POOLED FUND STUDY #SPR-3062

ITS DEPLOYMENT RESEARCH AND PROFESSIONAL CAPACITY BUILDING

FINAL RESEARCH REPORT

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EXECUTIVE SUMMARY

OVERVIEW

California and Texas, both leaders in the deployment of Intelligent Transportation Systems (ITS), are involved in national deployment programs such as Southern California Priority Corridor, Houston ITS Priority Corridor, and San Antonio Model Deployment Initiative. As ITS is implemented into major metropolitans areas, there is a need to share the successful accomplishments, challenges encountered, and topics needing more research. Coordinating the development of these systems will foster greater consistency and interoperability between urban areas within states and the states themselves. The involvement of the research organizations would help bridge the gap between practitioners and emerging technologies that may directly impact the daily activities of such agencies in maintaining and operating their prospective ITS inventories. The sharing of information between practitioners and researchers will also educate professionals in each state about the latest in emerging technologies, advanced operating strategies, and multi-modal integration systems. This is consistent with the federal professional capacity building initiative and will lead to expanding the breadth and depth of knowledge within each of the participating agencies.

MEMORANDUM OF UNDERSTANDING

To accomplish the above goals the ITS Deployment Research and Professional Capacity Building Pooled Fund Study was initiated in 1998, initially between two State Departments of Transportation (DOT) and two university research organizations in California and Texas. A signed Memorandum of Understanding (MOU) established the working relationship among the initial partners, for an effort specifically designed to coordinate ITS deployment research activities. The research organizations were to serve as the coordinators for a series of planned meetings, working closely with the states to develop the desired agenda for each meeting. They were also responsible for developing an effective agenda to maximize the value of the meeting time, prepare records of meeting minutes, and develop and maintain a website dedicated to the Pooled Fund Study providing access to all of the products and records. Another two state DOTs, Washington and Minnesota, joined later to form the four state Pooled Fund Study. At that time the Pooled Fund Study changed its title to Multi-state Operations Research and Implementation Program or **MORIP**. All references to MORIP in the body of this report is referring to this Pooled Fund Study.

FUNDING & SCOPE OF WORK

Under this agreement, the states of California and Texas agreed to obligate $50,000 per year for 3 years starting on July 1, 1998, through June 31, 2001. Washington and Minnesota each agreed to obligate $10,000 per year, to bring the funding level to a total of $360,000 for the life of the Pooled Fund Study. Part of the funding was allocated to allow DOT personnel and university researchers to participate in a series of six coordination meetings, scheduled twice a year in different cities where various ITS activities were being pursued. Each participating agency was given the opportunity to examine host agency's ITS projects up-close, and was exposed to its lessons learned and experiences. Furthermore, the group reviewed the national research agenda periodically and provided input into the upcoming research activities focusing on the following areas: 1) Sharing information on current ITS deployment initiatives; 2) Identifying critical issues associated with ITS deployment nationwide; 3) Developing plans for joint research to address and resolve critical issues; and 4) Educating transportation professionals on the design, implementation, and evaluation of leading ITS deployments. Another part of the funding was allocated to develop research white papers on the topics that the Pooled Fund Study participants deemed critical in deployment of ITS, and beneficial in maintaining and operating the ITS component.

TECHNOLOGY TRANSFER

This Pooled Fund Study was designed from the outset with technology transfer aspects in mind. The exchange of information and sharing of lessons learned were invaluable to the participants. One of the more notable outcomes was TxDOT agreeing to make the source code and documentation on San Antonio ATMS software available to UCI Testbed, for further analysis and integration of a ramp meter control module. This work is currently ongoing in Testbed, the results of which will be shared with TxDOT. The success of this Pooled Fund prompted the participants to vote for continuation of it for the next two years, in the last scheduled meeting in April of 2001. TxDOT is currently perusing to be the Lead State for the continuation of these collaborative efforts on a new pooled fund study arrangement.

DELIVERABLES

Meeting Proceeds: Each scheduled meeting started from a problem-oriented approach in identifying the common and unique problems each state is trying to address. These discussions focused on identifying the technical issues, integration problems, and institutional challenges being experienced with deploying specific ITS projects. Approaches to solving those issues and challenges were also discussed in attempts to build upon the experience and strength of each organization. A document summarizing the discussions of each meeting was produced, and a strategic plan was developed to leverage the research that was taking place in each participating state. These documents along with a copy of all of the presentations can be viewed by accessing the Pooled Fund Study Website at: http://morip.tamu.edu/

Business Plan: A business plan developed to create linkages between the Pooled Fund long-range plans and the work plans used by project implementers. The Pooled Fund Study participants were able to trace their contribution from the work plans they follow through the business plan. In addition, they were able to see how the Pooled Fund strategic objectives align with its mission and long-range plans. In the initial discussion it was identified that the Pooled Fund study will be involved in the following: 1) A forum for information exchange and technology transfer; 2) Sponsoring research and other types of projects; 3) Developing research proposals, some which could be funded by other pooled fund studies; and 4) Monitoring other related research activities, both locally and nationally.

Research White Papers: Three white papers were produced as identified in the business plan. The papers were developed by the collaborative efforts of the two research organizations that were involved with this Pooled Fund from the outset, namely Partners for Advanced Transit & Highways (PATH), and Texas Transportation Institute (TTI). The contractual mechanism used to contract out to these organizations were through PATH Master Agreement Task Order #4124. A copy of these reports is included as part of the final research report on this Pooled Fund Study. The three research papers are:

I. **Transportation Performance Measures:** The objective of this research paper was to focus on synthesizing recently completed and ongoing research in transportation performance measures and identifying "best practices" from the four participating states. It also identified implementation opportunities for states that might be interested in implementing ideas and practices that have been developed by other states.

II. **Data Sharing with Public/Private Sectors:** This report focused on examination of the current state of the practice of traveler information data sharing with the public and private sectors. A review of the literature was initially performed followed by an analysis of responses to a survey instrument that addressed the subjects of what data is shared, with whom it is shared, why it is shared, how it is institutionally arranged and managed, how effective the sharing enterprise has been, and how the enterprise can be improved.

III. **ITS Hardware Maintenance Management Systems:** This report focused on investigating existing maintenance management elements in use to track hardware maintenance histories within the participating four states. With the planning, design, construction, integration, and operation of TMCs and ITS technologies spreading throughout the country, various agencies are responsible for operating and maintaining these complex and expensive systems. The challenge facing DOTs presently is tracking the maintenance history for the various system hardware components and determining the life cycle cost of maintaining these systems. This cost information can be used for a variety of purposes, including determining the reliability and cost-effectiveness of individual hardware components, comparing the benefit/cost ratios of these systems and components, and justifying the maintenance fund requests.

APPENDIX I

Pooled Fund Study #SPR-3062
Final Research Report
December 2001

DATA SHARING OF TRAVELER INFORMATION WITH THE PUBLIC AND PRIVATE SECTORS:

STATE OF THE PRACTICE

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ABSTRACT
This report presents the results of its examination of the current state of the practice of traveler information data sharing with the public and private sectors. A review of the literature was initially performed followed by an analysis of responses to a survey instrument that was designed and administered to practitioners in the field, primarily representatives from public sector agencies, who are in the business of collecting traveler information data. Survey results have addressed the subjects of what data is shared, with whom it is shared, why it is shared, how it is institutionally arranged and managed, how effective the sharing enterprise has been, and how the enterprise can be improved. More work is needed and a next step could be the development of an action plan to implement the lessons learned.

Key Words: traveler information, data sharing, survey

EXECUTIVE SUMMARY

This report constitutes the final deliverable for PATH Project Task Order 4124 — "Data Sharing of Traveler Information with the Public and Private Sectors: State of the Practice". The project investigated the primary questions relating to traveler information data sharing including:

- Who shares traveler information data?
- What data is shared?
- Why is such data shared?
- What are the institutional and/or policy-related settings associated with data sharing?
- How can the physical or technical aspects of data sharing be described?
- How effective has the data sharing experience been?
- Has the data sharing experience provided lessons learned for the future?

To get answers to these questions, a survey instrument was designed and administered and responses were analyzed. The survey was administered to members of the public and private sectors with knowledge and experience in the data sharing business in order to elicit insight and expertise from these real-world practitioners. A total of thirty-six completed and returned surveys was analyzed and forms the basis of the findings documented in this report. A comparison was also made between overall responses and responses restricted to members of the four-State Multi-State Operations Research and Implementation Program (MORIP) Pooled Fund Study: California, Minnesota, Texas, and Washington.

Principal findings include:

- Generally, more than ½ of survey respondents share data with members of the private sector.
- From eighty to over 90% of survey respondents share data with public sector organizations.
- Highway electronic/digital data, both real-time and static, is shared with both the private and public sectors, to a greater degree compared to verbal and video type of data.
- Transit data, regardless of the type of data or with whom it is shared, is shared only in limited and small ways, relative to highway data.
- Data is shared verbally to a considerable degree, especially given the ever-increasing electronic and digital format of traveler information data.
- The most important reason given as to why agencies and organizations share data is to enhance coordination levels among the region's transportation agencies to improve overall travel conditions
- Approximately ½ of all respondents and three-quarters of MORIP respondents have a formal policy toward data sharing and of those with a formal policy, a majority stated that the policy was developed either because agency wants to help disseminate traveler information or to establish process for handling data requests
- For those respondents without a formal policy, agency views are usually expressed through contracts or agreements with recipients
- Over 85% of respondents, both overall and MORIP, require a written agreement when sharing data at least some of the time
- Approximately only ⅓ of respondents, both overall and MORIP, seek to recover revenue from the use of their agency's/organization's data beyond the costs of making it

accessible; Of these respondents, more than ½ view such arrangements as successful and would recommend revenue sharing to others

- Exclusive arrangements for data access are used only minimally
- At least 80% of respondents, both overall and MORIP, require that users pay for their own hardware, communications, and/or software costs for accessing the data
- At least 85% of respondents, both overall and MORIP, require that users acknowledge the source(s) of the data, while ½ to ⅔ of respondents impose technical and use restrictions
- Over ¾ of respondents, both overall and MORIP, favor the development of guidelines as a proper federal activity to promote data dissemination
- The Internet is the most popular means through which data is retrieved with approximately 60% and 75% of overall and MORIP respondents, respectively, selecting the Web
- Generally, MORIP and overall responses follow very similar response patterns though differences in degree exist
- Respondents' most important lessons learned include:

1. Standards and consistency would be very valuable, e.g., data collection methods, data format, protocol
2. Establish and maintain open lines of communication among agencies as to data availability, its benefits, and what other organizations are doing—a marketing effort
3. Be realistic and practical about costs, especially, O&M costs of data sharing
4. ATIS marketplace is very immature with a small user base, financially weak, and limited market demand
5. Establishing partnerships is time consuming and cumbersome with public sector lagging market speed
6. Public sector role should be to supply data, not serve a retail role nor prescribe outcomes while performing data collection/processing functions and delivering multiple data types while private industry serves as a source for customized distribution
7. Cost of data sharing is burdensome on public agencies driving a search for ways of "sharing the costs of sharing the data" with private industry
8. Establish up-front written agreements and policies
9. Work needed to maintain data accuracy, timeliness, reliability and to enhance the type and quality of shared data
10. Too much competition on whose system is better; do more for common good
11. Need for education in the data sharing business
12. Take the time up-front to define objectives, plans and system design in data sharing enterprises vis-à-vis available funds
13. Resources need to be adequate and reliable to handle and maintain data requests
14. Need to have a common and centralized point of access for data

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1.0 INTRODUCTION

This report constitutes the final deliverable for PATH Project Task Order 4124 — "Data Sharing of Traveler Information with the Public and Private Sectors: State of the Practice". The remainder of this section discusses the motivation for, objectives of, and the methodological approach used in the project.

1.1 Motivation and Objectives

With the installation of more and better traffic surveillance equipment and better methods for collecting, processing, and characterizing this information, its potential value to travelers has been and will be enhanced. Better processing of 911 data may also provide more timely information on incidents. Paralleling the enhancement of information is the improvement of methods to disseminate the information through such means as the Internet/World Wide Web, in-vehicle computers, hand-held devices, and other methods yet to be developed. At the same time private industry is developing other sources of traffic information, most notably cell phone tracks, which give information on travel times not only on freeways but on arterials with signals, where standard surveillance devices can not provide travel times. These tracks may also be able to provide information on origins and destinations and vehicle volumes if combined intelligently with other data sources, such as household travel surveys and loop detector counts. There is also a potential for private firms to perform conventional traffic surveillance for public agencies, just as many municipal services, such as waste collection and disposal are now contracted out to private firms. So sharing can work two ways, the public sector providing data to private industry and private industry providing data to public agencies.

With such changes in many aspects of the traveler information data usage business, the MORIP four-State Group felt it was an appropriate time to step back and assess where the state of the practice is by taking a snapshot of current activities especially in the context of the four MORIP States of California, Minnesota, Texas, and Washington, yet also, to the extent possible, on a national scale.

The primary objectives of this work were to assess the state of the traveler information data sharing practice to be able to answer the following major questions:

- Who shares traveler information data?
- What data is shared?
- Why is such data shared?
- What are the institutional and/or policy-related settings associated with data sharing?
- How can the physical or technical aspects of data sharing be described?
- How effective has the data sharing experience been?
- Has the data sharing experience provided lessons learned for the future?

1.2 Methodological Approach

To fulfill the project's objective, we initially identified partial answers to some of the above questions by means of reviewing the literature and the knowledge and experience of project team members. Next, we honed these incomplete answers from the experiential point of view of individuals working on traveler information data sharing in the "real world". We gained insight from people with direct and first-hand data sharing experience by designing and administering a survey instrument to numerous individuals around the U.S. and subsequently analyzing survey responses. By design, the survey sample size was relatively small and thus even with a large response rate, survey response analysis was accomplished more descriptively than statistically with an assessment of current opinions on this topic rather than a scientific study.

During the course of the project, we learned of very similar and concurrent work sponsored by the Federal Highway Administration[1]. There were several areas of overlap between the two projects, including:

- Objective
- Use of survey instrument to collect data
- Survey questions
- Sites for case studies
- End date

Because of the enthusiasm for collaboration to leverage the projects off each other, the two teams merged their projects through an informal arrangement with a common Statement of Work and survey instrument, survey administered to a list of Points-Of-Contact that were jointly identified, shared survey results, and separate final reports (deliverables). The advantages are three-fold:

- Opportunity for state/federal collaboration
- Potentially have much wider geographic coverage for survey
- Avoid making multiple calls to same people

1.3 Contents of the Report

This is the first of five sections. Section 2 provides general background material along with a summary of previous work on this subject. Discussion of the survey design and administration is presented in Section 3, followed by the analysis of survey findings in Section 4. Conclusions are provided in Section 5.

2.0 BACKGROUND

This section provides a brief discussion, based on a review of the literature, of the questions being raised with respect to traveler information data sharing practices in the U.S. This review serves as a foundation from which the survey work—its design, administration, and analysis—flows.

2.1 Macroscopic Examination of Traveler Information Data Sharing

The primary sources of information for the review of the literature were two workshops held under the auspices of the Advanced Traveler Information Systems (ATIS) Committee of the Intelligent Transportation Society of America (ITS-A). The first workshop was held in San Diego, California in October 1997 and focused on the development of business models for ATIS deployment (References 1 and 2). The second workshop was held in Scottsdale, Arizona in

[1] The prime contractor for this work was Battelle Corporation.

February 2000 and focused on ATIS-related data collection and data quality (References 3 through 8).

Data sharing issues/questions raised at the ATIS data collection workshop include:

- Who has the data?
- What data will be made available?
- Who needs the data?
- What kinds of policies are in place to maintain the integrity of the data?
- How much enthusiasm are there on the part of the public sector, usually the collector and maintainer of traveler information data, to share with the private sector?
- Is the data gathered by the public sector sufficient for private ATIS needs?
- Under what limitations will the public sector allow the private to use the regional data?
- What are the constraints in sharing data between public sector agencies or the private sector sharing their data with the public sector?
- How will the data be accessed?
- To whom will the data be made available?
- How often will the data be accessed?
- Is there a cost to provide access, and is there an appropriate cost recovery mechanism?
- Are there system or privacy security issues and how will they be handled?
- Are there to be assurances or caveats to users regarding accuracy, reliability or availability?
- Should there be "performance" or data integrity requirements to ensure that the data are "properly" used?
- Is there any liability for use of the data, or relief from such liability?
- How would archived data be made available to interested public and private parties?

Both public sector agencies and private industry have their own perspectives and concerns about data sharing and about each other relative to this enterprise, including issues of access, service, data quality, and costs. Members of the private sector view the public sector as having data that they are not making available to them, while some in the public sector see private sector requests as unreasonable, costly, or contrary to public policy considerations. Some, but not all, states and metropolitan areas seem to have worked out agreements.

The following steps were proposed at the Workshop as a starting point:

- Gain a better understanding of the issues of all parties.
- Identify the parties' specific objectives, how they vary, and what barriers exist.
- Identify examples where those barriers have been creatively addressed.
- Share the information in the form of recommended best practices, model agreements, etc.
- Recommend other actions, if required

The issues and questions about data sharing that have been raised have assisted the project team in designing a survey instrument that focuses on most, if not all, of these same issues to elicit the insights from field practitioners regarding data already being collected to determine if this data are being leveraged to the maximum extent possible for traveler information applications.

3.0 SURVEY DESIGN AND ADMINISTRATION

The survey instrument was designed and administered to solicit the "real world" opinions and experiences of individuals actively involved in the sharing of traveler information data. The opinions of respondents provided this study with insight and expertise grounded in experience intended to provide guidance for on-going and future data sharing activities. Our goal was to investigate the following topics:

- Extent of data sharing
- Content and format of data sharing
- With whom is data sharing taking place
- Objectives, expectations for sharing of data
- Type of policy(ies)/mechanism(s) set up to share data including level of exclusivity, method to recover revenue, and conditions on data access
- Effectiveness of alternative data sharing models
- Lessons learned and recommendations for improvement

3.1 Participant Identification

An initial candidate list of potential participants was developed based on the experience of the project team members in the area of traveler information data. Breadth across rather than depth within individual organizations was preferred. This initial list was reviewed and additional names supplied by the teams' management oversight partners, both from MORIP and FHWA. Additional potential participants were identified following-up on leads obtained from early contacts.

3.2 Design of the Survey Instrument

On the survey, participants were identified by their city/region, job title, and organizational type. The survey (See Appendix A) contents consisted of a set of twenty questions requiring mainly simple check-off "Yes" or "No" responses as well as multiple choice responses together with open-ended questions that gave respondents the opportunity to convey more detail in their answers as well as allowing the questioner (See Section 3.3 Survey Administration) to probe for additional information with follow-up questions. There is naturally a trade-off between the close- and open-ended questions. The former allows for much simpler data reduction and analysis processes than the latter, while the latter provides the opportunity to get added detail and more enriched answers. Participants also had the option not to respond if they thought a question was "Not Applicable" to them or they felt they just did not know how to answer a specific question. Finally, participants could list additional issues they felt were overlooked by the survey.

The team, that is, the extended MORIP/Battelle team, designed a draft survey covering the primary issues listed above in Section 3.0. This instrument was tested for comprehensiveness, readability, and clarity by administering it to individuals familiar with the data sharing knowledge domain but who would not be part of the pool of potential respondents. The survey was revised and finalized based upon the results of these tests.

3.3 Survey Administration

The survey was administered by initially placing telephone calls to each person on the master survey contact list, which contained 51 names. The purpose of these initial calls was to introduce the project to potential participants and request participation in the survey. The MORIP and Battelle team members called the MORIP and non-MORIP contact names, respectively[2]. Repeated attempts (two to three calls) to contact people on the master contact list were made. Due to the time constraints of both project team members and potential participants, especially in the scheduling of and administering a telephone interview survey, the team felt it would be better to give potential participants the option of filling out the survey on their own and returning it to the project team without the interviewer/interviewee interaction while the survey was being administered. While the survey was not purposely designed to fill out on-line, this method could be and was used by several respondents and returned via e-mail. Of course, the survey could be printed, filled out, and returned by fax. Giving participants this alternative helped increase the number of completed and returned surveys than otherwise possible, but at the cost of the interaction between interviewer and interviewee. Where appropriate and necessary, follow-up calls were made to compensate for this shortfall.

3.4 Survey Limitations

Initially 51 people were identified as potential survey participants and were contacted by the project team, resulting in 40 people willing to participate in the survey and 36 returned and completed surveys from the four-State MORIP Group as well as numerous other regions in the U.S. including Georgia, Kentucky, Missouri, and Pennsylvania (See Appendix B for a complete listing of respondents' regions). The decrease from 51 to 40 was due to candidates 1. not returning telephone calls, 2. declining to participate either at the initial contact stage or once they read the survey and not providing a substitute contact, 3. not returning the survey in time to be included in the analysis of responses, and/or 4. selecting only one individual to represent an organization rather than multiple representatives.

There were two occasions in which the survey was implemented in a group setting with multiple respondents, one occasion with two people and the other with three people. The completed survey represented the group's consensus views considered more as a unit rather than two or three individuals. On one other occasion, a willing participant returned the survey answering "No" to the initial question ("Do you currently share data used in traveler information with private and public entities?") and thus ending participation in the survey. This clustering resulted in 36 completed surveys on which the analysis was based. The study and its associated sample size were, a priori, not intended to be of the sort or the magnitude where standard statistical validity concerns and associated techniques would come into play, such as the use of over sampling to obtain a pre-determined distribution of particular respondents by a certain attribute. Due to the small number of survey participants, we did not intend this survey to be a statistical evaluation but rather a descriptive one with study findings interpreted as an assessment of current opinions and experience on this topic rather than a scientific study. We believed a small, yet

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[2] There is some likelihood of inconsistency in survey administration because more than one Project Team member administered the survey. However, this was moderated by the fact that several of the participants filled out the survey without the benefit of an actual interview and thus differences in interview style would have been lessened.

knowledgeable and experienced group of participants would provide greater insight than a larger population of speculative or uninformed participants.

When viewed on a state-by-state basis, it appears as though the findings may be skewed toward certain geographical regions of the U.S., especially California and Texas, because of the number of responses from those two states, namely, 7 and 5, respectively, representing 19% and 14% of the total number of responses (See Appendix B). Whereas each returned non-MORIP survey almost unanimously represented distinct states and regions in the U.S. However, each of the two large state "delegations" from California and Texas represent not only different branches of the same organization, e.g., Caltrans and TX DOT individual district offices, but also different organizational types, e.g., department of transportation, metropolitan planning organization, and regional transit authority. These differences are represented in the variety of responses observed. Surveys were distributed to approximately equal numbers of participants per individual organization. Overall, the objective was to obtain information from as wide a variety of different regions, including major urban and non-urban areas.

3.0 SURVEY FINDINGS: OVERALL AND FOUR-STATE MORIP GROUP

This section presents the results from our analysis of the completed surveys. The sub-sections correspond to major survey components. Survey findings were based on two separate analyses of survey responses:

- Findings based on all responses
- Findings restricted to the four-State MORIP Group

Approximately three-quarters of the respondents, both overall (26/36) and when restricted to the four-State MORIP Group (12/16), were affiliated with State Departments of Transportation (DOT), thus making the responses heavily weighted toward the opinions and views of State DOTs (Appendix B). As a result, a separate analysis of DOT-only responses was not made. The remaining 10 respondents from the total population of 36 include four transit agency respondents, two from the private-sector, a single regional transportation planning agency representative, a single respondent from a countywide roadway authority for construction and maintenance, and two multi-jurisdictional transportation organizations (each containing state DOT representation). Because all other respondents pooled together from transit authorities, the private sector, MPOs, and other organizations comprised only 25% of the total respondent population, segmenting the responses into other such groupings would leave us with even fewer responses from which to analyze results as well as make it more difficult to maintain the confidentiality promised of all potential participants when first contacting them.

It must be reiterated that comparisons that are made, e.g., between overall and MORIP results, while informative and valuable, must be viewed through a more qualitative than quantitative and statistically rigorous lens.

4.1 Data Recipients

This section addresses the question: Who gets the data? The results are summarized in Table 1 for the survey findings overall and restricted to the MORIP 4-State Group. The first five data recipients listed in Table 1 are private sector entities[3]. Overall, except for local newspapers, more than one-half of survey respondents shared data with these members of the private sector. For the MORIP Group, in all these private sector cases, more than one-half of responses shared data with them. Relative to sharing data with public sector organizations, from eighty to over ninety percent of survey responses indicated a sharing of data with such entities. The biggest differences between the overall responses and those from the MORIP Group are relative to sharing data with local newspapers and the "Other" category. An explanation for this difference could be that the non-MORIP respondents simply just have not tapped the newspaper market and/or do not yet view this as a valuable outlet.

TABLE 1. Recipients of Data

Who gets the data?	OVERALL (% of 36 responses)	MORIP (% of 16 responses)
Local TV or cable TV stations	77.8	75.0
Local radio stations	66.7	81.3
Local newspapers	36.1	68.8
Private sector Internet Service Providers	52.8	62.5
Traffic reporting organizations (private sector)	75.0	75.0
Other public agencies	91.7	81.3
Other	38.9	56.3

Examples of the types of "Other public agencies" include:
- Police Agencies/departments (local, state)
- Chambers of Commerce
- Colleges/Universities
- Transit Authorities
- Municipal agencies
- Courts
- Local cities, towns, and counties
- Regional Transportation Planning Agencies (Metropolitan Planning Organizations, Councils of Governments)
- Emergency medical response

Examples of the types of "Other" include:
- Local sports teams/franchises
- Major activity centers/traffic generators (malls, other businesses)
- Commercial vehicle operators
- Information integrators

4.2 Contents of Data

This section answers the question: What are the contents of the data? The results are summarized in Tables 2a and 2b for the survey findings overall and the MORIP 4-State Group, respectively.

[3] With the possible exception of local TV in the case of local public television stations such as KTEH and KQED in the San Francisco Bay Area.

Data types were grouped into two categories: real-time and static. Real-time data refers to frequently changing information, sometimes also referred to as "dynamic". "Static" data refers to information that either does not change or changes so infrequently that it could be considered to be unchanging for purposes of this investigation. For example, "Transit/static" data could include bus schedules and route maps; "Highway/static" could include posted speed limits or long-term construction projects (e.g., seismic retrofit of San Francisco Bay Area bridges). The numbers listed in the tables indicate the percentage of survey respondents who share this type of data with either private entities or public organizations. The following observations may be made from the tables:

1. Highway electronic/digital data, both real-time and static, shared with both the private and public sectors garnered the largest percentage of affirmative responses compared to verbal and video type of data.
2. Transit data, regardless of the type of data or with whom it is shared, is shared only in limited and small ways, relative to highway data.
3. Data is shared verbally to a considerable degree, especially given the ever-increasing electronic and digital format of traveler information data.
4. MORIP and overall responses follow very similar patterns though differences in degree exist.

TABLE 2a. Contents of Data (OVERALL)
(% Of 36 Responses)

	Electronic/Digital		Verbal		Video	
	Private	Public	Private	Public	Private	Public
Highway/real-time	75.0	69.4	52.8	55.6	63.9	66.7
Highway/static	58.3	63.9	38.9	36.1	2.8	5.6
Transit/real-time	5.6	11.1	2.8	11.1	0.0	8.3
Transit/static	16.7	19.4	0.0	11.1	0.0	2.8

TABLE 2b. Contents of Data (MORIP)
(% Of 16 Responses)

	Electronic/Digital		Verbal		Video	
	Private	Public	Private	Public	Private	Public
Highway/real-time	93.8	75.0	43.8	50.0	68.8	68.8
Highway/static	68.8	68.8	31.3	25.0	6.3	6.3
Transit/real-time	12.5	6.3	0.0	0.0	0.0	0.0
Transit/static	37.5	18.8	0.0	0.0	0.0	0.0

4.3 Institutional Aspects of Data Sharing

This section presents the institutionally related findings from the survey with a discussion of the following topics:

- Motivation
- Policy making
- Cost recovery
- Conditions on data use
- National role

4.3.1 Motivation

This section addresses the question of why data is shared in the first place. Respondents were asked to rate the reasons they share data on a scale of "1" to "5" with "1" indicating the highest rating and "5" the lowest. Results are shown in Table 3. The table entries in parentheses indicate the number of responses who rated the corresponding reason while the other number indicates the average rating based on all the scores a particular reason received. For example, for Reason #1, 23 out of a total of 36 responses rated this reason while the other 13 respondents did not and of these 23 responses, the average rating on a scale of 1 to 5 was 2.6. Once again, overall and MORIP responses closely match each other with the highest rated motivation for sharing data being to enhance coordination levels among the region's transportation agencies to improve overall travel conditions. Respondents were also given the option of stating their own reasons and examples include:

- Contractual obligations
- Out of altruism (for public agencies)
- Helps promote centralized data collection operations

TABLE 3. Motivation for Sharing the Data
Average Rating (Number of responses to this question)

Why do you share the data?	**OVERALL (36)**	**MORIP (16)**
1. My organization is currently participating as an institutional partner in a regional program that requires my agency to share data.	2.6 (23)	2.3 (9)
2. My organization has received data solicitations from the private and public sectors.	3.0 (29)	2.8 (10)
3. To enhance coordination levels among the region's transportation agencies to improve overall travel conditions.	1.6 (32)	1.8 (13)
4. My organization has an internal policy to use traveler information to improve utilization of the transportation system.	2.4 (31)	2.4 (14)

4.3.2 Data Sharing Policies

This section discusses the policy-related aspects of data sharing. Findings are presented in Tables 4 through 6.

With respect to the responses overall and MORIP, 52.8% (19/36) and 75.0% (12/16) of respondents, respectively, indicated that their organization does have a formal policy toward data sharing. Reasons why such a formal policy was developed are provided in Table 4. For both overall and MORIP responses, a majority stated that the policy was developed either because the agency wants to help disseminate traveler information and/or to help establish a process for handling data requests. These policies range in age from 0-1 year old to 30 years old, with approximately half of the policies being no older than three years. Examples of other reasons for establishing formal policies include:

- Manage expectations and assets by being formalized up-front
- Facilitate agency coordination for incidents and construction activities
- Help ensure fair and equal treatment across all data requests, i.e., for consistency and standardization purposes
- Issues of privacy

- Help establish partnerships
- Mutual agreement

**TABLE 4. Formal Policies for Data Sharing
(% Of Applicable Responses)**

Does your organization have a formal policy about data sharing?	**OVERALL (19)**	**MORIP (12)**
Policy developed because agency wants to help disseminate traveler information	57.9	58.3
Policy developed to establish process for handling data requests	68.4	58.3
Policy developed for other reasons	42.1	25.0

For respondents who do not have a formal policy, i.e., the remaining 17 out of 36 overall respondents and remaining 4 out of 16 MORIP respondents, Table 5 provides the means through which organizational views on data sharing are expressed. Again, overall and MORIP responses follow a similar trend though have differences. Nevertheless, in both cases contracts and agreements with recipients is the primary means through which such views are expressed.

**TABLE 5. Means of Expressing Data Sharing Views
(% Of Applicable Responses)**

Without a formal policy, how are your agency's data sharing views expressed?	**OVERALL (17)**	**MORIP (4)**
Contract or agreements with recipients	52.9	25.0
Training or procedure manuals	11.8	0.0

(Percentages do not add up to 100% because some respondents did not answer this question)

The respondents who do not have a formal policy were then questioned on whether they have plans on issuing a formal policy. Of the 17 and 4 responses overall and for MORIP, respectively, only 6 respondents overall and no MORIP respondents indicated any plans for issuing a formal policy. Reasons for issuing a policy and the level of support are stated in Table 6.

**TABLE 6. Future Plans for Data Sharing
(% Of Applicable Responses)**

Do you have plans for issuing a formal policy?	**OVERALL (6)**	**MORIP (0)**
We have such plans because agency desires to help disseminate traveler information	83.3	N/A
We have such plans to establish process for handling data requests	83.3	N/A
We have such plans for other reasons	16.7	N/A

The next question investigated dealt with the need for documenting in some way any data sharing activity. Results applied to all respondents, i.e., 36 and 16 respondents overall and MORIP, respectively. Results show (Table 7) that for both overall responses as well as for

MORIP responses, at least 86% of respondents require some form of written agreement documenting any data sharing agreements.

TABLE 7. Requirement for Written Agreement (% Of All Responses)

Is a written agreement required when you share data?	OVERALL (36)	MORIP (16)
All the time	50.0	50.0
Sometimes	36.1	37.5
None of the time	11.1	6.3

(Percentages do not add up to 100% because some respondents did not answer this question)

4.3.3 Cost Recovery Mechanisms

This section addresses the cost-related issues associated with data sharing. The issues considered include:

- Effectiveness of cost recovery mechanisms
- Exclusivity of data access arrangements
- Financial arrangements for data access

Regarding the effectiveness of cost recovery mechanisms, survey respondents were asked whether they sought to recover revenue from the use of their data beyond the costs of making it accessible. Twelve of 36 respondents overall and 5 of 16 MORIP respondents said "Yes" to this inquiry. The "Yes" respondents were then asked whether they thought such mechanisms were successful and if they would recommend revenue sharing to others. Percentages of "Yes" responses to these two follow-up questions are shown in Table 8, again displaying very close behavior between MORIP respondents and the overall perspective. Reasons given for recommending revenue sharing to others include:

- Provides opportunity to offset costs (O&M and infrastructure)
- Helps develop additional funding mechanisms to expand data coverage
- Encourage alternative forms of "revenue" sharing, such as through bartering

TABLE 8. Effectiveness of Cost Recovery Mechanisms (% Of Applicable Responses)

Do you seek to recover revenue from the use of your data beyond costs of making it accessible?	OVERALL (12)	MORIP (5)
Such arrangements are successful	58.3	60.0
Would recommend revenue sharing to others	66.7	60.0

Regarding the exclusivity of data access arrangements, survey respondents were asked whether they have exclusive arrangements for entities for data access. Five of 36 respondents overall and 1 of 16 MORIP respondents replied "Yes" to this inquiry. The "Yes" respondents were then asked what these exclusivity arrangements were intended to accomplish and if their agency funds or in any way subsidizes such entities for disseminating data. Percentage of "Yes" responses to the first of these two follow-up questions is shown in Table 9. Responses to this inquiry showed the greatest difference between the MORIP Group and all respondents as a group, however, these findings should be viewed with caution given the extremely small sample size upon which they are based. Examples of "Other reasons" include:

- Helps encourage alternative/unusual productive partnerships
- Convenience factor

Only 1 of the 5 responses overall and none of the MORIP responses fund or in any way subsidizes such entities for disseminating data.

TABLE 9. Exclusive Arrangements for Data Access
(% Of Applicable Responses)

Do you have exclusive arrangements for entities to access your data?	**OVERALL (5)**	**MORIP (1)**
Intended to maximize return to agency for use of the data	40.0	0.0
Intended to minimize burden on agency by creating distribution channel for data	80.0	0.0
Other reasons	40.0	0.0

Regarding financial arrangements for data access, survey respondents were asked whether specific financial arrangements were required of users of their data. MORIP and overall responses display very close behavior relative to each other. More than 80% of respondents overall and for MORIP agreed that data users need to pay for their own hardware, communications, and/or software costs to access the data.

TABLE 10. Financial Arrangements for Data Access
(% Of All Responses)

Which of the following data sharing arrangements are required of the user?	**OVERALL (36)**	**MORIP (16)**
Reimburses agency for its costs to provide data	22.2	18.8
Pays for its own hardware, communications, and/or software costs for accessing the data	80.6	81.3
Required to share a portion of the revenue generated from its business	22.2	18.8
Makes in-kind contribution	22.2	31.3
Makes its value-added information available to agency for its internal use	41.7	25.0

4.3.4 Conditions on Use of Data

This section examined the area of conditions on the use of data and respondents were asked about such conditions. Results are shown in Table 11. Thirty out of 36 total respondents and 15 out of 16 MORIP respondents said there were data use conditions. Table entries indicate the percentage of these respondents indicating which type of conditions is applicable for them. Again, MORIP and overall responses parallel each other closely with approximately 90% of each group saying that source acknowledgement is definitely a condition for data usage. A few respondents from each group indicated other types of conditions that are listed below.

TABLE 11. Conditions on the Use of the Data
(% Of Applicable Responses)

Are there conditions you place on the use of the data?	**OVERALL (30)**	**MORIP (15)**
Technical specifications	53.3	66.7
Use restrictions (cannot use personally identifiable information, not for law enforcement, no injury/fatality scenes vis-à-vis P-T-Z[4] during accidents)	66.7	60.0
Acknowledgement of source(s)	90.0	86.7
Other	16.7	20.0

Examples of "Other" conditions include:
- Presentation of data
- Provide status on data usage
- Acknowledgement of lack of data accuracy warranty
- Can not resell (a private sector respondent)

4.3.5 Extent of National Role

This section presents the survey findings on the extent of the national role to help promote or encourage productive data sharing endeavors. Twenty-eight of the 36 respondents (77.8%) and 13 of the 16 MORIP respondents felt there is a need for a national or industry-wide standard format for sharing or archiving travel-related data. Exactly the form of national/federal participation to promote data dissemination was the subject of another question with results shown in Table 12. MORIP and overall responses again display similar response patterns with "Development of guidelines" attracting the greatest level of support among respondents. There is little, if any, support for the legislative route with voluntary means capturing the most support among the alternatives.

TABLE 12. Federal Activities to Promote Data Dissemination
(% Of All Responses)

What means are there to promote data dissemination at the national level?	**OVERALL (36)**	**MORIP (16)**
Information distribution or technical assistance regarding best or common practices	63.9	43.8
Development of guidelines	75.0	62.5
Promulgation of regulation or statute	8.3	0.0

[4] PTZ = Pan-Tilt-Zoom camera movements

4.4 Data Retrieval, Access, and Format

This section addresses the physical aspects of the data sharing process considering the means through which entities access data, limitations on the volume of simultaneous data accesses, means through which the public receives information, and data format.

Figure 1 shows the different physical ways data is retrieved and its level of use by all respondents and MORIP respondents. MORIP and overall responses again display similar response patterns. By a sizable margin over all other media, the Internet captures from approximately 60% to 75% of all and MORIP responses, respectively, as a means through which data is retrieved. An almost totally monotonic decrease in level of other media use may be seen in the figure. Almost all respondents reported that more than a single medium is used for data retrieval.

Seventeen out of the 36 respondents (47.2%) and 10 out of the 16 MORIP respondents (62.5%) indicated that there was an upper limit on capacity for the number of simultaneous data accesses possible. While precise upper limits depend on the nature of the specific system, these limits can take the form of the number of port connections for Internet, phone, fax, e-mail, and video output usage.

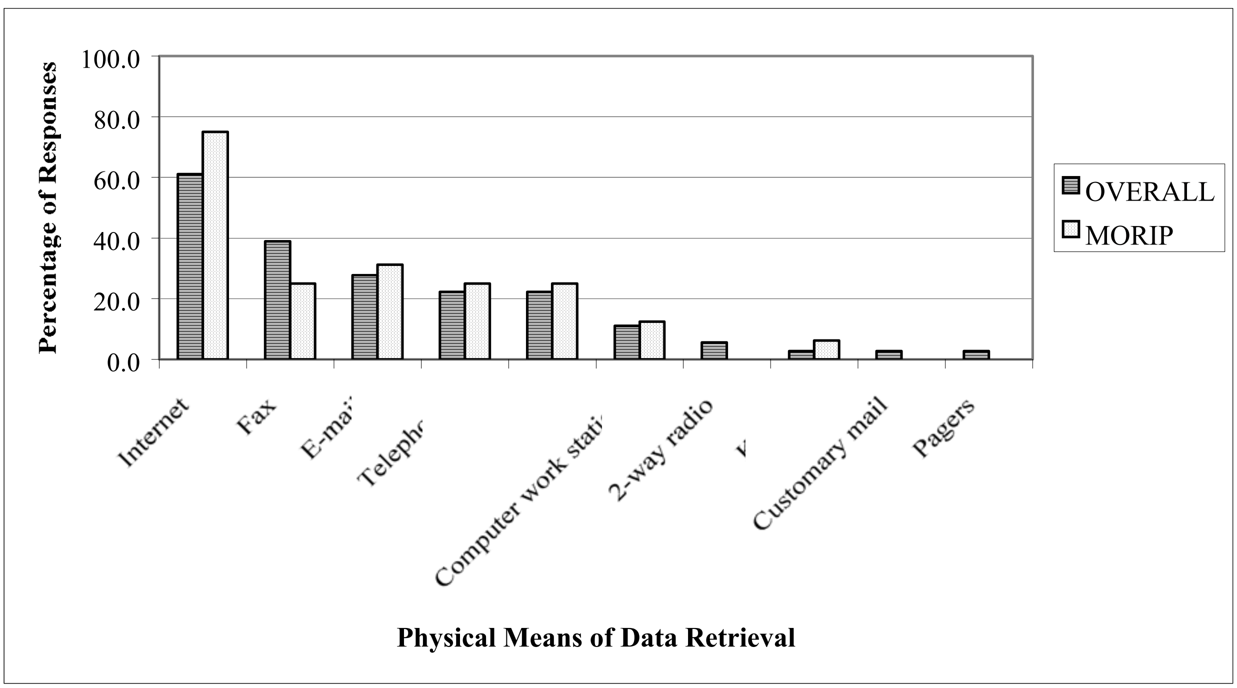

FIGURE 1. Physical Means of Data Retrieval

Thirty-four of 36 total respondents and all 16 MORIP respondents said that their organizations either currently or has plans to deliver traveler information directly to the public. Of these respondents, various means are used as a delivery device and are shown in Figure 2. MORIP and overall responses again display similar response patterns. As was the case with respect to ways of data retrieval, the Internet, i.e., Web sites, are the primary medium through which the public receives traveler information, followed by VMS/CMS and Kiosks, then HAR and IVR. Examples of other medium mentioned by survey respondents include:

- E-mail via pagers and beepers
- Personal Digital Assistants
- Cell phones
- Local cable TV
- Fax

Twenty-one out of the 36 respondents (58.3%) and 13 out of the 16 MORIP respondents (81.3%) indicated that a common format was used for the distribution of data to the private sector as well as to public agencies. This correlates with the responses regarding participation at the national level (See Section 4.3.5) for a national or industry-wide standard format for sharing or archiving travel-related data.

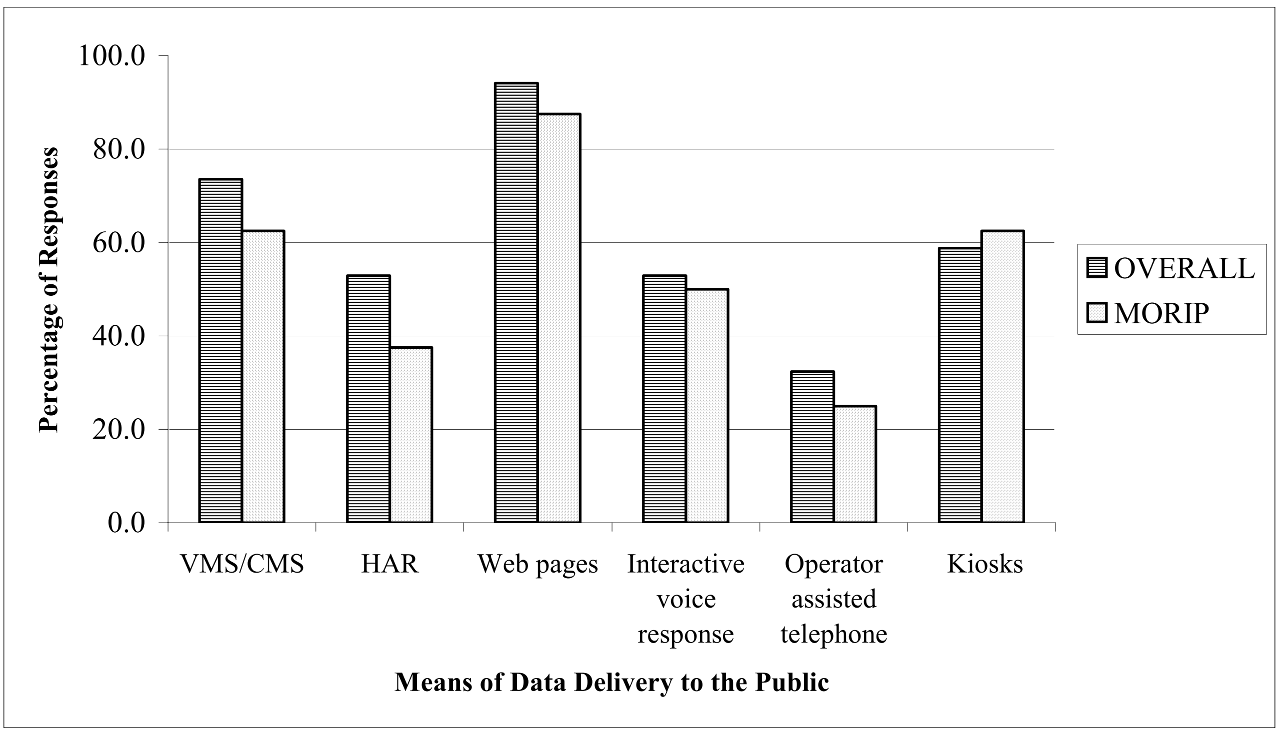

FIGURE 2. Means of Data Delivery to the Public

4.5 Lessons Learned

Respondents were asked to summarize the overall effectiveness of their organization's data sharing methods in meeting its objectives on a scale of 1 (not at all effective) to 5 (completely effective). The average rating given by the respondents overall and by the MORIP Group were very close: 3.7 and 3.9, respectively. Each group felt positive about its organization's efforts, with over 60% of all respondents and of all MORIP respondents giving a rating of 4 or 5.

These high ratings notwithstanding, 35 out of 36 respondents provided lessons learned about their data sharing experiences. These are summarized below with the number in parentheses after each topic area indicating the number of respondents who mentioned that topic, except for those topics that were suggested only once, which remain unnumbered.

1. Standards and consistency would be very valuable, e.g., data collection methods, data format, protocol (6)
2. Establish and maintain open lines of communication among agencies as to data availability, its benefits, and what other organizations are doing—a marketing effort (4)
3. Be realistic and practical about costs, especially, O&M costs of data sharing (3)
4. ATIS marketplace issues (3):
    - still very immature, small user base, financially weak, limited market demand with limited information supply though has large growth potential and expectation
5. Institutional partnerships (3):
    - market conditions outpace contact terms, establishing relationships is time consuming, public sector lags market speed, public/private partnerships are cumbersome, RFP process obsoletes finished product
6. Roles of public and private sectors: public provide data supply role, not retail role, do not prescribe outcomes, perform data collection/processing functions, deliver multiple data types while private industry be a source for customized distribution (3)
7. Cost of data sharing is burdensome on public agencies driving a search for ways of "sharing the costs of sharing the data" with private industry, e.g., its distribution (2)
8. Establish up-front written agreements and policies (2)
9. Work needed to maintain data accuracy, timeliness, reliability and to enhance the type and quality of data that is shared, e.g., include travel time (2)
10. Too many turf wars and competition on whose system is good, better, and the best; do more for common good (2)
11. Need for education, e.g., newcomers in the data sharing business, public agency staff in certain technical issues (2)
12. Take the time up-front to define your organization's goals, objectives, plans and system design in data sharing enterprises vis-à-vis available funds (2)
13. Resources need to be adequate and reliable to handle and maintain data requests (2)
14. Need to have a common and centralized point of access for data (2)
15. Training is an important element to a successful data sharing enterprise
16. Need institutional leadership, perhaps at State level, to work out issues
17. Bring the parties together and first focus on solving the technical issues
18. Encourage open architecture, e.g., open software
19. States should be open and adaptable to public input in the traveler information arena
20. One size may not fit all: State, county, city solutions to issues may differ
21. Protection of personally identifiable information—privacy is still an issue
22. Remember the multi-modal nature of traveler information needs, i.e., the entire trip
23. Work to fill the data gaps and coverage, and enhance 24/7 data feed reliability
24. Data gap and coverage issues: existing data not always available to others, deficiency may be institutionally caused (public policy, funding, management resources, or no local desire to support)
25. Gaps in infrastructure need to be addressed
26. Know and understand your audience: data expressed through more visual means is better than just words, numbers, or maps

5.0 CONCLUSIONS

Data sharing of traveler information plays an important role in the daily business lives of both public transportation agencies and members of private industry. This report documents a snapshot look at the current state of the practice of data sharing with the public and private sectors. Documenting this state of the data sharing practice involved as its central task addressing the often repeated inquiries of what data is shared, with whom it is shared, why it is shared, how it is institutionally arranged and managed, how effective the sharing enterprise has been, and how it can be improved. This was performed through a nationwide survey with an added focus on the major players in the traveler information and traffic management arenas, such as California, Texas, Minnesota, and Washington. However, the sample size was small and the analysis of survey responses was performed more descriptively than statistically, valuable insight was gained into this ever-changing field, with changes coming mainly as a result of advances in technology.

More work remains to be done to help smooth out the rough edges of the data sharing enterprise. Naturally, local and regional conditions and stakeholders play a significant role that must be integrated into the entire process. Survey respondents have shared with us the valuable lessons that they have learned over time in this business. These lessons need to be taken the next step, i.e., development of an implementable action plan and beyond.

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8. Schuman, R., "White Paper 5 – ATIS Data Collection Guidelines Input", Prepared for ATIS Data Collection Guidelines Workshop, U.S. Department of Transportation, Federal Highway Administration, Joint Program Office, Washington, D.C. January 2000.

APPENDIX A: List of Survey Respondents

NAME	STATE/REGION	TYPE OF AGENCY
M. Seiler	Missouri	DOT
M. Knopp	Utah	DOT
R. Dye	Maryland	DOT
B. Smith	Georgia	DOT
J. Galas	Illinois	DOT
R. Bamford	NY/NJ/CT	Transcomm[5]
A. Satraitis	Michigan	DOT
B. Stoeckert	Connecticut	DOT
J. Corbin & P. DeCabooter	Wisconsin	DOT
L. Wassong	New Jersey	Transit Authority
D. Love	Chicago, Illinois	Transit Authority
K. Lamb	Washington, D.C.	Transit Authority
S. Bravo	Florida	DOT
S. Evans	Ohio & Kentucky	DOT
D. Munizza	Pennsylvania	DOT
D. Wetherelt	Montana	DOT
G. Piotrowicz	Oakland County, Michigan	Road Commission Oakland County (RCOC)
S. Hanshaw	Virginia	DOT/Smart Traffic Center
N. Rohleder	Nevada	Las Vegas Area Traffic Computer System[6]
D. Jenkins	South Carolina	DOT
V. Avedissian	California	DOT
C. Aboufadel	California	DOT
A. Chen	California	DOT
J. Chen	California	DOT
M. Berman & E. VanWagoner	California	Metropolitan Planning Organization (MTC of SF Bay Area)
J. Coxx	California	Private Sector (Traveler Advisory News Network = TANN)
D. Delgado	California	Transit Authority
N. Thompson & S. Groth	Minnesota	DOT
S. Bahler	Minnesota	DOT
J. Trotsky	Minnesota	Private Sector (SmartRoutes)
W. Ewell, G. Flores, & K. Woods	Texas	DOT
S. Wegmann	Texas	DOT
B. Fariello	Texas	DOT
A. Obelander	Texas	DOT
A. Kosik	Texas	DOT
D. McCormick	Washington	DOT

[5] Multi-jurisdictional organization comprised of Connecticut DOT, Metropolitan Transportation Authority, MTA Bridges and Tunnels, New Jersey DOT, New Jersey Highway Authority, New Jersey Transit Corporation, New Jersey Turnpike Authority, New York City DOT, New York City Transit Authority, New York State DOT, New York State Police, New York State Thruway Authority, Palisades Interstate Park Commission, Port Authority of New York and New Jersey, Port Authority Trans-Hudson Corporation
[6] Multi-jurisdictional traffic signal system managed by cities of Las Vegas, North Las Vegas, and Henderson, Clark County, Clark County Regional Transportation Commission and Nevada DOT

APPENDIX B: Survey Instrument

Telephone Survey on Data Ownership and Sharing with Private and Public Sectors

Name of respondent: ____
Job title: ____
Agency/Company: ____
Contact information: ____

Date and time of interview: __________________________________
Name of interviewer: __________________________________

Interview can be prearranged or done at the time of the first call if respondent is available. Agency needs to be screened to confirm it is sharing data with the private sector or public agencies.

Introductory remarks: Hello, my name is _________________ of Battelle/The PATH Program at the University of California Berkeley/Texas Transportation Institute, and I am conducting a survey of knowledgeable persons in the field of traffic management and traveler information. We have been asked by the U.S. DOT and several state departments of transportation to investigate the current approaches to sharing and ownership of data being taken by public and private sector organizations. This interview will take about 20 to 30 minutes to complete.

Definition of data: For the purposes of this survey, please consider data for traveler information to be electronic or digital (original or processed), audio (e.g. verbal information), or video images. The data can be real-time or not and deal with highway or transit transportation.

1. Do you currently share data used in traveler information with private and public entities?
   ____Yes ____No
   (*INTERVIEWER*: If "Yes", continue with Question 2, if "No", ask "Why not" and end the interview.)
   ____

2. What types of organizations are receiving data directly from you? (check all that apply)
   a. Local television or cable TV stations
   b. Local radio stations
   c. Local newspapers
   d. Private sector Internet Service Providers
   e. Traffic reporting organizations (e.g. Metro Networks, SmartRoute Systems)
   f. Other public agencies ____

g. Other (specify) ___________________________________

INTERVIEWER: Please note whether answers to Question 2 pertain entirely to the private sector, to public agencies, or a combination of the two. If answers are of only one type, ask all remaining questions consistent with this type. If answers involve a mix of both private and public then consistently ask questions relative to one of these (and note which one) with a follow-up question inquiring about any differences pertaining to the other, if any.

3. What types of data do you share? (check all that apply and indicate with how many private and public entities you share this data.)

	Electronic/digital		Verbal		Video	
	Private	Public Org.	Private	Public Org.	Private	Public Org.
Highway/real-time						
Highway/static						
Transit/real-time						
Transit/static						

4. Why do you share the data? (Check all that apply and please prioritize them, i.e., "#1', "#2", etc.)
   a. My organization is currently participating as an institutional partner in a regional program that requires my agency to share data.
   b. My organization has received data solicitations from the private and public sectors.
   c. To enhance coordination levels among the region's transportation agencies to improve overall travel conditions.
   d. My organization has an internal policy to use traveler information to improve utilization of the transportation system.
   e. Other (specify) ____

5. Does your organization have a formal policy about sharing of data?
   ____Yes ____No
   If "Yes", continue with this question then skip to Question 7.
   If "No", skip the rest of this question and go to Question 6.
   a. When was the policy issued?
   b. Why was the policy developed? (Check all that apply)
      i. Agency desires to help disseminate traveler information
      ii. To establish process for handling requests being made for agency data
      iii. Other (specify) __________________________
   c. May I get a copy of the policy (by e-mail, preferably)? (*REMINDER TO INTERVIEWER*: At this point, skip Question 6 and go to Question 7).

6. a. For recipients outside your organization, are agency views regarding data sharing expressed in
      i. Contract or agreements with recipients?
      ii. Training or procedure manuals?

iii. If "Yes" to either of the above, may I get a copy of the applicable documents?

b. Do you have plans for issuing a formal policy?
____Yes ____No
i. If "Yes, why are you planning?
1. Agency desires to help disseminate traveler information
2. To establish process for handling requests being made for agency data
3. Other (specify) ___________________________
ii. If "No", why are you not planning? (e.g., no demand for data, problem)
____

7. When you share data with other entities (check all that apply):
a. Is a written agreement required?
i. All the time
ii. Sometimes. (Specify what conditions.) ____________________________
iii. Never

8. Have you sought to recover revenue from the use of your data beyond the costs of making it accessible?
____Yes ____No
If "Yes", continue with this question.
If "No", skip the rest of this question and go to Question 9.
a. Have such arrangements been successful?
i. Yes
ii. No. Why not? __________________________________

b. Would you recommend revenue sharing to other public agencies?
i. Yes, why?___________________________________
ii. No, why not?_________________________________

9. Does your agency have any exclusive arrangements with entities for getting access to your data?
____Yes ____No
If "Yes", continue with this question.
If "No", skip the rest of this question and go to Question 10.
a. Are such arrangements intended to (check all that apply)
i. Maximize the return to the agency for use of the data?
ii. Minimize burden on the agency by creating a broker or distribution channel for the data?
iii. Other? (specify)_____________________________________
b. Does your agency fund or subsidize such entities for disseminating data?

10. Which, if any, of the following arrangements regarding data sharing apply? (check all that apply)

a. User reimburses agency for its costs to provide data
b. User pays for its own hardware, communications, or software costs for accessing the data
c. User required to share a portion of the revenue generated from its business
d. User makes in-kind contribution (e.g. sharing part of a communications fiber)
e. User makes its "value added" information available to the agency for internal use.
f. Any other forms? If so, specify.______________________________________

11. When you share data with other entities, are there conditions that you place on accessing data?
____Yes ____No
If "Yes", check all that apply and ask respondent to explain.
If "No", skip the rest of this question and go to Question 12.
a. Technical specifications (e.g. hardware or software required)
____
b. Restriction on use (e.g. depiction of injury or identity on video images)
____
c. Acknowledgement of the source (e.g., use of logo, verbal mention)
____
d. Any other conditions? _____________________________

12. How do entities (again, private and public) retrieve the data from your system from a technical and/or physical perspective, e.g., via e-mail, direct hardwired connection over the Internet, fax, etc.)?

____

13. Is there a limit to the number of entities that can simultaneously access your system for data?
____Yes ____No
a. If "Yes", what is the limit? ____
b. If "Yes", what causes it?____

14. Does your agency currently (or have plans) to deliver traveler information directly to the public?
____Yes ____No
If "Yes", check all that apply, otherwise, go to Question 15:
a. VMS/CMS
b. HAR
c. Web pages
d. Interactive voice response (automated telephone)
e. Operator assisted telephone
f. Kiosks
g. Other (specify) ____

15. What traveler information is made available to the public by private entities in your region, such as Metro Networks or local television stations? (check all that apply)
    a. Traffic and road conditions
    b. Incident information
    c. Transit delays
    d. Special events information (e.g. stadium or concert transportation)
    e. Planned construction information
    f. Other (specify)

16. Do you have a common format for distribution of data to the private sector and to public agencies?
    ____Yes ____No

17. In your view, is there a need for a national or industry-wide standard format for sharing or archiving of travel related data?
    a. Yes, why? ________________________________
    b. No, why not?________________________________

18. In your view, which, if any, federal activities regarding travel data dissemination would be helpful? (check all that apply)
    a. Information distribution or technical assistance regarding best or common practices?
    b. Development of guidelines
    c. Promulgation of regulation or statute
    d. Other activities?

    If yes to any of the above, please elaborate. ________________________________
    ____

19. Overall, how effective have your organization's data sharing methods been in meeting its objectives? (Circle only **one** number with "1" representing "least effective" or "not at all" and "5" representing "completely effective".)

    1 2 3 4 5

20. What, if any, lessons have you learned from your organization's data sharing experience that you have observed from technical, operational, or institutional perspectives and can use to improve data sharing in the future?

    ____
    ____
    ____

This completes the prepared questions. Do you have any other comments you would like to make on the subject of data ownership or data sharing?

Thank you for your assistance. Good-bye.

APPENDIX II

ITS HARDWARE MAINTENANCE MANAGEMENT SYSTEMS

WHITE PAPER
For
MORIP POOLED FUND STUDY

By

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INTRODUCTION

With the planning, design, construction, integration, and operation of transportation management centers and intelligent transportation system (ITS) technologies spreading throughout the country, various agencies are responsible for operating and maintaining these complex and expensive systems. One of the challenges associated with these systems is tracking the maintenance history of the various system hardware components to determine the actual cost of maintaining these systems using a long-term perspective. This cost information can then be used for a variety of purposes, including determining the reliability and cost-effectiveness of individual hardware components, estimating the benefit-cost ratios of these systems and components, and justifying the request of maintenance funds and the use of those funds for ITS systems.

Some entities already use a maintenance management element, either by using an element developed specifically for their system or adapting an off-the-shelf maintenance management element. Agencies that are planning to purchase or develop a maintenance management system can gain insight from the experiences of agencies that are already using such an element.

The objectives of this paper are to:
- determine what maintenance management systems are currently in use,
- examine the issues that instigated the development of these systems, and
- assess the key components of a viable ITS hardware maintenance management tool.

In order to reach these objectives, researchers contacted representatives from the state Departments of Transportation in California, Minnesota, Texas, and Washington to better understand the systems used in these states.

CURRENT SYSTEMS

All of the states that were contacted during this project have some type of maintenance management system in place. However, the efforts to implement these systems are in different stages, and each agency is using a different approach to the development of the system. In some cases, efforts are underway to improve upon or upgrade the elements that have been in place for some time.

California

The initial efforts in California toward maintenance management were accomplished using basic spreadsheets or databases. One example is the Los Angeles district of the California Department of Transportation (Caltrans) where staff uses Microsoft® Excel as a means to track ITS hardware maintenance. Another system in use in Caltrans is being adjusted within District 4 (Oakland), where staff utilize a Transportation Operations Systems (TOS) database. This system was initially created in Filemaker®, but was later converted to a Microsoft® Access database. Currently, an effort is underway to transfer this database to an Oracle® based system. The reason for this transfer is that staff identified a problem in that the field elements are currently listed by type in a table and are not referenced by location.

A pilot project is currently underway in northern California, specifically the Oakland area, to test an off-the-shelf hardware maintenance management system entitled Tracker®. Although it is an off-the-shelf system, Caltrans has made several significant modifications to the software to meet their particular needs. Caltrans decided to follow this path based on the fact that the initial software package was inexpensive and that it could be modified to suit Caltrans' requirements. Modifications include alteration of the data entry fields presented to the user and a change of the accessing hierarchy. For instance, an administrator can see all of the areas in the state, but at a district level the user can only see the elements that are contained within their area. This accessibility change cleans up the user interface and makes it more manageable for the individual user.

The Tracker system is a web-based application that is simply the front-end part of a ITS hardware maintenance management system. At this time, access to the Tracker® system is available to the necessary users through the Caltrans Intranet. It is then backed by a database application. For the database, the user can specify their preferred database so that the Tracker® system works with the application preferred by the state.

The primary use of the Tracker® system is to create a "trouble ticket" for hardware in the field that requires maintenance. The trouble tickets are created by a group of users entitled "dispatchers". This ticket indicates the asset ID of the device that is not operating properly and also provides a location for the device. One problem that has been identified by Caltrans users is the definition of location; different implied options are the pole location, the cabinet location, or the electronic service location. This standard of reporting location is still being examined and clarified during this pilot phase of the system use.

Following the creation of the "trouble ticket", the information is then sent to the appropriate product manager who is responsible for assigning the maintenance of one set of hardware (e.g., cameras). The product manager gives the work to a field technician or contacts the contractor in charge of the specified equipment. It is then the responsibility of the user completing the work to log into the Tracker® system to update the "trouble ticket". The ticket is then moved to "resolved" status and proper operation of the hardware is verified by the product manager. If everything is operational, the ticket is closed. One useful feature during this process is that the ticket is time-stamped whenever data is entered into the database. This feature creates an accurate record of when work is assigned and completed.

Customization is possible with regard to how a user would like to be notified of a trouble ticket that requires their attention. This notification can be delivered as a standard email, or the user can specify that certain fields of information from the trouble ticket be sent to them through a cell phone, pager, or personal data assistant (PDA). Another feature that can be set by the user is the creation of a To Do list listing work that has been assigned to them. A feature of the trouble ticket system that eases the management of the maintenance efforts is that if a ticket has not been responded to within a specified amount of time, the product manager will be notified and can check on the assignment and possibly re-assign the work.

Minnesota

The current system used by the Minnesota Department of Transportation (Mn/DOT) is a computerized DOS-based system that was established in 1992. The name given to this system is Automated Facilities Management System (AFMS). The AFMS software was developed as a custom system for Mn/DOT. The central issue that was addressed through the development of the AFMS element was to improve the usability of the maintenance records. The AFMS serves as a means of looking at the maintenance history of the system, or a single component, by using a computerized database instead of hardcopy records. A drawback of the hardcopy document system was that it did not allow Mn/DOT to track maintenance costs, labor, or equipment.

The nine maintenance districts in the state of Minnesota are all able to access the AFMS software through the use of a dial-up connection. Because of this feature, the AFMS software is able to track hardware parts through a statewide inventory and track labor and work orders. There are four maintenance categories in the Mn/DOT structure: Traffic Management Center, Signal Systems, Freeway Lighting, and Counting Systems. The same tracking is used for all of the categories but each has a separate inventory. In addition, certain system defaults and work orders look different depending on what maintenance category is using the software.

In using the AFMS software, it is the responsibility of the maintenance personnel to return to the system and log their time, the parts used in the maintenance, and the miles that were put on state vehicles.

The AFMS software is also used in scheduling preventative maintenance activities. This scheduling is done semi-annually for all of the components in the Mn/DOT system. The AFMS software aids in preventative maintenance by making it possible to track ongoing problems with systems or components. The tracking is accomplished using ID numbers that are assigned to a system or component. This ID number can be individually called up with all of the maintenance activities that were logged for that particular system. The maintenance personnel are then able to determine if a system has experienced a high number of failures and can track reoccurring problems based on the identifying failure codes in the AFMS.

Another feature of the AFMS software is that it is able to track in-shop repairs that are being performed and can distinguish when these components are back on the shelf and ready for use in the field. It also tracks the parts used during the in-shop maintenance activities as a means of keeping an up to date inventory records.

Accident reports are also entered into the system. An accident is identifies as when a piece of hardware has been damaged due to a motorist collision or other incident. In the case of an accident, a work order will be generated based on the report along with an estimated cost to fix the equipment. If the party responsible for the damage is known, the state is then reimbursed through insurance for the cost of repairing the equipment.

Some additional features of the AFMS include the ability to create custom reports depending on the user's needs. For example, a report can be generated to find systems that experience a high number of problems. Also, annual cost reports for a given system or statewide can be generated using this software. These cost reports include not only equipment costs, but also labor and vehicle costs since all of this information is stored in the system. A final feature of the AFMS system is the inclusion of all maintenance agreements in the system. When a component that has a maintenance agreement is accessed, the user is provided with information on the responsible party (including contact information).

Mn/DOT has identified several problems within their current system, most of which is a result of it being an older, DOS-based Oracle® database. For example, only six to eight people are able to dial-up the system at any one time from remote locations. Furthermore, workers are not able to use cellular dial-up due to the unreliability of the system. However, Mn/DOT is currently working to upgrade to a Windows®-based standard format. In looking for a new package, they examined several off-the-shelf alternatives available on the market. However, none of the off-the-shelf packages were able to interface with the current archived records and therefore did not fit the needs of Mn/DOT. For this reason, Mn/DOT is again looking to have custom software created for their use. It is estimated that the new system will be available later this year.

Texas

Currently, two efforts are underway in Texas to establish ITS hardware maintenance management systems. One is in the San Antonio district of the Texas Department of Transportation (TxDOT) and the other is in TxDOT's Houston district.

San Antonio District

The initial impetus of an ITS hardware maintenance management system in the San Antonio district was a need to record and maintain maintenance work orders for the traffic management center, TransGuide. To meet the requirements for such a system in San Antonio, TxDOT worked with the Southwest Research Institute to create a custom software package, which is named the Integrated Maintenance Database Management System (IMDBMS). The IMDBMS has a graphical, web-based interface that is easily navigated by the user. Also, users with access to the advanced traffic management system (ATMS) map of the San Antonio area can use it as a means to interface with IMDBMS by clicking on a system component and selecting the "Work Order Request" option. The main navigational menu for the IMDBMS system contains the following options:

- Work Orders,
- Equipment Status,
- Inventory,
- Preventative Maintenance,
- Add Contract,
- Personnel,
- Reports,
- View Problem/Repair,
- Change Password, and
- Logout.

The major function of the IMDBMS software is to establish a means to efficiently handle work orders. This task is accomplished in three steps. The first step is to create the required work order. Multiple ATMS users such as field technicians, TMC operators, or contractors are able to do this. In the initial setup of a work order, a work order ID number is automatically generated. The user is then able to select the system asset that requires work and select a work order type from a drop down list. The different types of work orders that are defined by the system include: new work order (normal work order option), preventative maintenance, emergency, and contract (this is used when equipment maintenance is the responsibility of a separate party). Some interesting features of the software package are that it allows the employee to set a priority for the work order (0: High, 1: Normal, 2: Low) and that it also has a pop-up menu that contains previously defined problem codes and their descriptions. Further problem codes can be added to this list as needed.

Following the creation of a work order, the work order is cycled to a second set of users called "schedulers" who establish when the work should be done and assign it to a technician who will be responsible for the work. The schedulers are also able to modify work orders as appropriate.

Finally, after the problem has been addressed, the technicians will complete the work order in the system. This step is usually accomplished through a remote connection to the

IMDBMS via a web browser. One feature of the software that is designed to help the technician in the completion of the work order is the View Problem/Repair form. For each type of equipment, problem codes are associated with repairs that were made on previous work orders. This form can save valuable time in assessing necessary steps in the hardware repair.

The IMDBMS software allows users to go to a work order status form to view a list of current work orders, including those that have been completed during the day. In addition, a history of work orders for a particular piece of equipment can be viewed. In this screen, a user can identify past problems and repairs that were done on the equipment. This information is useful for diagnosing later maintenance needs or reoccurring problems. The equipment status portion of the software package allows users to add replacement equipment into the system, add equipment types that do not currently exist, or edit the existing information regarding a particular piece of equipment. Also, a list can be generated of pieces of equipment based on type, location, and status (active, not-in-service, failed). When this list is generated it gives the user the option of creating a work order for the equipment or viewing the work order history for a selected component.

Preventative maintenance is an integral part of keeping an ITS hardware system functioning. In the IMDBMS package, the user can define the required preventative maintenance tasks in much the same manner as a work order. Once the form is completed, it is then scheduled along side all other maintenance requirements. The preventative maintenance order gives a number of checklist items that must be completed during the task.

Finally, reports can be generated for equipment, inventory, and work orders using the IMDBMS software. The equipment and inventory reports can be organized using many different criteria including asset ID, asset type, manufacturer, or vendor.

Houston District

The Houston district started its effort to create a maintenance management tool as part of the regional signal operations plan that was being implemented in conjunction with Harris County. Both the county and TxDOT purchased a ready-made package entitled Signal Shop® that they could alter to suit the needs of both traffic signal and freeway hardware maintenance management. One of the initial selling points for the Signal Shop® software package was that it allowed the use of palm computers as a means of interfacing with the system. However, it was found that the software's heavy dependence upon the use of bar code reading as a means of identifying equipment for a work order was a cumbersome process for the technicians. Also, the cost of adapting the system to their needs became excessive compared to the initial cost of the software. Therefore, this effort was abandoned and the Houston district started exploring new options.

The next step for the TxDOT Houston district was to examine the software system that was developed for the San Antonio district. They determined that this software package met their needs and could easily be adapted to suit a different area. At present, the necessary modifications are being made to the freeway management system, and TxDOT is looking at developing a separate version of this software for signal maintenance management.

Washington

The initial need for a maintenance management system in Washington State was generated by legislative processes of funding allocation that required the Washington State Department of Transportation (WSDOT) to provide information about problematic locations within their system, as well as data regarding the cost of maintaining ITS systems. Initially, WSDOT investigated an off-the-shelf alternative for a maintenance management system, but found that they were too rudimentary and did not meet the needs of their system. Therefore, WSDOT is in the process of developing a custom software package. This system has been in development for one and a half years and is called the Signal Maintenance Management System (SIMMS), although the system is used to track all of the maintenance of ITS hardware.

At this time, the system is partially complete and is being used to store work reports and has a searchable database for recovering data based on such criteria as location, type of trouble, date, etc. The use of SIMMS has eased the process of storing and recovering data that can be used as supporting documentation for project proposals or in preparing decision package requests for the legislature in support of additional funding, personnel, or equipment as a means to improve maintenance efforts. An additional benefit of SIMMS is that WSDOT is able to provide maintenance information to the attorney general's office for use in court litigation where there is a need to account for completed maintenance work.

As SIMMS progresses to a completed maintenance management system, several features will be added to the software. WSDOT will have the ability to track work orders, as well as all tasks required to complete a given work order. A supervisor will electronically assign the work order tasks to a technician and will be able to track the progress of the work order. At this time, the technician cannot access the SIMMS software from the field, but adding this feature to the system is a long-term goal.

The preventative maintenance component of this system will function in much the same manner as a work order. For convenience in scheduling, SIMMS will track when preventative maintenance is performed and will automatically schedule the tasks when preventative maintenance is necessary. The supervisor will then have a list of all scheduled preventative maintenance tasks and will assign them to a technician. Once the preventative maintenance work has been completed, the technician enters a work report into the SIMMS system to show that the preventative maintenance has been completed. This work report is sent to the supervisor for review and approval of completion.

An added feature to the SIMMS package will be the ability to capture timesheet data based on the work reports. This data can then be exported to accounting for use with their record keeping. Finally, SIMMS will have the ability to maintain an inventory of all components installed at each location. The system will be able to account for the actual costs to support a portion or the entire equipment inventory.

Electricians, electronic technicians, and traffic signal technicians statewide will use the final version of the SIMMS software package. These staff are from all six regions of the state, and constitute approximately 90 personnel. The system will not have a limit as to how many users can be accessing the system simultaneously. There is currently a statewide team working on the final appearance of the SIMMS program, and they hope to have the consultant working to finish in July 2001. At this time, the software uses a Windows® based graphical interface, which is not expected to change with the final version. Some side benefits to this package are that WSDOT management can also search the database in addressing questions from the legislature. The program will also be available as read-only to the design and operation engineers to aid them in their work.

SUMMARY

The growing amount of ITS hardware being installed across the nation has highlighted the need to identify true cost for ITS systems. One part of identifying this cost is to better track the required maintenance for these systems. For this reason, ITS hardware maintenance management systems are becoming necessary as a means to retrieve the necessary information.

Most of the states contacted during this project stated that their primary reason for implementing an ITS hardware maintenance management system was to improve the usability and uniformity of maintenance records for their agency. WSDOT was unique in that the impetus for their system was a need to justify funding to the state legislature for maintaining ITS systems. In addition, they needed a way to track problematic systems for future reference. This method of funding justification is essential to agencies as they strive to make a case for continued support of ITS growth.

SYSTEM SIMILARITIES

As different states are striving to develop ITS hardware maintenance management tools, there are many similarities with their initial systems. The first, and most noticeable, similarity is that all of the systems are becoming Windows®-based and web accessible systems. The reasoning behind the decision to use this interface is that they are easy to use and are compatible with current technology. With the web accessible function, the system can be accessed remotely through a palm computer, cellular dial-in, or other available technology. This timesaving feature eliminates the need for the technician to return to the office to enter or access information when responding to multiple work orders. Simplifying the use of the system in this manner will help boost the accuracy of the records by lowering the burden of work placed on field personnel.

A second similar feature of the systems is that the ITS system components are tracked based on asset ID numbers as well as by asset location. However, it should be noted that this feature is only similar to the pilot software being tested in California, and not the current database systems. In the current systems, the identification of components by location is not available. In addition, the basic input information for the systems is relatively consistent across the different locations. For example, all of the systems require information on when and where a problem has occurred, as well as the nature of the problem. A work order number is then assigned to the problem and the work order is routed to the appropriate responder.

Preventative maintenance is an integral part of maintaining an ITS hardware system. The systems that have been developed in Minnesota, Washington, and Texas all address the need to track preventative maintenance as part of their maintenance systems. In Minnesota and Washington, the work orders are automatically generated using a tracking feature of the software to identify when the work is necessary. This feature allows for greater control of the preventative maintenance work by eliminating human error in the scheduling of these tasks.

Finally, the majority of the states contacted are looking at systems that can be implemented on a statewide basis that will be interconnected throughout the state. The use of such an approach can be beneficial in that it allows easy transferring of information between districts and creates a statewide inventory of system components.

SYSTEM DIFFERENCES

Just as the currently developed ITS hardware maintenance management systems have many similarities, each one does have some distinctive characteristics. In the Minnesota and Texas systems, the user has an option to create customized reports based on the information gathered from the work orders. This feature can be very useful to the user in demonstrating justification for the ITS systems and maintenance needs.

The Minnesota system is unique in that it tracks both labor and vehicle costs for the maintenance work orders. The interface of the system including these costs is important because labor and vehicle use are costs that may often be overlooked when addressing the issue of ITS funding requirements. These details account for much of the expense related to hardware maintenance work and through the collection of this information, it is possible to more closely estimate future costs for an ITS system. Also, having the ability to access this type of historical data is another aid in justifying expended resources. The system in Washington also tracks labor, but it is used in a different fashion. In their SIMMS system, timesheet information for the maintenance technicians is captured from the work orders and sent to the accounting department as a tool to be used for record keeping.

Finally, a unique feature in the California pilot test of the Tracker® system is that work orders have a specific amount of time in which they can be addressed by a technician. If the technician has not addressed the problem during this allotted time, the manager receives notification of such and is then able to determine why the work has not been accomplished and take appropriate actions. This feature allows for less chance of a failed piece of equipment to be overlooked and not repaired in a timely manner.

RECOMMENDATIONS

All of the contacted agencies investigated an off-the-shelf option as a first step to finding an ITS hardware maintenance management tool. However, each agency ultimately decided to have a custom built system created for their use. One lesson that may be gained from these efforts is that for larger systems, such as those examined in this effort, off-the-shelf systems were lacking in detail and flexibility for the agencies' specific purposes; thus, the states had to develop either custom systems or consider significant modifications to existing software. In a smaller system this lack of flexibility and detail may not be an issue. Off-the-shelf products may be well suited to these less complex networks. One exception to this issue is California where a pilot test for an off-the-shelf system is currently running in a limited portion of the state. Therefore, an agency should be mindful that with the constant change of available technology new options are always emerging for potential use.

One key concern to keep in mind when either designing or purchasing a maintenance management system is the user. In most cases an agency will need to consider personnel at all levels of an organization as possible users of the maintenance information. Also consider how each of the different groups will be using the systems and in what form the information will need to be presented. For example, someone in the management office trying to justify expenses will need different information than the technician who is doing work in the field. This examination of an agency's proposed use for the software would aid in the decision of whether an off-the-shelf software package will be sufficient (either with or without modifications) or if it will be necessary to create a custom package. No matter what solution an agency arrives at, one key point to consider during the selection or design of a software package is that it must be flexible enough to accommodate future needs and changes as a system progresses. Keep in mind that the system should not have a limitation on the number of users that can access it simultaneously or the effectiveness of this tool could be limited.

Another consideration that should be taken into account in the selection of an ITS hardware maintenance management system is the amount of detail that the selected system will require from the user. It is important to examine how the information will be used to ensure that it maintains the important details, but does not include extraneous information that will over complicate the use of the system. This issue is another reason to keep a system flexible in that further details can be added as new areas of information are called for.

In closing, state agencies can benefit from the use of an ITS hardware maintenance management system. It can aid in tracking overall maintenance costs, logging maintenance history, identifying problem equipment and locations, supporting preventative maintenance operations to ensure reliability, and serve as a tool in justifying the cost of ITS systems. However, only the agency can determine the best method for implementing this tool such that it meets the overall ITS goals and objectives of their jurisdiction.

APPENDIX III

Pooled Fund Study #SPR-3062
Final Research Report
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USING ARCHIVED OPERATIONS DATA TO BETTER LINK DECISIONS TO PERFORMANCE

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EXECUTIVE SUMMARY

This report summarizes current practices in using archived operations data to better link decisions to transportation system performance. The joint research team of PATH and TTI investigated data archiving and performance monitoring activities in selected locations, with a primary focus on the use of performance measures in improving operations. We first provide an overview of a traffic performance measures system and its components, then we summarize the major findings for each system component. The major findings and conclusions of our research are summarized below.

- **Better Utilization of Archived Data Will Take Time and Experimentation with Data:** Typically, the regions in which data archiving and performance monitoring are most prevalent and widespread are those in which local/state agencies have been archiving and analyzing data for at least 5 or 10 years. For example, the archived data in Seattle has been widely distributed for at least the past 5 years and has become somewhat institutionalized. This finding suggests that agencies in other regions may be likely to adopt archived data for performance monitoring once they 1) learn more about how much and what data is available from this "new" intelligent transportation system data source; 2) have the quality and use of that data demonstrated through practical applications; and 3) experiment with archived data to ensure that it meets their needs. It is hoped that this report may help TMCs build upon the experience of other TMCs, thus reducing the time needed to fully implement a performance measurement system based on archived traffic data.
- **Archived Traffic Data Should be Used to Improve Traffic Management Center (TMC) Performance:** This review of TMCs found that many view their mission solely as "crisis management." Some see little connection between historical archived data and the crises they manage on a day-to-day basis. However, numerous other "operations-based" companies inside and outside of transportation make extensive use of "archived" operations data because their profits depend upon their ability to exploit that data to develop ways to operate more efficiently and effectively. For example, trucking and package delivery companies keep extensive records of package locations and times, and then analyze these shipping times to find locations of inefficiency. Similarly, TMCs should analyze performance data to determine the optimum way to manage crises and to develop other means of operating the transportation system at its maximum efficiency. Because most TMCs are already short of resources, more resources will be needed to meet this true operations mission.
- **The Key to Effective Data Archives Is Assignment of Responsibility and Adequate Funding:** Our review found numerous institutional models used in maintaining ITS data archives. One thing was clear: there are numerous uses of the data beyond any single workgroup or agency. To date, archived data are being used by operators, planners, researchers, air quality analysts, transit providers, consultants, media, and others. In most cases, however, the data were being maintained by operations personnel simply because they own the equipment that collected the data. In some areas, metropolitan planning organizations are preparing to fill the role of maintaining operational data archives (e.g., Dallas-Ft. Worth, Cincinnati, Detroit). In other areas, the state or local DOT has taken on this responsibility (e.g., California, Seattle, Houston, Atlanta, Phoenix). The determination of which agency maintains data archives has been highly dependent on existing institutional structures and relationships. Although there are many possible

models, and it is not clear whether one model is better than the others. It is clear that an adequately funded organizational unit responsible or archiving and disseminating the data is essential to obtaining the full benefit from the traffic data that TMCs collect.

INTRODUCTION

Traffic Performance Measure System Structure

Operations managers collect traffic data in order to better manage traffic. However, this information can also be used to measure performance. Performance measures have several potential uses. They can be used to measure the state of the system, the traffic volumes, the distribution of travel time and delay, vehicle emissions, and the safety of the facilities. This tells decision-makers where improvements are needed and where needs are greatest and thus can inform decisions regarding where to allocate resources and the total level of resources to seek.

Evaluating actual changes in operating strategies or capital improvements by comparing performance before and after provides a basis for estimating the effects of future actions. If "before and after " performance data are available, the performance of two different facilities can be compared and inferences made regarding the effects on performance of differences in operations, facilities or demand.

Even the traffic information used to inform travelers and manage traffic in real time can be thought of as performance measures. So performance measures can inform the decisions of travelers as well as system operators and people who plan operations, design facilities, develop capital programs, and allocate funds.

The process of creation and use of performance measures can be thought of a circle in which measures of traffic conditions are used to inform actions by the users and providers of transportation, which in turn, affect the traffic conditions. Figure 1 shows the components of a traffic performance measure system.

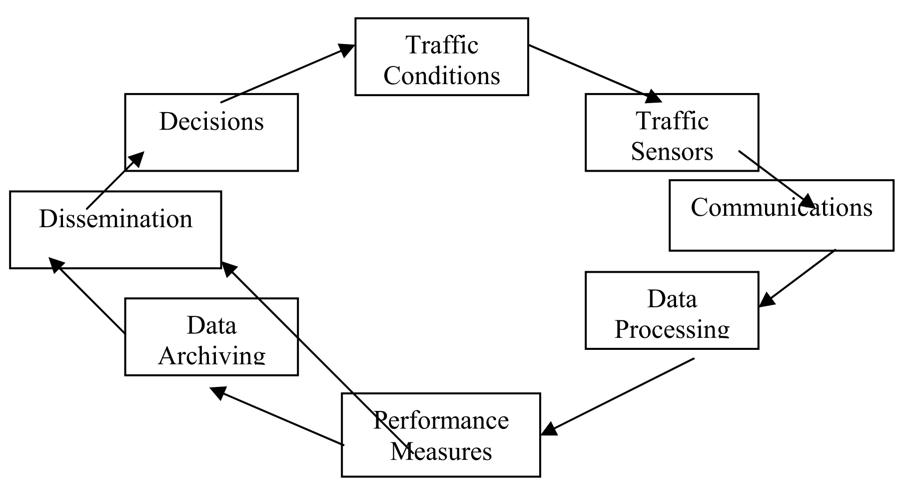

Figure 1. Components of a Traffic Performance Measures System

The traffic conditions are recorded by some type of sensor, which transforms what is sensed into a standard format that is recognized by the data processor. Some type of communication system sends the data to the processing location. The raw data from the sensors is processed into performance measures, ideally into multiple formats for multiple users. The performance measures are disseminated to users immediately or may be archived for later dissemination to users or retrieval by users. They then use the performance measures to make decisions that, in turn, affect traffic. In most regions the circle is broken at some point for most, if not all, users. For a particular type of decision-maker the circle can break down at many points:

- there may not be functioning sensors at critical locations
- the communications may not be in place or may not be functioning properly
- the data processing may not include sufficient checks for errors and may not provide information in a useful form for all users
- data may not be archived for a long enough period
- dissemination methods may be inadequate
- decision-makers may not have good tools or sufficient resources to fully utilize the performance measures for decision making.
- This paper will focus on the data collected by the TMCs in the course of managing operations. However, the TMCs are not the only agencies that collect traffic data. Planning units of state departments of transportation, metropolitan planning organizations (MPOs), and local transportation agencies may also collect traffic data for their own uses. Although it makes sense for TMCs to share the data they collect in the course of managing operations, it should not be assumed that they should be responsible for meeting all traffic data needs. It may be more cost-effective for other organizations to sample some traffic data as needed than for TMCs to set up a permanent infrastructure to continuously collect all the data needed by all potential users.

Goals

The ultimate goal of the traffic performance measure system should be to provide measures needed to support decisions by the providers and users of the transportation system. Considering the current state of most systems, it may be more useful to define a more modest and immediate goal. We submit that this should be to consider the state of the circle described above, consider the value of the different uses of information, consider the costs of completing the circle for these uses, and develop an overall plan for and justification of investment in the system.

Organization of This Paper

This paper generally follows the circle shown in Figure 1, first discussing the decisions and the performance measures needed to inform each type of decision. Then various types of sensors, communications, and data processing tasks are discussed. In each section, the state of the practice is described. The report concludes with recommendations for improving the traffic performance measure system. Appendix A contains the case studies from which the state of the practice and recommendations are drawn. Because the major cost of improving the system is likely to be the installation and maintenance costs of sensors, Appendix B outlines a methodology for developing a traffic surveillance investment plan.

Decisions Informed by Traffic Performance Measures

As noted in the introduction, traffic performance measures can inform the decisions of several groups of people. Table 1 shows the different groups of potential data users. Although they use similar data, the format of the data will be quite different.

In many of the areas surveyed, performance measures were much more prevalent at the MPO or planning level than at the operations level. At the planning level, performance measures are used for investment analyses and project prioritization. However, a few of the operating agencies surveyed are using or are planning to use performance measures. For example, WSDOT produces an annual report of performance measures using archived operations data on major freeways. Caltrans has similar plans for performance measures using the Performance Measurement System (PeMS) and their archived operations data.

Travelers and Commercial Vehicle Operators

Travelers make decisions regarding departure time, route, mode, and destination as well as whether to travel or not. Although these decisions are based primarily on the activities the trip serves, the value of these activities, and the locations at which these activities can take place, they are also based on traffic conditions, such as travel time, the variability of travel time, ease of driving, and safety. Similarly commercial vehicle operators' decisions are based primarily on cargo origins and destinations and other customer needs, but their decisions regarding routes and times of day to travel are based on traffic conditions. Both groups are most interested in the locations of incidents and travel times.

Table 1. Traffic Performance Measure Needs of Various Potential Users

Data Item	Travelers and Commercial Vehicle Operators	Traffic Information Providers	Transportation System Operators	Planners and Policy Makers	Facility Designers	Researchers
Link-based Information						
Real-time link travel times	X	X	X			
Historical link travel time distributions	X	X	X	X	X	X
Current link densities and flows and historical distributions of link densities and flows		X	X	X	X	X
Raw Traffic Data						X
Incident Information						
Real-time indication of incidents	X	X	X			
Real-time incident particulars	X	X	X			
Historical incident records		X	X	X	X	X

Transportation System Operators

The primary tasks of operators are incident management, ramp metering, lane control, and the provision of traffic information. The decisions they make are how to manage incidents, what metering rates to use, what hours to operate HOV lanes, and what information to provide to travelers and traffic information providers, such as radio stations.

Although incident detection relies heavily on 911 calls, and incident response decisions depend on personnel at the incident site or CCTV when it is available at the incident site, most other decisions made by operators depend on speeds, volumes, and travel times. These include decisions regarding where to position warning-sign trucks in case of an incident and what ramp metering rates to use at various locations at various times of day, as well as what traveler information to provide.

Historical[7] speed, volume, and travel time data is used for scheduling maintenance and construction activities. This data is also used to plan operational strategies, such as what hours to operate HOV lanes and what time-of-day ramp metering rates to use. Historical incident information is used to develop strategies to deal with future incidents. It and the historical traffic data may be used to justify additional investment in resources to manage incidents or recurring congestion or to gather information.

Operators need detailed site- and time-specific information. In California, loop detector data are typically reported at 30-second intervals. This level of detail is useful for locating an incident or the location of the end of a queue. It can be averaged over longer time periods for other uses, such as traveler information or scheduling maintenance and construction.

Capital Investment Planners and Facilities Designers

Historical speeds, volumes, and travel times tell decision-makers at many levels where delay is worst. This can be used to allocate funds between regions and between projects within a region, as well as for the design of projects. In order to locate and design facilities in a way that is most cost-effective in reducing delay, planners must have volume and speed data for other facilities that might be affected by changes in capacity in these locations. Facility designers need information on ramp and mainline volumes in order to provide extra capacity where needed but not where it would not reduce delay.

Each type of decision-maker needs different levels of geographical and temporal aggregation. In determining how to allocate funds between regions and within regions, the total level of delay or changes in the total delay would be most useful. Allocations between projects within a region are more likely to be based on the effects of the projects, which would be based not only on the level of delay but also on the cost-effectiveness of various alternative projects in reducing delay. Determining this would require detailed volume and speed data over the entire congested period in the region affected by the project.

Researchers

The same basic data can be used by researchers to develop new guidelines for highway design, to assess the effects of operational strategies such as ramp metering, to develop new ramp metering strategies, and to better understand traffic dynamics. All of this research requires good volume, speed, and density data, but different types of research require different levels of aggregation. Some research requires raw sensor data, such as times when vehicles are sensed or vehicle inductance patterns. This usually requires putting additional components or software in the sensor controller boxes.

[7] The term historical is used here to describe any data that is not real-time.

Data Characteristics

From the above discussion it is clear that although many types of people use the same measures, the data characteristics they need for a particular measure may be different:

- geographic scope – a facility designer needs data only for the area that will be affected by the facility, whereas a system operator needs data for the entire congested region
- geographic aggregation – a planner needs accident data by specific location in order to determine where safety improvements are most needed, whereas a policy maker needs overall accident data in order to decide what level of resources to assign to safety improvements
- temporal scope – a traveler unfamiliar with the area may want travel time for any time of day, whereas a system operator may need it only for congested periods
- temporal aggregation -- system operators typically use volumes aggregated over intervals of less than a minute, but facility designers can use more aggregated data, the level of aggregation is key in calculating
- currency – real-time measures are needed for applying operational strategies, but historical measures are needed for developing these strategies
- accuracy – traffic adaptive ramp metering requires very accurate measures, but travelers can accept a higher level of error—a travel time estimation error of 2 or 3 minutes would probably be considered acceptable by most travelers
- availability – traffic adaptive ramp metering requires that data be available when the meters are operating, but less reliability is required for planning, which utilizes data over a longer period of time, requiring only that data be available for locations of interest at least some of the time

What these differences imply is the need for archiving data in a large database that can be easily accessed by the various users and for providing software with which various users can select, aggregate, and format the data they need.

Traffic Performance Measures Derived from Data Collected by TMCs

These performance measures can be derived from the type of data collected by TMCs:

- travel time – can be measured directly or estimated from spot speed or volume and occupancy measurements
- speed – spot speeds can be measured at detector locations or inferred from travel times
- reliability – this is the variance in travel time, which can be estimated from the distribution of travel times
- safety – can be measured by the rate and absolute number of various types of accidents by specific location, link, or area, by time of day, week, or year or by weather conditions.

Traffic volume, a key measure for making decisions regarding how to reduce travel time, as well as density, which with volume determines travel time, are generally not included in agencies' lists of performance measures. However, they are included as such in this paper because of their widespread usefulness. Furthermore, volume is a measure of the use of the transportation system, and therefore of its benefit.

How Are TMC-Collected Performance Measures Currently Being Used?

Most TMCs use their real-time data to manage incidents and provide roadside information when needed. Many make incident data and speed data available to travelers, either directly via the Internet or through a traveler information provider. The most common uses of archived data by operations staff appear to be:

- ITS evaluations – archived data are used to compare conditions before-and-after deployment of new operational strategies;
- Work zone management – data are used to determine optimum times or penalty costs for freeway reconstruction and maintenance activities; and
- Performance monitoring – a few agencies use the data to monitor performance on a monthly or annual basis.

The most common uses of archived data by other agencies appear to be:

- Research on ITS and operations – research agencies use archived data to develop and/or evaluate operating strategies (e.g., ramp metering) and algorithms (e.g., incident detection).
- Planning analyses – planning agencies use archived data for numerous activities, such as model calibration, traffic volume factors and characteristics, and congestion management programs.
- Air quality analyses – air quality analysts are beginning to use archived data to develop and calibrate mobile source emissions models.

Few TMCs have routine methods of data access for other users, although some provide data to universities, planners, or consultants upon request. An exception is the Seattle TMC which, as part of the TRAC project, has been archiving detector data and making it available to other users for several years. It currently produces a CD of traffic data every 3 months. California's PeMS, an on-line database of loop detector data that can be downloaded in a variety of formats, is being developed and managed by the University of California. PeMS currently contains about a year's worth of data from the Los Angeles detectors that are providing data to the TMC and is beginning to provide data from detectors in the Sacramento area, Orange, and Riverside counties. Other TMCs are developing systems whereby another agency, such as a research institute or metropolitan planning agency archives the TMC data for access by other users.

Sensors

The previous section discussed the types of information needed. This section discusses the type of sensors that can provide the information.

Linking Measures to Types of Sensors

Table 2 shows the links between sensors and the type of measures they provide. Two X's indicate that the source provides good information and one X indicates that the source provides some information.

Table 2. Data Sources for Various Data Needs

Data Item	Road-based sensors other then Closed Circuit Television (CCTV)	CCTV	Vehicle-based sensors	Patrol/Traveler Call-in
Link travel times	X	X	XX	
Link densities and flows	XX	X		
Incident detection	X	X	X	XX
Incident details		XX		X

Travel times can be estimated from point speeds at road based sensors, but they can be more accurately estimated by vehicle probes or platoon or vehicle tracking using various features captured by road based sensors and/or video cameras. The latter are currently under development, and may shortly elevate road-based sensors to XX status for collecting travel times. However, with vehicle-based sensors, travel times can be measured directly. Road based sensors are the best means for measuring flows and densities. Reliability is calculated from the distribution of travel times.

Sensor Types and Performance

Primary considerations in selecting detectors are: accuracy of information, reliability, purchase and installation costs, operations and maintenance costs, and useful life span. Less than optimum maintenance may reduce maintenance costs but it will likely also reduce accuracy, reliability and life span. The detectors currently available are described below.

Road-based Sensors

Loop Detectors

These are the most commonly used detectors. They sense when a car enters the pavement over the loop and how long it covers the loop, thus providing a count of vehicles crossing the loop and a measure of the time the loop is occupied from which the vehicle density (vehicles per mile) can be estimated. Loop detectors are sometimes installed in pairs with one a few meters upstream from the other, so that speed can be more accurately estimated. Loop detectors are not always accurate and often are non-functional. The inductance can change with temperature, rain, corrosion, and mechanical deformation. The controller can malfunction, data can be processed in a way that causes errors at low traffic levels, and communications can malfunction or be interrupted. Performance can be enhanced by correcting any shortcomings in the infrastructure surrounding the detectors, updating the controllers used for the loop detectors, updating the communications system for sending loop data to the TMC, and installing "health check software" to identify non-performing and potentially inaccurate loops. Inductive signature detector cards that can automatically adjust for changes in the loop characteristics that cause errors have been developed. These cards can also be used to identify trucks and for matching inductance patterns of vehicle at successive detectors in order to obtain travel times between the detectors [Ritchie and Sun, 1998]. Double loops can be used to measure the lengths of vehicles or groups of vehicles so that they can be matched at successive detector sites. This method is currently being used to estimate travel times on I-80 near Berkeley. [http://www.its.berkeley.edu/projects/freewaydata]

New loop geometries that provide higher spatial resolution and fewer pavement cuts are being developed. Already developed are micro loops, which are placed in tubes installed a few feet below the roadway. They are less sensitive and have lower resolution than conventional loops but they are less vulnerable to damage and can often be installed and replaced from the side of the road.

RADAR Detectors

These detectors provide counts and density, just like loop detectors. They are commercially available and have been installed in locations in the United States, Asia, and Europe. However, they are not yet widely deployed for freeway traffic monitoring. They are mounted on the side of the road and are relatively easy to install. One sensor can monitor several lanes of traffic. One supplier has agreed to bundle each detector with a solar electric panel and wireless communication to that they can be installed anywhere, even without electricity or telephone connections.

Video Image Detection Systems

These have been commercially produced for several years and have been used for actuated intersection detection, automated traffic counts, ramp metering, freeway management and automatic incident detection. They can count vehicles and determine presence, like a loop detector. They can also read license plates so that vehicles can be reidentified in order to estimate travel times and origin destination patterns. However, their accuracy can be compromised by occlusion of vehicles, glare, day-night transitions, and reflections from rainy roads.

Comparison of Road Based Sensors

Tables 3 and 4 show the results of a Texas Transportation Institute study of road-based detector performance. [Middleton, Jasek, and Parker, 1999]. These tables are based on data from 1997 and 1998 and so do not reflect the latest performance levels. In addition, performance can be influenced by local conditions and particular configurations. The costs displayed in these tables include costs of poles and mast arms. The data for loop detectors does not include traffic control and motorist delay costs during installation, which would both be greater than for the competing non-intrusive detector technologies.

Table 3. Quantitative Evaluation of Detectors at Signalized Intersections[a]

Technology/Product	Intersection Cost	Detection Accuracy (%)	
		Overhead	Sidefire
Inductive Loops	$3,278	98	NA
Active Infrared	14,520[b]	97[c]	NA
Passive Infrared	8,051	97	NA
Radar	3,590	95	90
Doppler Microwave	6,496	NA	NA
Pulse Ultrasonic	6,350	NA	NA
VIDS	3,370	95	82

[a]Four-by-four intersection with single left-turn lane. [b]Assumes four poles with mast arm are needed; no motorist delay or traffic control included. [c]Dropped to 77 percent in inclement weather.

Table 4. Quantitative Evaluation of Detectors on Freeways[a]

Technology/Product	Cost/Lane[b]	Overhead Accuracy (% of ILD)		Sidefire Accuracy	
		Count	Speed	Count	Speed
Inductive Loops	$746	98	96	NA	NA
Active Infrared	1,293	97[c]	90	NA	NA
Passive Infrared	443	97	NA	97	NA
Radar	314	99	98	94	92
Doppler Microwave	659	92	98	NA	NA
Passive Acoustic	486	90	55	NA	NA
Pulse Ultrasonic	644	98	NA	98	NA
VIDS	751	95	87	90	82

[a]Six-lane freeway. [b]Includes cost of pole with mast arm for active IR; includes no motorist delay, but does include traffic control costs for LDs. [c]Dropped to 77 percent accurate in inclement weather.

Closed Circuit Television

Video cameras, especially those with remote pan, tilt, and zoom, are widely deployed for traffic monitoring. Video feeds to television and the internet are favorites with travelers because they give an immediate, comprehensive picture of traffic conditions. They are also useful for planning and managing incident response if the incident is in a camera's field of view. Providing communications between the cameras and the TMC can be expensive. However, systems to provide solar power at the camera site and wireless communications can reduce these costs and the cost of installation.

Vehicle Probes

Toll Tag-equipped Vehicles

This is the simplest and most accurate way to obtain travel times (actually distributions of travel times) between two points. The method that has been most widely deployed is using transponders (generally already used for electronic toll payment), which are read at various locations and matched with readings from other locations. If enough vehicles are equipped with transponders and there are enough readers, this can also provide origin/destination patterns. Incidents can be detected quickly by a sudden and unexpected drop in travel times. Houston is the city where this type of system has been used most extensively. It has been used on a limited basis in New York and New Jersey (the Transmit program), and there are plans to extend the system there.

Vehicles with Cell Phones

The tracking of cell phones promises to provide large amounts of low-cost travel time information, but this technology is still in the early development stage. A test is currently underway in Maryland.

GPS-equipped Vehicles

GPS systems and wireless modems can be installed in vehicles and can be programmed to send a signal to the TMC whenever it passes locations of interest, such as major streets. This system, is also still under development.

<u>What Types of Detectors are Currently Being Used?</u>

Most agencies use some loops, many use double loops. Spacing is often ½ mile, but can range up to 2 miles. The area covered in Detroit is 180 miles, but coverage is much less in most areas. A few agencies use radar, microwave, acoustic, or video image detection. Houston and San Antonio use vehicles equipped with transponders, such as used for electronic toll collection, as probes. In Houston the readers are spaced every 2.8 miles on average. All agencies use CCTV.

Communications

Lack of communications between field devices and the TMC is a common cause of a break in the traffic performance measure system circle. One TMC has had 20 miles of double loop detectors at ½ mile spacing deployed for 11 years without a connection to the TMC. Communications are an integral part of the performance measure system and they have a large impact on both costs and performance of the system throughout its lifetime. The best communications technologies to use for communicating traffic data will depend on the nature and volume of data, distances between where the data is collected and processed, communication services available in the area, and their cost.

Technologies

There are two categories of communications technologies: wireline and wireless. Wireline technologies include:

- Twisted pair copper
- Coaxial cable
- Fiber optic (multimode and single mode)

Wireless technologies include:

- Microwave
- Cellular (digital and analog)
- Cellular digital packet data (CDPD)
- Spread spectrum
- Digital and trunked radio systems

Table 5 compares the attributes of the various communications technologies. The table was prepared in 1995, so some characteristics of the media have changed. In particular, there has been a rapid expansion in wireless communication.

Table 5. Comparison of Communication Technologies

	Medium Range Data (5+ miles)	Long Range Data Speed (15+ miles)	Full-Motion Video Compatible	Relative Cost ($ per bps)	Reliability
Wireline					
Copper twister-pair	1.5 Mbps	1.5 Mbps	No	Low	High
Coaxial cable	100 Mbps	100 Mbps	Yes	Medium	Medium
Multi-mode fiber	500 Mbps	NA	Yes	Low	Very High
Single-mode fiber	40 Gpbs	40 Gbps	Yes	Very Low	Very High
Wireless					
Digital microwave	155 Mbps	155 Mbps	Yes	Medium	Medium
Digital packet radio	250 Kbps	NA	No	Medium	Medium
Cellular	19.2 Kbps	19.2 Kbps	No	High	Medium
Micro-cellular	NA	NA	Yes	Low	Medium-High

Kbps = thousand bits per second; Mbps = million bits per second; Gbps = billion bits per second
Source: "Benefits of Optical Fiber vs. Copper or Coaxial Transmission Media in ITS Systems", Aberrantly, B., Richards, M., and Niebur, D., 1995 ITS America Annual Meeting Proceedings, pp.859-868

Network Topology

There are also choices in the way in which the communication links are connected. These are shown in Figure 2.

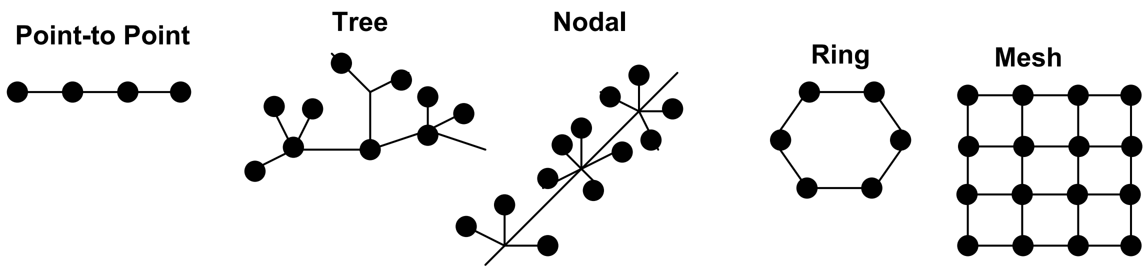

Figure 2. Possible Network Topologies

Source: Federal Highway Administration, Joint Program Office, *Communications for Intelligent Transportation Systems, Successful Practices, Reaching Cost-Effective Solutions through Better Decision-Making Techniques, August 2000*

The choice of communications media and network topology depend on communications needs, system configuration, and cost.

What Types of Communications Do Agencies Currently Use?

Fiber optic cable is a preferred communication medium because of its high capacity and reliability, but it is too expensive for many locations. However, some departments of transportation have been able to obtain low cost fiber optic service as part of the compensation for allowing communications companies to lay fiber optic cable in their rights-of-way. Leased telephone lines have been a common medium, but agencies must make sure that they are providing reliable service. Increasingly, agencies are shifting to radio modems, which are generally less expensive than leased telephone lines. Most agencies use a combination of communications media. For example, Detroit has a fiber optic ring with microwave spokes to hub locations from which copper cables are linked to the field devices.

Data Processing

Some processing takes place at the sensor site, where the raw data is generally converted into traffic data. For example, with a loop detector the magnetic impulse is generally processed into an average flow and occupancy for a short time interval, such as 30 seconds. Alternatively, the data may be averaged over only 1 second, or the times between successive impulses may be calculated. The ultimate uses of the data will determine how the data should be processed at the detector site before transmission to the traffic management center. However, the more detailed the data that is transmitted to the traffic management center, the higher the communications cost. Therefore, an agency may choose to transmit data at the level of detail needed for real-time traffic operations and to accumulate samples of more detailed data at the sensor site, to be retrieved manually or transmitted to the center off peak.

Data Quality

Quality has a number of aspects:

- Accuracy -- a high level of accuracy is needed for optimal ramp meter control, but a much lower level of accuracy will suffice for travel time estimates for travelers. At a recent workshop on traffic monitoring Caltrans attempted to obtain consensus on data accuracy requirements. It was clear that the required accuracy depends on the use.

- Reliability -- the data collection system should be maintainable with available resources at the level of reliability needed for it to be useful. The experience in many locations has been that loop detectors require a high level of maintenance. Experience with other detector systems is limited, but experience with video surveillance suggests that any types of detector will require significant maintenance. Maintenance practices clearly affect reliability.
- Absence of Bias – this refers to the extent to which the sensor data reflects the entire facility or network being monitored. Because point detectors sense traffic at only one point, to be truly representative they should be located wherever the traffic conditions would differ from adjacent locations, for example on an on-ramp and between each pair of ramps. In a probe vehicle system utilizing toll tags, spacing of toll tag readers determines the level of geographic aggregation, and the number of probe vehicles needed to adequately represent conditions between each pair of readers depends on the variance in vehicle speed and the rate at which speed is changing. Research has found that a relatively small number is sufficient. However, the further the distance between readers, the smaller the proportion of vehicles that will travel the full distance between them.
- Validity of estimation methods – in some systems missing data is replaced by estimated data; users who are unaware of this practice can draw erroneous conclusions from the data. Data collection, processing, and error handling methods should be documented and readily available to all data users.

Table 6 shows the accuracy and reliability requirements for various uses of the different types of data.

Table 6. Data Accuracy, Reliability, and Currency Requirements for Various Uses

Data Item	Information for Travelers and Commercial Vehicle Operators	Incident Detection	Adaptive Ramp Metering or Signal Control	Planning and Policy-Making	Facility Design	Research
Link-based Information						
Real-time link travel times	A= m R= h	A= h R= v	A= v R= v			
Historical link travel time distributions	A= m R= m	A= h R= h	A= v R= v	A= m R= m	A= h R= m	A= h R= m
Current and historical link densities and flows		A= h R= v	A= v R= v	A= m R= m	A= h R= m	A= h R= m
Raw Traffic Data						A= v R= m
Incident Information						
Real-time indication of incidents	A= h R= h	A= v R= v	A= v R= v			
Real-time incident particulars	A= h R= h	A= v R= v	A= v R= v			
Historical incident records		A= v R= v	A= v R= v	A= m R= m	A= v R= m	A= v R= m

A= accuracy R= reliability v= very high h= high m= medium

How Do Agencies Currently Control Quality?

One way to improve data quality and reliability is to perform continual error checks on the data to determine if it is reasonable. This makes it possible to detect problems with the data and promptly correct them. Most agencies use some type of basic error checking that identifies physically impossible or implausible data values, such as average 5-minute speeds greater than 80 mph or total 5-minute by lane vehicle counts greater than 250. This error checking is performed at either the detector controller level or the central database/archiving level. Most agencies will set data errors to special codes (e.g., "-1" or "255"), but few provide information or codes as to why the data was considered erroneous and dropped. A few agencies use more sophisticated error checking, such as checking for implausible combinations of data values, such as occupancy less than 5 percent but speed less than 20 mph. Researchers at several locations have developed more sophisticated error checking procedures, but these have not been implemented because a) they require more data than is typically available in real-time or through the controller or b) the error checking algorithms are too complex for most operating agencies to implement.

Some agencies prepare reports on which devices are not reporting. Some do maintenance on a weekly cycle, some on a daily basis. Generally those agencies that find loop detectors to perform well are those that investigate any lack of signal or apparent error as soon as it occurs and then make prompt repairs.

Data Format

Earlier, the differing data characteristics required by users were discussed. Ideally, the most detailed data received from the sensors would be stored in a large database and software would be provided to allow users to specify the temporal and geographical scope and level of aggregation and the data layout needed for their use. The software could also provide useful graphical representations. Thus the same database could serve many users and uses.

Data Archiving

The huge reductions in the cost and space required for storing data have made it possible to archive orders of magnitude more data at a higher level of detail than would have been possible even only a few years ago. However, managing and retrieving data still requires significant resources unless the storage and retrieval process can be fairly automated.

Although the archived traffic is useful to planners, facility designers, and researchers, meeting their data needs is generally not considered a responsibility of the people at the TMC who collect the data. Organizations do well in those things that are closely related to their core mission. Few organizations have the staff to provide a high level of service to other organizational units that are not involved in carrying out this mission. The mission of the TMC is to manage traffic, particularly incidents. It is not generally to plan, design facilities, or conduct research. This presents an organizational problem that must be overcome if full use is to be made of the traffic data. One way is to transfer the TMC data to another agency or organizational units whose responsibility is to archive the information and make it available to all potential users in a useful format.

How Is Traffic Data Currently Archived, Managed and Disseminated?

A USDOT study found that over 80% of agencies collecting traffic volume data archive that data and over 60% collecting speed data archive that data (see Table 7). In many locations, the de facto group for maintaining a data archive has been the operations workgroup/agency, since they are simply saving their own data. However, in some of these locations, the operations workgroup only maintains "recent" data until it can be transferred to some other group/agency for ultimate long-term storage and/or management. Alternatively, in some cases, the operations workgroup archives data in a convenient storage format (compressed text) but does not make the data accessible or easy to use or analyze.

Table 7. Summary of Data Archiving Practices as Reported to U.S. DOT, 1999

Type of System	Type of Data	% of Agencies Archiving
Freeway Management	Vehicle traffic volumes	87% (59 of 68)
	Vehicle classification	76% (37 of 49)
	Traffic incidents (time sequence of events, location, cause, number of lanes blocked, etc)	67% (35 of 52)
	Vehicle speeds	66% (31 of 47)
	Current and scheduled work zones (location, number of lanes closed, scheduled duration, etc)	53% (34 of 64)
Arterial Street Management	Vehicle traffic volumes	83% (134 of 162)
	Turning movements	83% (94 of 113)
	Traffic incidents	83% (34 of 41)
	Phasing and cycle lengths	80% (91 of 114)
	Vehicle speeds	79% (80 of 101)
	Traffic signal preemption info	75% (46 of 61)
	Current work zones	72% (52 of 72)
	Scheduled work zones	67% (43 of 64)

Source: U.S. DOT ITS Deployment Tracking Database, 1999 Results.

In a few areas, the MPO or another agency has taken the lead in maintaining and managing a data archive for themselves and other agencies in the region. These data archive managers then consider themselves responsible for providing these basic data archive functions:

- Ensuring that the data is easily accessible, either through the Internet or on CDs by request.
- Providing information and documentation on the data.
- Performing quality control
- Providing software applications that help to analyze the data, or providing data formats that can be easily analyzed by other's software.

For example, the operations group in WSDOT has developed analysis software and publishes an archived data CD every 3 months. In California, Caltrans has taken the lead in developing PeMS, which makes archived data and various data summaries available through a web site. In Virginia, the Virginia Transportation Research Council has been charged with maintaining statewide ITS data archives, and handle the long-term management and distribution of this data. With a few exceptions, agencies that are using archived operations data for significant analyses are storing that data in a relational database (e.g., Oracle, Sybase, Informix, SAS). Access to the data in a relational database is then provided by using either special programming languages (e.g., SQL, or structured query language) or through a graphical user interface, such as a web browser or database query window. For example, several universities have developed data archives in which the relational database is queried using simple menus and selections in a web browser window. In most cases, the use of a relational database also requires a database administrator who manages day-to-day operations of the database and develops user applications.

Several agencies are archiving their operations data in file-based systems (e.g., either ASCII or binary). In locations like Seattle, they have developed custom software that can be used to manipulate the numerous data files associated with their archive. In other locations, compressed text files have simply been used as either a long-term storage format or as an intermediate format in which to distribute the data to other agencies. For example, agencies in Austin, San Antonio and Phoenix archive operations data into a compressed ASCII-text file for later use by other agencies.

The storage period for data archives varies depending upon data uses, but most agencies use some type of data cataloging process whereby the most recent data is kept “on-line” (e.g., a computer hard disk drive) and older data is kept “near-line” or “off-line” (e.g., CD or magnetic tape cartridges). Nearly all agencies do keep a permanent archive, with very few “erasing” or disposing of old data. Several agencies are planning to have the most recent 12 months on-line and available, whereas owners of smaller archives maintain several years on-line. Additionally, some agencies keep summaries (such as hourly averages) of older data on-line while permanently archiving detailed data (such as 1 or 5-minute data).

CONCLUSIONS AND RECOMMENDATIONS

Better Utilization of Archived Data Will Take Time and Experimentation

Archived data are a rich resource for improving all types of transportation decisions, but are rarely fully utilized. Typically, the regions in which data archiving and performance monitoring are most prevalent and widespread are those in which local/state agencies have been archiving and analyzing data for at least 5 or 10 years. For example, the archived data in Seattle has been widely distributed for at least the past 5 years and has become somewhat institutionalized. This finding suggests that agencies in other regions may be likely to adopt archived data for performance monitoring once they 1) learn more about how much and what data is available from this “new” data source (ITS); 2) have the quality and use of that data demonstrated through practical applications; and 3) experiment with archived data to ensure that it meets their needs. Changing the way that institutions make decisions, particularly costly infrastructure investment decisions, is slow and evolutionary. However, it is hoped that this report may help TMCs build upon the experience of other TMCs, thus reducing the time needed to fully implement a performance measurement system based on archived traffic data.

Archived Traffic Data Should be Used to Improve Traffic Management Center Performance

This review of TMCs found that many view their mission solely as “crisis management.” Some see little connection between historical archived data and the crises they manage on a day-to-day basis. However, numerous other “operations-based” companies inside and outside of transportation make extensive use of “archived” operations data because their profits depend upon their ability to exploit that data to develop ways to operate more efficiently and effectively. For example, trucking and package delivery companies keep extensive records of package locations and times, and then analyze these shipping times to find locations of inefficiency. Most automated manufacturing facilities will track performance of certain machines or equipment to ensure maximum efficiency. Similarly, TMCs should analyze performance data to determine the optimum way to manage crises and to develop other means of operating the transportation system at its maximum efficiency. Because most TMCs are already short of resources, more resources will be needed to meet this true operations mission.

The Key to Effective Data Archiving Is Assignment of Responsibility and Adequate Funding

Our review found numerous institutional models used in maintaining ITS data archives. One thing was clear: there are numerous uses of the data beyond any single workgroup or agency. To date, archived data are being used by operators, planners, researchers, air quality analysts, transit providers, consultants, media, and others. In most cases, however, the data were being maintained by operations personnel simply because they own the equipment that collected the data. The maintenance of data archives by TMCs could be seen as burdensome in some locations, particularly if the operations agency did not use the data. Essentially, what is needed is an "transportation information services" unit that can collect and disseminate this type of data. In some areas, metropolitan planning organizations are preparing to fill this role (e.g., Dallas-Ft. Worth, Cincinnati, Detroit). In other areas, the state or local DOT has taken on this responsibility (e.g., California, Seattle, Houston, Atlanta, Phoenix). The determination of which agency maintains data archives has strongly depended on existing institutional structures and relationships. Although there are many possible models, and it is not clear whether one model is better than the others, it is clear that an adequately funded organizational unit responsible for archiving and disseminating the data is essential to obtaining the full benefit from the traffic data that TMCs collect.

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AGENCIES AND PEOPLE INTERVIEWED

DALLAS. TEXAS

- Ms. Terry Sams, TxDOT (214) 320-6231 tsams@mailgw.dot.state.tx.us
- Mr. Andy Oberlander, TxDOT

FORT WORTH, TEXAS

- Mr. Wallace Ewell, TxDOT (817) 370-6788 wewell@dot.state.tx.us
- Ms. Gina Flores, TxDOT (817) 370-6820 rflores@dot.state.tx.us

HOUSTON, TEXAS

- Ms. Sally Wegmann, TxDOT (713) 802-5171 swegman@mailgw.dot.state.tx.us

SAN ANTONIO, TEXAS

- Mr. Pat Irwin, TxDOT (210)731-5249 pirwin@mailgw.dot.state.tx.us

ATLANTA, GEORGIA

- Mr. Mark Demidovich, Navigator, Georgia DOT (404) 635-8009 mark.demidovich@dot.state.ga.us
- Dr. John Leonard, Georgia Tech Research Institute (404) 894-2360 john.leonard@ce.gatech.edu

DETROIT, MICHIGAN

- Mr. Arvyd Satritis, Michigan DOT (312) 256-9800 satritisa@mdot.state.mi.us

HAMPTON ROADS, VIRGINIA

- Mr. Stephany Hanshaw, VDOT Smart Traffic Center (757) 424-9907 hanshaw_sd@vdot.state.va.us
- *Mr. Rod Turochy, Virginia Transportation Research Council* (804) 293-1918 turochy@vdot.state.va.us

MONTGOMERY COUNTY, MARYLAND

- Mr. Bruce Magnum, Montgomery County DOT (240) 777-8778 bmangum@dpwt.com
- Mr. Richard Roisman and (301) 495-4547 rroisman@mncppc.state.md.us
- Mr. Don Ostrander, Maryland-National Capital Park and Planning Commission (M-NCPPC) (301) 495-2184 pstramder@mncppc.state.md.us

PHOENIX, ARIZONA

- Mr. Manny Agah, Arizona DOT (602) 712-7640 magah@dot.state.az.us
- Mr. David Wolfson, Maricopa County DOT (602) 506-6950 DaveWolfson@mail.maricopa.gov

ORANGE COUNTY, CALIFORNIA

- Mr. Mahesh Bhatt, Irvine TMC, Caltrans (949) 724-2400 mahesh_bhatt@dot.ca.gov

SAN DIEGO, CALIFORNIA

- Mr. Tarbell Martin, San Diego TMC, Caltrans (858) 467-3204 tarbell_martin@dot.ca.gov

ANAHEIM, CALIFORNIA

- Mr. John Thai, City of Anaheim (949) 765-5202 jthai@anaheim.net

MINNEAPOLIS, MINNESOTA

- Mr. Nick Thompson, MnDOT (612) 341-7269 nick.thompson@dot.state.mn.us

DALLAS, TEXAS

Contact Names and Agencies:

- Ms. Terry Sams and Mr. Andy Oberlander, TxDOT
- US DOT 1999 ITS Deployment Tracking Database, http://www.itsdeployment.its.dot.gov/

What functions does your operations center currently provide?

- Incident detection & management (closed circuit TV)
- Traffic control & management (changeable message signs)
- Traveler information (pre-trip is provided via web site and media outlets, en-route via roadside message signs)
- Caltrans does not track system performance; however, they have recently begun to deploy freeway traffic monitoring capability (video detection).

What data is currently collected (and how) to support these functions?

- in the near future, point data (volume, occupancy, speed) from video
- video from CCTV
- incident information
- current & scheduled work zones

What data is currently archived?

- incident information
- current & scheduled work zones

Who uses archived ITS data and for what?

- At this point, significant data are not archived.

Describe particulars about archived data (e.g., who maintains/operates, quality control, storage life).

- Not applicable.

Are performance measures used for decision support? If so, for what decisions and how?

- Not applicable.

Any question/concerns/comments are noted here.

FORT WORTH, TEXAS

Contact Names and Agencies:

- Mr. Wallace Ewell, Ms. Gina Flores, TxDOT
- Mr. Dan Rocha, North Central Texas Council of Governments
- US DOT 1999 ITS Deployment Tracking Database, http://www.itsdeployment.its.dot.gov/

What functions does your operations center currently provide?

- Incident detection & management (detector surveillance, closed circuit TV)
- Traffic control & management (ramp meters, changeable message signs, lane control signals)
- Traveler information (pre-trip is provided via web site and media outlets, en-route via roadside message signs)
- TxDOT-Ft. Worth has developed procedures to track system performance that rely on archived data; however, they have not implemented these procedures on an ongoing basis yet.

What additional functions would you like to provide or enhance?

- Have plans to operate a data warehouse at TransVISION, as well as share data with NCTCOG's central information clearinghouse.

What data is currently collected (and how) to support these functions?

- point data (volume, occupancy, speed, percent trucks) from double loops and radar detectors, typically every ½-mile
- current coverage is about 39 miles
- video from CCTV
- metering rates and ramp queues
- incident information
- current & scheduled work zones

What data is currently archived?

- video snapshots associated with incidents
- incident information
- current & scheduled work zones

Who uses archived ITS data and for what?

- At this point, archived data used mostly by state universities.
- Data used for research purposes, ITS evaluation, and traffic planning purposes.

Describe particulars about archived data (e.g., who maintains/operates, quality control, storage life).

- TransVISION has plans to operate a local data warehouse for their purposes, as well as share data to other centers, such as NCTCOG's planned information clearinghouse. Particulars about the TransVISION and NCTCOG data archives are being planned at this time.

Are performance measures used for decision support? If so, for what decisions and how?

- Archived data has been used to evaluate ramp metering, as well as being used in other research evaluation projects.

Any question/concerns/comments are noted here.

HOUSTON, TEXAS

Contact Names and Agencies:

- Ms. Sally Wegmann, TxDOT
- US DOT 1999 ITS Deployment Tracking Database, http://www.itsdeployment.its.dot.gov/

What functions does your operations center currently provide?

- Incident detection & management (detector and probe vehicle surveillance, closed circuit TV)
- Traffic control & management (ramp meters, changeable message signs, lane control signals, HOV lanes)
- Traveler information (pre-trip is provided via web site and media outlets, en-route via roadside message signs)
- TxDOT-Houston tracks system performance on an annual basis using probe vehicle data from the AVI traffic monitoring system. The TranStar web site also contains charts that show current travel times versus historical performance.

What additional functions would you like to provide or enhance?

- Has plans to operate the TranStar data warehouse, which will contain selected data items generated by TranStar and be shared with partnering agencies.

What data is currently collected (and how) to support these functions?

- point data (volume, occupancy, speed, percent trucks) from double loops and some VIDS, typically every ½-mile, about 30 miles of coverage in 1999
- probe vehicle travel times from the AVI traffic monitoring system, average AVI tag reader spacing is 2.8 miles
- video from CCTV
- metering rates and ramp queues
- incident information
- current & scheduled work zones

What data is currently archived?

- anonymous vehicle travel times
- volume, occupancy and speed from loops and VIDS since mid-2000 by TTI

Who uses archived ITS data and for what?

- At this point, archived data used mostly by state universities.
- Data used for research purposes, ITS evaluation, and traffic planning purposes.
- Data also being used in FHWA Mobility Monitoring Study being conducted by TTI/Cambridge Systematics.

Describe particulars about archived data (e.g., who maintains/operates, quality control, storage life).

- TTI-Houston office currently maintains travel time data from the AVI traffic monitoring system. The TTI-Houston office has also been archiving loop detector data from the TranStar database since mid-2000 under agreements with TxDOT.
- Planning is underway for the TranStar data warehouse, which will eventually archive numerous data elements being generated or collected at TranStar. The data warehouse will be managed through a relational database, with access through internal networks or the Internet.

Are performance measures used for decision support? If so, for what decisions and how?

- Archived data has been used to evaluate ramp metering as well as overall system performance at TranStar.
- For the past several years, TranStar has published an annual summary of benefits that draws upon data collected by the AVI traffic monitoring system. This document is distributed to all of the TranStar partner agencies.

Any question/concerns/comments are noted here.

SAN ANTONIO, TEXAS

Contact Names and Agencies:

- Mr. Pat Irwin, TransGuide, TxDOT
- US DOT 1999 ITS Deployment Tracking Database, http://www.itsdeployment.its.dot.gov/

What functions does your operations center currently provide?

- Incident detection & management (detector surveillance, closed circuit TV)
- Traffic control & management (changeable message signs, lane control signals)
- Traveler information (pre-trip via web site or low-powered TV, en-route via roadside message signs)
- Highway-rail intersection monitoring
- TransGuide does not track system performance. The MPO is responsible for developing a congestion management system, and TxDOT participates through their planning group.

What additional functions would you like to provide or enhance?

- Operational strategies? Capital planning? Work zone management?
- VIA Metropolitan Transit has plans to use their automatic vehicle location data to track performance and contribute to the MPO's congestion management system.

What data is currently collected (and how) to support these functions?

- point data (volume, occupancy, speed) from double loops, video detectors typically every ½-mile
- link travel times from AVI traffic monitoring system
- current coverage is about 53 miles
- video from CCTV
- incident information
- current & scheduled work zones

What data is currently archived?

- traffic volume, occupancy & speed
- probe vehicle travel time
- vehicle classification
- ramp queues (??)
- incidents
- current & scheduled work zones
- road & weather conditions

Who uses archived ITS data and for what?

- Archived data used mostly by agencies other than TransGuide, such as state universities and other research groups.
- Data used primarily for research purposes, ITS evaluation, and traffic planning purposes.
- Data also being used in FHWA Mobility Monitoring Study being conducted by TTI/Cambridge Systematics.

Describe particulars about archived data (e.g., who maintains/operates, quality control, storage life).

- TransGuide currently maintains a publicly-accessible FTP site that has the most recent month of data files in ASCII-text format. Various users download files as needed and develop/maintain their own databases locally.
- Data are stored as 20-second lane records from freeway mainlanes and entrance/exit ramps.
- Basic quality control is presumably done at the controller level, but is unknown.

Are performance measures used for decision support? If so, for what decisions and how?

- Does TransGuide uses archived data and any performance measures to help make decisions about capital projects, maintenance, etc?

Any question/concerns/comments are noted here.

- TransGuide archives most of their data to ASCII-text files for use by other agencies, but they do not see themselves as regular users of data archives and thus have not further developed their data archive beyond what already exists.

ATLANTA, GEORGIA

Contact Names and Agencies:

- Mr. Mark Demidovich, Navigator, Georgia DOT
- Dr. John Leonard, Georgia Tech Research Institute
- US DOT 1999 ITS Deployment Tracking Database, http://www.itsdeployment.its.dot.gov/

What functions does your operations center currently provide?
- Incident detection & management (detector surveillance, CCTV, service patrol)
- Traffic control & management (changeable message signs, lane control signals)
- Traveler information (pre-trip via web site and media, en-route via roadside message signs)
- Atlanta's Navigator does archive detector data but at this point does not systematically monitor performance.

What data is currently collected (and how) to support these functions?
- point data (volume, occupancy, speed) from VIDs, typically every 1/3-mile
- current coverage is about 40 miles
- video from CCTV
- incident information
- current & scheduled work zones

What data is currently archived?
- traffic volume, occupancy & speed

Who uses archived ITS data and for what?
- To date, archived data used mostly by university researchers (Georgia Tech).
- Data used primarily for research on operational strategies, ITS evaluation, and traffic monitoring and planning purposes.
- Data also being used in FHWA Mobility Monitoring Study being conducted by TTI/Cambridge Systematics.

Describe particulars about archived data (e.g., who maintains/operates, quality control, storage life).
- GDOT maintains archived data in ASCII-text files at the 15-minute level.
- GDOT also provides this data on CD upon request.
- Researchers at Georgia Tech also maintain the archived data in a relational database, and use the data for a variety of research projects.

Are performance measures used for decision support? If so, for what decisions and how?
- Performance measures used mostly at the MPO level (Georgia Regional Transportation Authority).

Any notable items or questions/concerns/comments are noted here.

DETROIT, MICHIGAN

Contact Names and Agencies:
- Mr. Arvyd Satritis, Michigan DOT
- US DOT 1999 ITS Deployment Tracking Database, http://www.itsdeployment.its.dot.gov/

What functions does your operations center currently provide?
- Incident detection & management (detector surveillance, CCTV, service patrol)
- Traffic control & management (ramp meters, changeable message signs, lane control signals)
- Traveler information (pre-trip via web site and media, en-route via roadside message signs)
- Track performance???

What additional functions would you like to provide or enhance?

What data is currently collected (and how) to support these functions?
- point data (volume, occupancy, speed) from double loop detectors, typically every 2 miles
- current coverage is about 180 miles
- video from CCTV
- incident information
- current & scheduled work zones

What data is currently archived?
- traffic volume, occupancy & speed

Who uses archived ITS data and for what?
- Archived data shared with Detroit MPO for traffic planning and analysis purposes.
- Data also being used in FHWA Mobility Monitoring Study being conducted by TTI/Cambridge Systematics.

Describe particulars about archived data (e.g., who maintains/operates, quality control, storage life).

- Michigan DOT collects data in 20-second intervals from the detectors, then aggregates to 1-minute once at the center. MDOT maintains the most recent data "on-line" for a short period (about one week), then permanently archives to magnetic tape cartridges.

Are performance measures used for decision support? If so, for what decisions and how?

- Most performance measurement activity in Detroit is focused at the MPO.

Any notable items or questions/concerns/comments are noted here.

HAMPTON ROADS, VIRGINIA

Contact Names and Agencies:

- Mr. Stephany Hanshaw, VDOT Smart Traffic Center
- Mr. Rod Turochy, Virginia Transportation Research Council
- US DOT 1999 ITS Deployment Tracking Database, http://www.itsdeployment.its.dot.gov/

What functions does your operations center currently provide?

- Incident detection & management (detector surveillance, closed circuit TV)
- Traffic control & management (changeable message signs, lane control signals)
- Traveler information (pre-trip via web site and media, en-route via roadside message signs)
- Hampton Roads Smart Traffic Center (STC) does not currently track system performance.

What data is currently collected (and how) to support these functions?

- point data (volume, occupancy, speed) from double loops, microwave radar and acoustic detectors typically every ½-mile
- current coverage is about 47 miles
- video from CCTV
- incident information
- current & scheduled work zones
- road & weather conditions

What data is currently archived?

- traffic volume, occupancy & speed
- incident information

Who uses archived ITS data and for what?

- Archived data used mostly by Virginia Transportation Research Council (VTRC).
- Data used primarily for research on operational strategies, ITS evaluation, and traffic monitoring and planning purposes.
- Data also being used in FHWA Mobility Monitoring Study being conducted by TTI/Cambridge Systematics.

Describe particulars about archived data (e.g., who maintains/operates, quality control, storage life).

- VTRC operates and maintains the ITS data archives for VDOT, as per their most recent data sharing policy. VTRC polls the STC real-time database in Hampton Roads every two minutes to retrieve updated traffic data.
- VTRC stores 2-minute detector and station data, as well as any incident data, in an Oracle relational database.
- VTRC does basic quality control on the data using min/max value thresholds for volume and occupancy, as well as looking at average effective vehicle lengths.

Are performance measures used for decision support? If so, for what decisions and how?

- Hampton Roads STC uses some performance measures for decision-making, but no measures based upon the archived data. The MPO uses performance measures in several of its programs.

Any notable items or questions/concerns/comments are noted here.

- VTRC, as the research arm of VDOT, has been designated to maintain the ITS data archives. Although research agencies are the primary users in many areas, Virginia is the only state where a research agency has been officially charged with managing and maintaining the archived data.

MONTGOMERY COUNTY, MARYLAND

Contact Names and Agencies:

- Mr. Bruce Magnum, Montgomery County DOT
- Mr. Richard Roisman and Mr. Don Ostrander, Maryland-National Capital Park and Planning Commission (M-NCPPC)
- US DOT 1999 ITS Deployment Tracking Database, http://www.itsdeployment.its.dot.gov/

What functions does your operations center currently provide?

- Incident detection & management (loop detectors, closed circuit TV, fixed-wing aircraft)
- Arterial traffic control & management (closed-loop signal system, emergency vehicle preemption, changeable lane assignment signs, transit)
- Traveler information (pre-trip via web site, cable TV, kiosk and media; en-route via highway advisory radio, telephone, and roadside message signs)
- Operating center does not track performance except for periodic evaluation or benefit studies.

What data is currently collected (and how) to support these functions?

- sampling (at mid-block) and presence (at intersections) loop detectors
- current coverage is about 200 intersections
- video from 80 CCTV cameras
- incident information and special events
- current & scheduled work zones

What data is currently archived?

- Traffic volumes are transferred to and archived by M-NCPPC
- Probe vehicles
- Incidents
- Current & scheduled work zones

Who uses archived ITS data and for what?

- Archived data used primarily by (M-NCPPC) for traffic planning and analysis purposes, such as network volume maps, model calibration, alternative network testing, time series analysis, and quick "traffic snapshots."

Describe particulars about archived data (e.g., who maintains/operates, quality control, storage life).

- Montgomery County DOT stores 5-minute volumes in an Informix database on a short term-basis.
- M-NCPPC uses Internet protocols (TCP/IP) and a custom software product to query the DOT database in the early morning and retrieve the most recent 24 hours of 5-minute volume data (at this time, a 7 MB file transfer). Once the data has been retrieved, M-NCPPC loads the data into an Oracle server, does error checking, and then computes peak hour intersection volumes and other volume quantities used in planning applications.

Are performance measures used for decision support? If so, for what decisions and how?

- Some performance measures are used, but these measures are not derived from any archived data.

Any notable items or questions/concerns/comments are noted here.

- The coordination and resource sharing of an operations and planning agency is notable. This partnership occurred largely because an operations manager transferred to the planning agency—this person provided the institutional connection to make the data sharing work.

PHOENIX, ARIZONA

Contact Names and Agencies:

- Mr. Manny Agah, Arizona DOT
- Mr. David Wolfson, Maricopa County DOT
- US DOT 1999 ITS Deployment Tracking Database, http://www.itsdeployment.its.dot.gov/

What functions does your operations center currently provide?

- Incident detection & management (detector surveillance, closed circuit TV, incident response team)
- Traffic control & management (changeable message signs, HOV lanes)

- Traveler information (pre-trip via web site, cable TV, kiosks, pagers, e-mail, and media; en-route via telephone, pagers, roadside message signs)

What data is currently collected (and how) to support these functions?

- point data (volume, occupancy, speed, vehicle classification) from double loops and passive acoustic detectors, acoustic detectors typically every 1/3-mile
- current coverage is about 75 miles
- video from CCTV
- incident information
- current & scheduled work zones

What data is currently archived?

- traffic volume, occupancy, speed, & vehicle classification

Who uses archived ITS data and for what?

- Archived data used mostly by ???.
- Data used primarily for research on operational strategies, ITS evaluation, and traffic monitoring and planning purposes.
- Data also being used in FHWA Mobility Monitoring Study being conducted by TTI/Cambridge Systematics.

Describe particulars about archived data (e.g., who maintains/operates, quality control, storage life).

- ADOT maintains the original 20-second data as collected from the detectors. They store recent data on-line in compressed text formats, and keep old data on CDs. They have developed software to provide archived data upon request in a number of different aggregation levels and formats.
- The Maricopa County DOT is planning to operate a regional archived data server (RADS), which will include ADOT's freeway data as well as other data sources. This regional data archive may not be operational until 2002.

Are performance measures used for decision support? If so, for what decisions and how?

- There are plans for performance measures at the MPO, but no current plans for performance measures at the operations level.

Any notable items or questions/concerns/comments are noted here.

- The Arizona DOT does have a history of archiving detector data, with data on CDs extending back to 1995.

Orange County, California

Contact Name and Agency:

- Mr. Mahesh Bhatt, Caltrans, Irvine TMC

How do you use the data you collect?

Traveler information

Incident information goes to the media, CHP also broadcasts on the net, can post it on 49 CMS at major decision points on major streets and highways (will have more in the future), Anaheim also has signs, uses 6 portable signs on trucks that follow the back of the queue.
Congestion information: OCTA uses database to obtain congestion information, which it then disseminates.

Real time operations

Ramp metering: they do not have centralized control of ramp meters. If there is a problem that lasts more than 4 hours or a planned event (such as at the Anaheim convention center) they go out and change the meters and local intersection signals manually.
The CHP manages the 32 FSP tow trucks out of the TMC. Tow trucks have assigned beats determined by the CHP.
The TMC uses the data for planning link closures for maintenance or special events.

Developing operational strategies

The system support staff (as opposed to the operations staff) analyzes the data to determine what the ramp metering rates should be.
The system support group uses the data for a lane control database.
The data is also used for evaluation and analysis of major incidents.

System monitoring

They do periodic manual studies of occupancy on HOV lanes. All HOV lanes operate 24 hours a day.

Capital planning

The planning department uses the data, which is archived for 1 year, to determine what alternatives to consider in planning capital improvements. They use it in doing their B/C analyses of alternatives.

TMC staff training

Their data is used in the simulator at the training centers at Cal Poly at San Luis Obispo

Research

UC Irvine has a direct fiber optic link to the TMC, which provides loop and video data.

Planned new uses

Operations group plans to use it for accident analysis

Data sources

Video –now have 50 cameras, ultimately want 180 to 200 so that they can see the entire freeway network
Loops—now have 560 stations, single loops every ¾ to 1 mile
Ramp meters also do counts

Communication

Information now communicated by phone lines. Field devices will be connected to the new center by fiber optics.

Data processing

The system support group prepares reports regarding which devices are down and which need repair. Every Monday morning they check the loops and make a maintenance plan for the week.
They receive both 15 second and 30-second data. Most people use the latter.

Data storage

Data is stored on the server for a year and is backed-up on tape. The data is handled by the system support group.

Data access

Data is public record. It is available to anyone at no charge. The only users now are cities, Anaheim and Irvine, and universities, CalPoly and UCI. The cities like the data. It is shared electronically.

Emerging technologies

Working with the So Cal Priority Corridor on tying everything together.

Problems encountered

No lessons learned. Open architecture has worked well. No data problems.

What they want to know

Information about the performance and cost of new types of sensors. Benefit of TMC activities.

<u>San Diego California</u>

Contact Name and Agency:

- Mr. Tarbell Martin, Caltrans, San Diego TMC

How do you use the data you collect?

Traveler information

Caltrans volume and speed estimates from loops, as well as information on confirmed incidents are sent via the internet to the media and traffic reporting services for dissemination to travelers.

Real time operations

The TMC's principal activity is incident management. They have a close working relationship with the CHP, which is also located in the TMC. Although they have a system that tells them when speeds drop precipitously, 911 calls are the principal source of incident detection, but locations given by callers tend to be quite inaccurate. Therefore, they rely on a CHP officer or freeway service patrol operator to verify the incident and provide information regarding incident particulars. This data is used to determine what type of equipment to send to the scene, where to locate mobile changeable message signs and what information to provide on changeable message signs and through the media. The TMC operates a limited number of CCTV cameras, but they are expensive to install and unreliable. There are 270-300 ramps that have meters. There are loop detectors on these ramps and adjacent mainlines.

Developing operational strategies

Sometimes these decisions are supported by hard data, sometimes they are based on experience. Accident and incident information is kept in the CHP log, but is not plotted on a map. The TASAS database is good but does not include information on accidents that did not involve injuries.

Capital planning

The TMC keeps 30-second data on speed, volumes, and peak 3 ½ hour plots on a server for 13 ½ months. During this time planners can download the data from the server.

Construction and maintenance scheduling and monitoring

Traffic data is used for determining what time of day to do construction and maintenance. It is also used to verify that contractors adhere to the schedule.

Research

Several research organizations use the data for various studies, including federal projects.

Data sources

Loops—There are loops on the 270+ on-ramps that are metered and the adjacent mainlines. There are also 20-30 miles of double loops spaced every half- mile that have been in the road for 11 years but that are not yet connected to controllers.
Other sensors—They have tried sonic and infrared sensors but did not find them as economical as loop detectors. There is a group of electrical technicians who keep the loop detectors functioning. If communications from any of the loops is reported, they investigate as soon as possible, usually the same day.

Communications

Loop data is sent to the TMC via leased telephone lines, which have high priority in case of an emergency. When there is a freeway incident that lasts for an hour or more, the cell sites often become overloaded by calls from people stuck in the resulting traffic.

Data processing

The people who manage the servers and do the analytical work are located in the TMC building and are highly valued.

Data storage

Loop data is stored on the server for 13 ½ months, and then destroyed.

Emerging technologies—Plans for the future

The TMC has proposed an ambitious Incident Management & Non-Recurrent Congestion Relief program that includes increasing the efficiency of incident scene management, providing better communications to the media and traveler, deploying more resources to manage queues, and enhancing emergency management team coordination. The purpose is to clear accidents sooner and reduce secondary accidents.
They want to connect the double loops that have been installed but not connected to the TMC. They want to install more loop detectors on ramps and to have loop detectors at ½ mile spacing in all congested areas so that they can be used to verify incident locations. They want to have more complete information so that they can better assess the effects of changes in operations and justify programs such as the incident management and congestion relief program noted above.
Public information program to train the public in the use of 911, to improve the accuracy of information they report.

What they want to know

They want to know how to assess the benefits of changes in traffic management strategies and justify investments in information gathering and incident management.

<u>Anaheim, California</u>

Contact Name and Agency:

John Thai, Manager of Traffic Management Center, City of Anaheim

How do you use the data you collect?

Traveler information

They do not provide information directly to travelers. They send their loop data to a Travel Tip work station where it is processed and combined with other information for dissemination from Travel Tip servers to the Internet, a highway advisory telephone system, and kiosks.

Real-time operations

Their primary job is event management for Disneyland, the Arrowhead Pond, the Convention Center and the Edison International Fields. They use the information to change signal timing and messages on 10 large changeable message signs that provide route and parking information. They operate from 7 AM to 7 PM and additional hours as needed for special events.

Developing operational strategies

The traffic data is archived only as needed for developing basic time of day signal plans and making and evaluating plans handling special events.

No Plans for Using the Data in Other Ways

Data sources

Loop detectors
Signals – all signals are actuated and provide flow
Video –now have 50 cameras
Video image processing –these are getting more reliable but still are not quite as accurate as loop detectors

Communication

There is fiber between the TMC and 8 hubs. Copper, twisted pair connects the hubs to the 285 signals and the CMSs.

Error Checking

This is not necessary because if equipment is not functioning properly, signals do not operate properly and travelers let the TMC know.

Minneapolis, Minnesota

Contact Name and Agency:

- Mr. Nick Thompson, Operations Manager, Metro District Transportation Management Center

How do you use the data you collect?

Traveler information

They have a map on the web that shows congestion levels every minute and icons indicating various types of incidents. They also post the data on a server that can be accessed by organizations providing traffic information. It is used to provide traffic reports on the radio and television, SmarTraveler's telephone traveler information and other traffic web sites.

Real time operations

Detector data is used for incident detection and for setting metering rates at 430 ramp meters in the region. The ramps were originally activated by congestion. Now they also use historic detector data to set fixed rates by time of day. They also use real time information to advise travelers with changeable message signs.

Developing operational strategies

Yes.

Capital planning

It is used for simulations for evaluating capital projects. It is also used by the MPO and the DOT.

Construction and maintenance scheduling and monitoring:

It is frequently used for scheduling lane closures.

Data sources

Loop detectors are located about every ½ mile on 75% of the metropolitan area's 250 miles of freeways. There are about 4000 detectors. They check for errors in the detectors using software that was developed in-house. Approximately 96% are functioning at any one time. They also have about 230 closed circuit televisions.

Communications

Communication in most locations is via fiber optics. Communications between the loops and cabinets is sometime via twisted pair. MDOT owns and maintains the communication system, which they also designed.

Data processing

Data storage

Traffic data has been archived since 1984. It is now stored on the server for 1 year and then transferred to CDs. Anyone in MnDOT can access the data anytime. They also have a data sharing agreement with the University of Minnesota and the MPO. Consultants can access the data upon request.

Emerging technologies—Plans for the future

The traffic management center is moving to a new center that will be jointly used by maintenance personnel, the state patrol, and the signals group.

They plan to install a new computer system that will provide the potential to do more with the data, such as producing more performance measures. They have 5 in-house programmers.

They plan to replace the 170 controllers, hopefully skipping to a new technology.

APPENDIX B. IMPROVING THE TRAFFIC PERFORMANCE MONITORING SYSTEM

There are three primary considerations in improving an existing system:

1) the data needed
2) the existing system:
    a) the extent to which it provides the needed data
    b) the feasibility and cost of expanding or improving it to meet currently unmet data needs
3) the resources available for data collection improvements

Usually there are insufficient resources to do everything that is needed, so choices must be made. The first step is to develop criteria for identifying the road segments for which traffic information is most useful. For example, real time information about a road that rarely experiences congestion will be of little use because the travel time will always be about the same unless there is some sort of incident. The second step is to collect data regarding these criteria for the road network and to use the criteria to identify the road segments for which information would have the greatest use and thus the highest value. This would include all uses, not just those related to traffic management center. All of this can be thought of as the demand side of the problem.

To examine the supply side of the problem, the first step is to determine what traffic monitoring facilities are already available for those road segments for which information would be most useful. If adequate monitoring is not already available, potential data collection systems [8] that could be used to obtain the desired data are identified. Given this supply and demand information for each segment, the most cost-effective method for acquiring needed data in each segment can be determined and its cost can be estimated.

Next, the various road segments are ranked and organized according to the ratio of their benefits to their costs. Potential funding sources are identified. The ranking is then used to construct a traffic surveillance improvement plan and funding program. An "ideal" traffic surveillance plan would include all investments with benefits greater than costs. But, because transportation funding generally is less than what would be needed to fund all such improvements, a "cost-constrained" traffic surveillance investment plan is developed as part of the overall transportation improvement plan. If unexpected funds become available, they are used for the highest ranked un-funded segment eligible for such funding. These steps are shown in Figure B-1.

[8] These systems include sensors, sensor data processing, and all necessary communications.

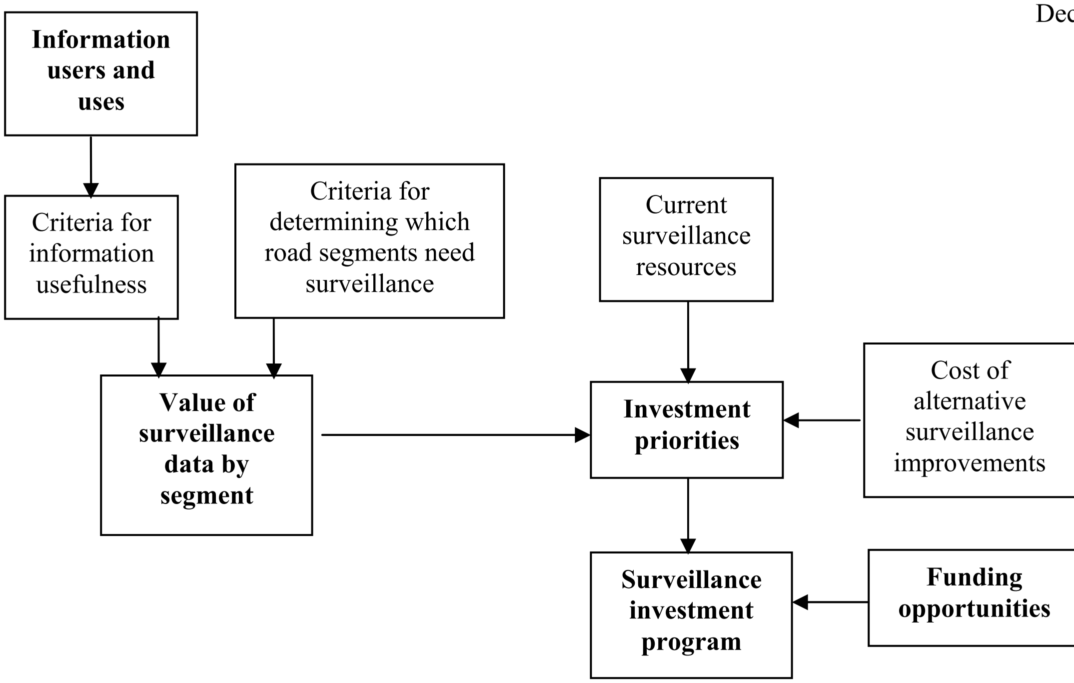

Figure B-1. Process for Developing a Traffic Data Investment Program

Criteria for Determining Where Traffic Surveillance Would Be Most Useful

Given that the priorities for surveillance coverage should relate to the benefits, the primary criteria for setting priorities should be the amount of delay and the variability of delay. Generally, the greater the average delay, the greater the variability in delay. However, some locations, such as routes to beaches or weekend destinations, may generally have little delay but may sometimes have extreme delay. The maximum delay per vehicle is also something to consider. For example, 1000 people who are each delayed for 50 minutes probably experience more total disbenefit than 10,000 people who are each delayed 5 minutes, even though the total delay is the same in both cases. Another factor to consider is the existence of a generator of a large number of time-critical trips, such as an airport, stadium, or large entertainment facility. The existence of alternate routes that allow travelers to exploit any differences in travel time will also make travel time information more useful.

Development of Investment Program

Once costs have been estimated, each highway segment (or group of segments) can be positioned on a graph with the total delay on that segment on the vertical axis and the cost of a surveillance system on that segment on the horizontal axis as shown in Figure B-2. The segments in Figure B-2 are numbered in ascending order of the ratio of cost of their surveillance improvements to total delay, those above the line being the most cost-effective. This also allows easy selection of the most cost-effective group of projects to make with a given amount of funding. For example, if $7 million were available, the best group of investments would be 1, 2, and 3. If an additional $5 million became available, the best choice would be 5, because there would not be enough funding for 4. If funding became available that could only be used for a certain class of investments, it should be used for the most cost-effective investments that fell in that class and that had a total cost within the limit of the funding.

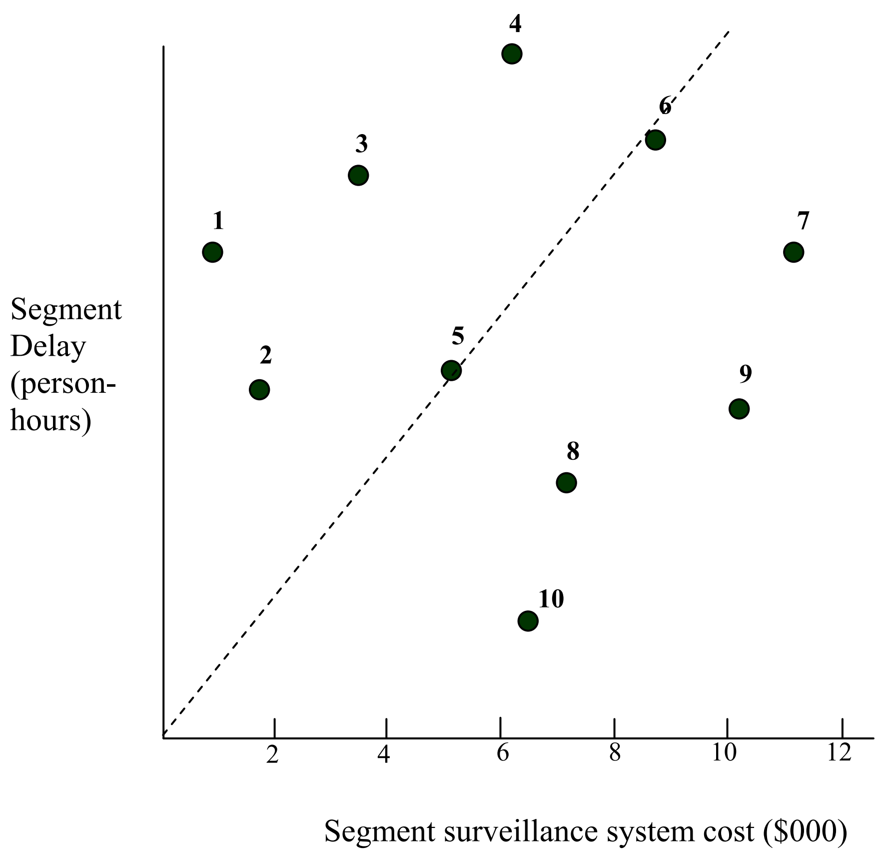

Figure B-2. Plot of the cost-effectiveness of alternate traffic surveillance investments

APPENDIX IV

Memorandum of Understanding
ITS Deployment Research and Professional Capacity Building

I. RECITALS

A. California and Texas, both leaders in the deployment of intelligent transportation systems (ITS), are involved in national deployment programs (i.e., Southern California Priority Corridor, Houston ITS Priority Corridor, and San Antonio Model Deployment Initiative). No one state, however, needs to be responsible for funding or undertaking the breadth of research, education, and training needed to maintain successful deployment and leadership in the ITS field.

B. As ITS is implemented into major metropolitan areas, there is a need to share the successful accomplishments, challenges encountered, and topics needing more research. Coordinating the development of these systems (the Program) will foster greater consistency and interoperability between urban areas within a state and between the states themselves.

C. The sharing of information between practitioners and researchers will also educate professionals in each state about the latest in emerging technologies, advanced operating strategies, and multi-modal integration. This is consistent with the federal professional capacity building initiative and will lead to expanding the breadth and depth of knowledge within each of the participating agencies.

D. This memorandum of understanding (MOU) establishes a working relationship between the two State Departments of Transportation and university research organizations in California and Texas. Under this agreement, each state will allocate funding to allow DOT personnel and university researchers to participate in a series of Program meetings focused on: 1) sharing information on current ITS deployment initiatives, 2) identifying critical issues associated with ITS deployment, 3) developing plans for joint research to address and resolve critical issues, and 4) educating transportation professionals on the design, implementation, and evaluation of leading ITS deployments.

II. SCOPE OF WORK

A. Each state agrees to obligate $50,000 per year for the next 3 years to an effort specifically designed to coordinate ITS deployment research activities between the states. California and Texas are initiating this effort with the expectation that three to four additional states might choose to participate. One of the research organizations will be selected to host a Program meeting and invite key staff from the various state DOTs and university research organizations. Each state would attempt to send as many as four to six people to these meetings to be held in different cities where various ITS activities are being pursued. The meetings will last 2.5 days, with the first portion of the meeting being devoted to technical tours and briefings. The second portion of the meeting would be devoted to a discussion of relevant issues and developing strategies on how those issues will be addressed and advanced.

B. The state universities are to serve as the coordinators for these meetings, working closely with the states to develop the desired agenda for each meeting. The universities will be responsible for seeing that an effective program and meeting is developed to maximize the value of the time available.

C. The Program funds separately obligated by each of the states to their respective selected university (as previously noted) would be used to pay the travel costs for the individuals designated by that state to participate in these meetings. The Program funds will also go to pay the costs incurred by the universities in arranging and coordinating the meetings and preparing the necessary materials for the meetings. Travel costs for special invited speakers will also be paid from these funds.

D. The Program meetings are intended to develop a mechanism to allow the states to effectively coordinate ITS activities and learn from each other's separate ITS projects while also providing a mechanism for prioritizing problems that might be addressed through other funding sources in a cooperative manner. It is the intention of the parties that more cost effective development and deployment of ITS strategies in the different states should result.

III. Coordination Meetings

A. A typical agenda for one of the coordination meetings is presented below. The goal would be to have the first Program meeting in the Spring of 1998 and the second Program meeting in the Summer of 1998.

Day 1:	Arrive in host city in evening for Group Working Dinner	
Day 2:	8:00 AM to 12:00 PM	Technical Tours
	12:00 PM to 1:00 PM	Lunch
	1:00 PM to 5:30 PM	Overview of Selected Topic(s) Invited Speaker(s) Perspectives from States
	7:00 PM to 9:00 PM	Informal Working Dinner
Day 3:	8:00 AM to 1:00 PM	Discussion of Specific Problems/Issues Universities will Facilitate Discussion
	1:00 PM to 2:00 PM	Wrap up/Follow up responsibilities
	2:00 PM to 3:00 PM	Discussion of topic(s), agenda, location, and dates for next meeting
	3:00 PM	Adjourn

B. The meeting topic may be one issue to be explored in depth or several related topics to be discussed together. Topics to be addressed at the coordination meetings could be, but are not limited to the following:

- ITS data uses and management
- ITS system performance measures
- Advances in ramp metering design, control, and operations
- Advanced Traveler Information Systems (ATIS) business models
- Integration of public transportation with Advanced Transportation Management and Information Systems (ATMIS)

- ITS benefits
- Rural ITS

IV. Deliverables

A. One or more topics will be selected as the theme for a particular meeting. Prior to the meeting, background material will be gathered for the appropriate systems within each state. A white paper will be developed that summarizes the state-of-the-practice on that topic, including what each state is doing as well as any other significant national efforts. This material will also be produced in Powerpoint presentation format with a script describing the technical aspects of the projects to allow representatives at the meeting to share the information with their organizations to enhance ITS awareness and education. The material will also be posted at the university web sites to assist in technology transfer.

B. Each Program meeting will start from a problem-oriented approach in identifying the common and unique problems each state is trying to address. These discussions will focus on identifying the technical issues, integration problems, and institutional challenges being experienced with deploying specific ITS projects. Approaches to solving those issues and challenges will also be discussed in attempts to build upon the experience and strength of each organization.

C. A proceedings document will be produced for each meeting to summarize the discussions, develop a strategic plan for leveraging the research taking place in each state to arrive at more global solution, and identify future areas of ITS research with a potential for cost sharing between the states.

V. Memorandum of Understanding Status

A. No funds are obligated under the terms of this MOU. All Program funding will be obligated under separate documents initiated by the participants.

B. This MOU is not an enforceable contract and no obligations are created as between the signatory parties.

ITS Deployment Research and Professional Capacity Building

Cooperating Agencies

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B.F. Templeton, Assistant Executive Director, Field Operations Date
Texas Department of Transportation

Executed for the Executive Director and approved for the Texas Transportation Commission for the purpose and effect of activating and/or carrying out orders, established policies or work programs heretofore approved and authorized by the Texas Transportation Commission.

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Dennis Christiansen, Deputy Director Date
Texas Transportation Institute

____

John West, Program Manager Date
New Technologies and research Program
California Department of Transportation (Caltrans)

____

Professor Karl Hedrick, Director Date
California Partners for Advanced Transit and Highways (PATH)
Institute of Transportation Studies, University of California