.55
Traffic Systems	Sys. Software Specialist	2	15%	0.30
	Programmer Analyst	2	50%	1.00
	Assoc. Transport. Eng.	1	40%	0.40
Traffic Systems (meter ops.)	Electrical Eng. Tech.	1	50%	0.50
	Assoc. Transport. Eng.	1	5%	0.05
	Electrical Engineer	1	10%	0.10
Electrical Systems	Sr. Transport. Eng.	1	5%	0.05
	Transportation Engineer	2	30%	0.60
TMC	Transportation Engineer	1	30%	0.30
	Transport. Eng. Tech.	1	30%	0.30
	Jr. Engineering Tech.	1	30%	0.30
	Student Assistant	2	10%	0.20

5. EVALUATION OF EXISTING SYSTEM

The following is an evaluation of the capabilities of the existing traffic data system to support the objectives identified in Section 2.

5.1 Evaluation of Ramp Metering System Improvements

The District 11 ramp metering system is still incomplete. The system is ultimately planned to cover the entire urban freeway system. Consequently, future ramp metering evaluations may involve both system expansions and possible changes in metering strategies. Data required for ramp metering evaluations include traffic volumes, estimated average speeds or travel times, ramp queue counts, and accident rates. The

current system provides all these types of data except ramp queue counts, which have been discontinued due to a lack of resources. For evaluation studies, counts at each ramp for a total of five days before and five days after the improvement are recommended. In addition, most areas that do not currently have ramp metering also lack loop detectors. In the event of metering system expansions, loops and/or controllers will need to be installed and activated one to two months in advance of initiation of metering in order to collect a "before" data set. Also, improved methods for measuring average speeds and travel times should be considered, if and when they become available. Model 2070 controllers should be installed at double-loop surveillance stations as soon as resources permit and the necessary software is available. As with other types of evaluation studies, staffing must be identified. Staffing requirements are expected to be variable, since the number and complexity of evaluation studies will vary.

5.2 Evaluation of Incident Management System Improvements

Data required for evaluation of incident management system improvements include incident types, locations, and durations; estimated average speeds or travel times; accident and incident rates; accident report narratives; and CMS message logs. The current system provides all necessary data; however, the existing incident log is difficult to search or sort. Implementation of the proposed NET software package should alleviate this problem. **A** possible improvement to the existing NET incident log implemented in Orange County would be to develop an incident classification system and add an "incident type" field to the incident log data base. This improvement is not urgent, however. The current data base can be searched for key words, and this allows incidents of particular types to be identified. As with other types of evaluation studies, staffing must be identified. Staffing requirements are expected to be variable, since the number and complexity of evaluation studies will vary.

5.3 Evaluation of Motorist Assistance Services

Data required for evaluation of motorist information services such as FSPs include traffic volumes, estimated average speeds or travel times, incident logs, and **FSP** logs. All necessary data are available for freeways that currently have loop detectors; however, the existing incident log is difficult to search or sort. In the case of freeways not currently equipped with loop detectors, evaluations of the effects of motorist assistance services on travel times will require either expansion of the surveillance system of use of tach cars or probe vehicles. Possible improvements to speed or travel time estimates and the incident log are discussed in Sections 5.1 and 5.2. As with other types of evaluation studies, staffing must be identified. Staffing requirements are expected to be variable, since the number and complexity of evaluation studies will vary.

5.4 Congestion Monitoring Efforts

Data required for congestion monitoring include traffic volumes and estimated speeds or travel times. Congestion monitoring is possible for freeway segments currently equipped

with loop detectors; however, comprehensive congestion monitoring will require either expansion of the loop detector system or implementation of non-loop-based techniques for measuring travel time, such as probe vehicles. Additional staffing and additional data aggregation and reporting software may be required. The value of congestion monitoring activities will be limited until a unified statewide process is developed and implemented.

5.5 Planning and Management of the Freeway System

Data required for planning and management of the freeway system include traffic volumes, estimated speeds and travel times, and incident and accident rates. These are available, but volumes and estimated speeds and travel times are not available on a comprehensive basis. Better definition of monitoring objectives is required before staffing needs can be properly assessed. Issues include both the number of personnel required and the appropriate units to provide the staffing. This function may require transfer of sizable data sets to external users. Currently, District 11 has the capability to distribute data in real time. In the long run, however, it may be necessary to consider tradeoffs between increased data processing and storage by the TMC and the transfer of larger files (or real-time streams) of raw data.

5.6 Quality Control for Traffic Information

Data required for quality control of information disseminated to the public (directly or through private information service providers), other agencies, and other Caltrans units include error flags for loop detector data, CMS message logs, and incident logs. Necessary data are provided by the existing system, although incident logs are difficult to search and sort. Implementation of the proposed NET software package will improve ability to control data quality. It is possible, however, that data screening techniques for loop detector data provided by the current NET software can be improved. This is an area in which active research is underway. As new data screening techniques are developed, they should be evaluated for implementation. This function will require identification of staffing. In this case, it seems most appropriate that the staffing be provided by traffic operations. One technician, working half-time, will probably be required.

5.7 Evaluation of TMC Equipment Availability

Data needed include equipment status logs for various types of equipment. Equipment status logs will be provided as a part of the proposed NET software, at least for loop detectors. Similar logs may be required for other types of equipment such as computer hardware and software.

6. PROPOSED IMPROVEMENTS

Proposed improvements to the District 11 traffic data system are listed below. Some of the actions listed are primarily intended to improve performance measurement capabilities. Others are actions that are primarily intended to improve some aspect of

TMC performance, but which will also facilitate collection of data useful in performance measurement. Proposed actions include:

1. Install a modified version of the NET software package currently used in Orange County. This will provide for improved real-time display capabilities and improved logging systems for incidents and equipment status.

2. Install field controllers at, and provide communications links to, existing loop detectors that were previously constructed but left non-functional. This will extend detector coverage to several segments of I-5, I-8, and I-805 not currently covered by ramp meter system loops. It will also provide additional loops, and hence closer loop spacing, in some areas currently covered by ramp meter system loops.

3. Complete deployment of field detection and surveillance elements including loop detectors and closed circuit television (CCTV). Deployment of these should be based on a comprehensive planning study assessing locations and deployment priorities. At a minimum, loop detector coverage is proposed to include all of the San Diego urban area at approximately half-mile spacing. Proposed CCTV deployments include full coverage for the central urban areas, and limited coverage (high-incident locations and freeway-to-freeway interchanges) for the remaining segments within the urban area.

4. Deploy a communication system to provide adequate links to all detection and surveillance field elements. This system is to be a combination of state-owned fiber-optic cable in the central urban area and leased communications in the remaining areas. The area covered by the fiber-optics communication system will correspond to that for which full CCTV coverage is planned, since high bandwidth requirements and operational costs of leased communications make full coverage impractical for areas without fiber-optics. The limits of the fiber-optic system will be defined through planning studies but are likely to include the central urban area defined as:

    - I-5 from SR-54 to Via de la Valle
    - I-8 from I-5 to SR-125
    - I-15 from I-5 to Camino del Norte
    - I-805 from SR-54 to its junction with I-5 north of San Diego
    - SR-52 from I-5 to I-15
    - SR-54 from I-5 to I-805
    - SR-56 from I-5 to I-15
    - SR-75 from Coronado Bay Bridge toll booths to I-5
    - SR-94 from I-5 to SR-125
    - SR-125 from SR-94 to I-8
    - SR-163 from I-5 to I-15

5. Complete deployment of the district ramp metering system to cover all ramps within the urban area, including freeway-to-freeway connectors where justified.

6. Restore and expand the ramp queue counting program. Ramp delay data is essential to meaningful monitoring and evaluation of ramp metering systems. Routine monitoring should involve counts for several days at each ramp. Ramp metering evaluation studies will require at least five days worth of counts at each ramp.

7. Provide staffing arrangements for evaluation studies. The district needs to either identify in-house staff or develop contractual arrangements to provide evaluation studies for traffic system improvements.

8. Institute a traffic data monitoring program. This program will provide information on long-run trends in traffic volumes, congestion, incident frequency and duration, and surveillance and control equipment status. Further discussion will be required to clarify the traffic data needs of outside agencies (for instance, SANDAG) and Caltrans units not directly involved in traffic operations (for instance, Planning) and the proper relationships among the Caltrans units using and supplying data. In addition, staffing arrangements will need to made.

9. Institute a traffic data quality control program. This will allow systematic assessment of the quality of data being released to the public, other Caltrans units, and other agencies. It is also expected to improve traffic data quality.

7. RESOURCE REQUIREMENTS

Resource requirements for the potential actions identified in Section ***6*** are as follows:

1. Install a modified version of the NET software package currently used in Orange County. Installation of the NET software package is underway with completion expected before the end of calendar year 1997.

2. Install controllers and provide communications links to previously installed loop detectors, It is currently the district's intent that this element be completed as part of the fiber-optics system deployment. The cost of completing this element is included in the estimate for the fiber-optic communications system (see item 4 below).

3. Install additional detector loops and surveillance CCTV. Loop detectors: 819 stations at $3,400 each for a total of $2,784,600. CCTV installations: 250 sites at $12,000 each for a total of $3,000,000.

4. Install fiber optics communications systems: 250 miles of state-owned fiber optics cable at $150,000 per mile for a total of $37,500,000.

5. Complete deployment of ramp metering system: 150 sites at $250,000 per site for a total of $37,500,000

6. Restore and expand the ramp queue counting program. Ramp queue counts can be performed by personnel with a relatively small amount of experience and training. This activity is ideal for the use of students, who can be either student interns hired directly by Caltrans, or supplied under contract by local universities. For routine monitoring, a high-end estimate of the cost would be 2 individuals per ramp for 4 hours on each of 5 days per year, at $10/hour, for a total of $400/year/ramp. The current system involves about 120 ramps, which results in a total of $48,000 per year. Expansion in the number of metered ramps will lead to a proportional increase in costs.

7. Provide staffing arrangements for evaluation studies. Resource requirements for evaluation studies will be variable. If Caltrans adopts a policy requiring them, evaluation studies should be an integral part of traffic system improvement projects, and funding for them should be part of the funding for the project. Performance of evaluation studies may sometimes be done with Caltrans personnel, but in many cases either the time or the expertise will be lacking. If so, the evaluation studies should be contracted out, either to consulting firms of universities. One possible model is for Caltrans Headquarters to enter into a multi-year statewide contract with either a consulting firm with local offices throughout the state, or with PATH, which would subcontract with local universities. In the event of such an arrangement, local districts would issue task orders against the statewide agreement for individual evaluation studies. If no statewide agreement is provided, District 11 should enter into a multi-year agreement with a local consulting firm or university.

8. Institute a traffic data monitoring program. Resource will requirements depend on details of monitoring activities, which have not yet been decided. This activity will probably require additional data reduction and reporting software and additional staffing. Staffing may be provided either in-house or under contract with a local consulting firm or university.

9. Institute a traffic data quality control program. This is estimated to require 0.5 PY of technician time.

8. ACTION PRIORITIES

Action priorities are expressed in terms of the district's commitment to particular actions and the availability of resources. In the case of actions listed under Level 2, (actions to which the district is committed, but for which resources are not yet available) some resources may already be programmed, but the bulk of the resources required to complete the action are not yet available. These actions, which include expansion of communications, loop-detector-based surveillance systems, and ramp metering, are being

implemented on an incremental basis. At the present rate of implementation, it is estimated that up to twenty years will be required to fully complete these projects as outlined in Sections 6 and 7 of this plan.

Level 1. Action already underway:

- Install NET software package.

Level 2. Actions to which the district is committed, but for which resources are not yet available:

- Install controllers and provide communications links to previously installed loop detectors
- Install additional detector loops and surveillance CCTV
- Install fiber optics communications systems
- Complete deployment of ramp metering system

Level 3. High priority actions to which the district is not yet committed:

- Restore and expand the ramp queue counting program
- Provide staffing arrangements for evaluation studies
- Institute a traffic data monitoring program
- Institute a traffic data quality control program

APPENDIX B

TRAFFIC DATA SYSTEM IMPROVEMENT PLAN

CALTRANS DISTRICT 12 (ORANGE COUNTY)

1. SYSTEM DESCRIPTION

The District 12 Traffic Data System consists of traffic surveillance systems, traffic data management and display systems, traffic data bases, and the personnel required to supervise, monitor, operate, and maintain these. Most, but not all, of the traffic data system is provided as a part of the District Transportation Management Center (TMC).

Traffic surveillance systems include loop detectors, video surveillance systems, and voice radio and telephone communications systems used to report traffic conditions to the TMC.

Traffic data management and display systems include the hardware and software required to collect and record data, provide access to data, and display it. In addition, traffic data management systems may include pre-processors to screen data, traffic models, and post-processors to aggregate or analyze data.

Traffic data bases exist in both paper and electronic form. They include data on traffic volumes, occupancies, and speeds; incidents and accidents; information disseminated to the public (such as changeable message sign (CMS) messages); and equipment status and operational logs.

Personnel required to operate the traffic data system include supervisory personnel, traffic operation engineers, traffic management team members, TMC operators, computer programmers, hardware and software maintenance personnel, various other technicians, and data gatherers.

2. DATA SYSTEM OBJECTIVES

Objectives of the District 12 traffic data system are to support the following:

1. Evaluation of expansions or improvements to ramp metering systems and changes in ramp metering strategies.

2. Evaluation of incident management procedures.

3. Evaluation of motorist assistance services such as freeway service patrols (FSPs).

4. Congestion monitoring efforts.

5. Long- and short-range planning and management of the freeway system.

6. Quality control for traffic information disseminated to the public, other Caltrans units, and other public agencies.

7. Evaluation of TMC equipment availability.

3. DATA REQUIREMENTS

To achieve the above objectives, the following data are required:

1. Traffic volumes.

2. Estimated average speeds and/or travel times.

3. Freeway delay estimates.

4. Ramp queue counts.

5. Incident types, times, locations, and durations (including accidents).

6. Accident report narratives.

7. Accident and incident rates.

8. Changeable message sign (CMS) and highway advisory radio (HAR) message logs.

9. **FSP** logs.

10. TMC equipment status logs.

4. EXISTING SYSTEM

4.1 Traffic Surveillance System

The existing traffic surveillance system consists of loop detector stations and a video surveillance system. In addition, some information entered in the incident data bases is relayed to the TMC via voice radio from Caltrans maintenance units, the California Highway Patrol (CHP) computer aided dispatch (CAD) system, and cable news services.

Detector stations include both single-loop and double-loop installations, with single loop installations predominating. Traffic counting is performed by Model 170 traffic controllers. Since these do not have adequate capacity to handle double-loop installations, data are normally recorded for only one loop, even where double loops have been installed. Most detector stations are associated with ramp metering installations; a

few (33 out of 309) are intended for surveillance only. Coverage of the freeway network is almost complete. One major exception is southbound I-5 south of SR-1 (Camino Las Ramblas). Also, detectors are temporarily unavailable on southbound I-5 between I-405 and SR-1; these will be activated when construction that is currently underway is completed. Typical detector spacing ranges from about 0.6 to 1.0 mile.

The video surveillance system is used for confirmation, assessment, and location of incidents. The existing system consists of 64 video cameras and provides variable coverage for the freeway network. Thirty-five units have been installed by the California Private Toll Corporation (CPTC) on SR-91 and SR-55 in the vicinity of its interchange with SR-91. On the average, these units are spaced about a half mile apart. The remaining video cameras include 11 isolated or widely spaced units on I-5, SR-22, SR-55, SR-57, SR-91, and I-405 and groups of 5 on northbound SR-55, 7 on southbound I-405 and 4 on southbound I-405. Cameras in these groups are spaced about a mile apart. In addition, 42 additional video installations on I-5 and SR-91 are in the design or construction phase. The largest group of these is on northbound I-5; when complete, it will provide an average camera spacing of about 0.8 mile from Ortega Highway in San Juan Capistrano to SR-57. Several different communications media are used to link the CCTV units to the TMC. These include conventional telephone lines, fiber optic, microwave, and spread spectrum radio systems. Video systems involve both compressed video and real-time transmissions.

Other data sources monitored by the TMC include Caltrans Maintenance voice radio transmissions, the CHP CAD system, and cable news services. The CHP CAD data is displayed on a workstation located in the TMC. This workstation is a part of the CHP network and is not integrated with the Advanced Traffic Management and Information System (ATMIS) network that includes the other TMC workstations. The TMC monitors cable news services to provide information about disasters or other news events that might affect freeway operations.

In addition to the data described above, the district collects ramp queue counts by hand. At present, each ramp is monitored about once a year.

4.2 Data Communications Systems

Loop detector data is transmitted to the TMC by means of leased conventional telephone lines. Some fiber optic cable is also used on an experimental basis. Video signals are transmitted to the TMC by means of conventional telephone, microwave, fiber optics, and spread spectrum radio systems. Data are transmitted from the TMC to external data users by means of fiber optic systems and conventional leased telephone lines. Existing external data links include a fiber optic link to the City of Irvine and conventional leased line telephone links to Caltrans District 7 and National Electronic Technologies (NET) Corporation.

4.3 Data Management and Display Systems

The existing data management and display system consists of a network of servers, work stations, display monitors and CRT projectors for large screen displays, running a software package developed by Caltrans and NET Corporation. System functions include polling detector stations and recording data, data screening and repair, a data display system, incident detection, CMS control, incident logging, equipment status logging, and preparation of data reports. The software package is intended primarily to provide for real-time monitoring of the freeway system by the TMC. It provides TMC operators with visual displays of speeds, numerical detector data, CMS control, and incident logging capability as a part of integrated system. It also supports historical data bases for detector data, incident logs, CMS message logs, and equipment status.

Data screening is based on occupancy thresholds, lane-by-lane comparisons, volume state changes, etc. Raw and processed data are entered into the permanent data base, and possible data errors are indicated by flags. The system is also capable of simulating data to fill gaps in the record.

Incident detection algorithms are available as part of the system, but district personnel believe they require additional calibration to be reliable. These exhibited a high false alarm rate when initially installed. At present, thresholds have been reset so that they will react only to extreme congestion.

4.4 Data Bases

The detector data base provides detector status, traffic volume, occupancy, and estimated speed (calculated from volume and occupancy) for each loop at each detector station. The minimum time resolution of recorded data is **30** seconds. Data are recorded for all stations for 24 hours per day. Data are available for a period of one year after they are recorded. At present, external data users have access to real time data only.

The NET software also supports incident log and CMS message log data bases. These are accessed through ORACLE data base software that is **part** of an incident management expert system provided as part of the NET software.

The system is also capable of storing video images either on videotape or as digitized images on disk. No general data base of video images is maintained or planned, although images of specific incidents may be saved.

The Traffic Accident Surveillance and Analysis System (TASAS) data base may be accessed via Caltrans statewide computer network. In addition, copies of accident reports are on file.

The Traffic Census data base is used primarily for planning purposes. Although the Traffic Census data base is normally not used for operational purposes, the ATMIS data system is a source of data for it.

4.5 Personnel

The following personnel are employed in the operation of the existing District 12 traffic data system:

1. From Traffic Systems Development Branch, 7.5 PYs involved in supervision, hardware procurement, hardware maintenance, software development and procurement, and software maintenance.

2. From the TMC, one supervisor, 3 shift leaders (Engineers) and **6** Operators (Technicians).

3. From the Electrical Systems Branch, 1 PY (Engineer) to do TMC support, fiber optics, and CMS support.

5. EVALUATION OF EXISTING SYSTEM

The following is an evaluation of the capabilities of the existing traffic data system to support the objectives identified in Section 2:

5.1 Evaluation of Ramp Metering System Improvements

Since the District 12 ramp metering system is almost completely built out at present, it is expected that most ramp metering evaluations will be concerned with changes in metering strategy rather than system expansions. The only major freeway segment not currently metered is southbound 1-5 in the southern part of the county. Data required for ramp metering evaluations include traffic volumes, estimated average speeds or travel times, mainline speed plots, estimated total delay, ramp queue counts, and accident rates. The current system provides all these types of data. There is currently a deficiency in the area of ramp queue counts. These are performed on an average once a year at each ramp. For evaluation studies, counts at each ramp for a total of five days before and five days after the improvement are recommended. Also, improved methods for measuring average speeds and travel times should be considered, if and when they become available. In particular, Model 170 controllers at double-loop stations should be upgraded to Model 2070 controllers as soon as the necessary software is available, and **as** resources permit. As with other types of evaluation studies, staffing must be identified. Staffing requirements are expected to be variable, since the number and complexity of evaluation studies will vary.

5.2 Evaluation of Incident Management System Improvements

Data required for evaluation of incident management system improvements include incident types, locations, and durations; estimated average speeds or travel times; accident and incident rates; accident report narratives; and CMS message logs. The current system provides all necessary data. **A** possible improvement would be to develop an incident classification system and add an "incident type" field to the incident log data base. This improvement is not urgent, however. The current data base can be searched for key words, and this allows incidents of particular types to be identified. As with other types of evaluation studies, staffing must be identified. Staffing requirements are expected to be variable, since the number and complexity of evaluation studies will vary.

5.3 Evaluation of Motorist Assistance Services

Data required for evaluation of motorist information services such as FSPs include traffic volumes, estimated average speeds or travel times, incident logs, and FSP logs. All necessary data are provided by the existing system. Possible improvements to speed or travel time estimates and the incident log are discussed in Sections 5.1 and *5.2.* **As** with other types of evaluation studies, staffing must be identified. Staffing requirements are expected to be variable, since the number and complexity of evaluation studies will vary.

5.4 Congestion Monitoring Efforts

Data required for congestion monitoring include traffic volumes and estimated speeds or travel times. The existing system provides the necessary data. Additional staffing and additional data aggregation and reporting software may be required.

5.5 Planning and Management of the Freeway System

Data required for planning and management of the freeway system include traffic volumes, estimated speeds and travel times, and incident and accident rates. Better definition of monitoring objectives is required before staffing needs can be properly assessed. Issues include both the number of personnel required and the appropriate units to provide the staffing. This function may require transfer of sizable data sets to external users. The district already has plans to expand its access system to include a dial-in terminal server and is also considering providing access through a World Wide Web page. In the long run, however, it may be necessary to consider the tradeoffs between increased data processing by the ATMIS system and the transfer of larger files of raw data.

5.6 Quality Control for Traffic Information

Data required for quality control of information disseminated to the public, other agencies, and other Caltrans units include error flags for loop detector data, CMS message logs, and incident logs. Necessary data are provided by the existing system. It

is possible that data screening techniques for loop detector data can be improved. This is an area in which active research is underway. **As** new data screening techniques are developed, they should be evaluated for implementation. This function will require identification of staffing. In this case, it seems most appropriate that the staffing be provided by traffic operations. One technician, working full time, will probably be required.

5.7 Evaluation of TMC Equipment Availability

Data needed include equipment status logs for various types of equipment. Data are currently available for loop detectors. Similar logs may be required for other types of equipment such as computer hardware and software.

6. POTENTIAL IMPROVEMENTS

Proposed improvements to the District 12 traffic data system are listed below. Some of the actions listed are primarily intended to improve performance measurement capabilities. Others are actions that are primarily intended to improve some aspect of TMC performance, but which will also facilitate collection of data useful in performance measurement. Proposed actions include the following:

1. Complete projects related to data access. This includes getting the U. C. Irvine Intertie fully operational and instituting provisions (such as a Web page) for transferring historical data to external users.

2. Phase in 2070 Controllers at double-loop detector installations. This will improve the accuracy of speed measurements at these locations.

3. Expand coverage of the CCTV system. This is primarily intended to improve real-time surveillance capabilities and incident management, but will also improve the quality of incident logs used in performance measurement.

4. Expand the ramp metering system. Meters may be needed at up to 30 additional ramps. This is primarily intended to improve the freeway control system, but will also provide additional detector data.

5. Extend surveillance capability to Southbound I-5 from SR-1 to the San Diego County line. This will fill the last gap in the freeway surveillance system for the district.

6. Expand the ramp queue counting program. Ramp delay data are essential to meaningful monitoring and evaluation of ramp metering systems. Routine monitoring should involve counts for several days at each ramp. Ramp metering evaluation studies will require at least five days worth of counts at each ramp.

7. Provide staffing arrangements for evaluation studies. The district needs to either identify in-house staff or develop contractual arrangements to provide evaluation studies for traffic system improvements.

8. Institute a traffic data monitoring program. This program will provide information on long-run trends in traffic volumes, congestion, incident frequency and duration, and surveillance and control equipment status. In this case, further discussion will be required to clarify the traffic data needs of outside agencies (for instance, local cities) and Caltrans units not directly involved in traffic operations (for instance, Planning) and the proper relationships among the Caltrans units using and supplying data. In addition, staffing arrangements will need to made.

9. Institute a traffic data quality control program. This will allow systematic assessment of the quality of data being released to the public, other Caltrans units, and other agencies. It is also expected to improve traffic data quality.

In addition to these items, the district also plans to expand the CMS system. This will not provide additional data, but needs to be considered in data system planning. Message logs will need to be kept for the additional CMSs, and the CMSs may be the subject of evaluation studies.

7. RESOURCE REQUIREMENTS

Resource requirements for the potential actions identified in Section 6 are as follows:

1. Complete projects related to data access. Estimated cost is $800,000.

2. Phase in 2070 Controllers at double-loop detector installations. Estimated cost is $155,000 to convert 31 surveillance detectors to 2070 Controllers.

3. Expand coverage of the CCTV system. Estimated cost to provide fiber-optics cable and CCTV installations throughout the district is $25,000,000.

4. Expand the ramp metering system. Meters may be needed at up to 30 additional ramps. Estimated cost is $300,000 per ramp or a total of $9,000,000 for 30 ramps.

5. Extend surveillance capability to Southbound I-5 from SR-1 to the San Diego County line. Estimated cost is $227,700.

6. Expand the ramp queue counting program. Ramp queue counts can be performed by personnel with a relatively small amount of experience and training. This activity is ideal for the use of students, who can be either student interns hired directly by Caltrans, or supplied under contract by local universities. For routine monitoring, a high-end estimate of the cost would be 2 individuals per ramp for 4 hours on each of 5 days per year, at $10/hour, for a total of $400/year/ramp. The current ramp meter

system involves about 280 ramps, for a total of $112,000 per year. If 30 additional ramps are added (see item 4) the total increases to $124,000 per year.

7. Provide staffing arrangements for evaluation studies. Resource requirements for evaluation studies will be variable. If Caltrans adopts a policy requiring them, evaluation studies should be an integral part of traffic system improvement projects, and funding for them should be part of the funding for the project. Performance of evaluation studies may sometimes be done with Caltrans personnel, but in many cases either to time or the expertise will be lacking. In that case, the evaluation studies should be contracted out, either to consulting firms of universities. One possible model is for Caltrans Headquarters to enter into a multi-year statewide contract with either a consulting firm with local offices throughout the state, or with PATH, which would subcontract with local universities. In the event of such an arrangement, local districts would issue task orders against the statewide agreement for individual evaluation studies. In the event no statewide agreement is provided, District 12 should enter into a multi-year agreement with a local consulting firm or university.

8. Institute a traffic data monitoring program. Resource will requirements depend on details of monitoring activities, which have not yet been decided. This activity will probably require additional data reduction and reporting software and additional staffing. Staffing may be provided either in-house or under contract with a local consulting firm or university.

9. Institute a traffic data quality control program. This is estimated to require 1.0 PY of technician time.

Expansion of the CMS system is expected to cost about $3,500,000.

8. ACTION PRIORITIES

Action priorities are expressed in terms of the district's commitment to particular actions and the availability of resources. In the case of actions listed under Level 2, (actions to which the district is committed, but for which resources are not yet available) some resources may already be programmed, but the bulk of the resources required to complete the action are not yet available.

Level 1. Action already underway:

- Complete projects related to data access

Level 2. Actions to which the district is committed, but for which resources are not yet available:

- Phase in 2070 Controllers at double-loop detector installations

- Expand coverage of the CCTV system
- Expand the ramp metering system
- Provide staffing arrangements for evaluation studies
- Institute a traffic data quality control program
- Institute a traffic data monitoring program
- Expand the CMS system

Level 3. High priority actions to which the district is not yet committed:

- Extend surveillance capability to Southbound 1-5 from SR-1 to the San Diego County line
- Expand the ramp queue counting program