Title

An Information And Institutional Inventory Of California Transit Agencies

Authors
Hickman, Mark
Day, Theodore

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Mark D. Hickman
Theodore Day

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Abstract

This research identifies and investigates the current technical and institutional framework for information systems and technologies at public transit agencies in California. With the rapid development of new information systems and technologies over the past 10 years, there are many opportunities for public transit agencies to improve data collection, processing and dissemination. This study examines the current state-of-the-practice in California for the collection, use and sharing of data for operations monitoring, service planning, performance measurement and customer information. To investigate these topics, a broad survey of transit agencies in California was conducted, followed by detailed site visits and interviews with several representative agencies. This paper presents these survey results and generates some conclusions for improving current practice. First, the current means of data collection, processing and dissemination are reviewed, and strategies for application of new information systems and technologies are identified. It appears that California has considerable experience with computer information systems and APTS-related technologies; however, in many cases, these technologies are not being used to their fullest potential. Another aspect of the research reviews the technical and institutional environment for data sharing both within a transit agency and between the transit agency and other organizations. In this regard, many agencies are currently incorporating local- and wide-area networks, open software and hardware interface standards, and explicit management policies on data integration. In addition, there are several innovative transit agencies and third-party organizations that are working to enhance data coordination among transit agencies and between transit agencies and other transportation organizations. Based on this inventory, it appears that many California transit agencies are strategically expanding the capabilities and use of these new information systems and technologies. However, there are both technical and institutional areas that seem ripe for growth. On the technical side, there is a continuing need for state-wide participation, both of vendors and of transit agency personnel, to participate in interface standards development. Perhaps more importantly, greater institutional cooperation and information sharing between transit agencies is necessary to share experiences with new information systems and technologies.

Keywords: public transit, advanced public transportation systems, information storage and retrieval systems, technology assessment

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Executive Summary

Introduction

Many applications of information systems and newer information technologies in public transit are currently envisioned as part of the movement toward Intelligent Transportation Systems (ITS). These systems are expected to improve transit management, operations, maintenance and passenger information. However, for many transit agencies, the transition to the information age is not without its costs: these information technologies may involve significant financial costs as well as substantial changes in the technical capabilities, operating procedures and organizational structure of the agency. These factors can have significant implications for the successful adoption and long-term utility of these technologies.

It seems both timely and important to identify the potential opportunities and challenges for implementing new information technologies at transit agencies. More specifically, this research examines the current state of practice at transit agencies throughout California, with respect to:

- The current environment for data collection, maintenance and sharing
- The current technical and organizational climate with respect to new information systems and technologies
- Current, planned or potential future applications of various information technologies

This research investigates the current technical and institutional framework for the use of data and information systems at California transit agencies.

Research Method

To examine these issues, a two-phase research method was employed, beginning with a written questionnaire and following up with telephone interviews and site visits. Approximately 80 (public) transit agencies in California with known fleet sizes of 10 or more vehicles were identified, and the written questionnaire was sent to these contacts. A total of 30 transit agencies responded to the questionnaire, covering a broad range of agency sizes. Smaller agencies have a considerable representation in this sample. 28 of 30 offer fixed-route bus services, and 20 of the responding agencies provide paratransit services. One responding agency operates a light rail system, one a heavy rail system, and a third both light and heavy rail; each of the three rail systems also offers fixed-route bus service.

The survey instrument included over 50 questions, covering specific uses and needs for data and the current use of information systems and technologies. Specific questions in the survey asked about the data, functions, hardware and software, and use of new information technologies within each of the four functional areas: operations monitoring, service planning, performance measurement, and traveler information. The survey also asked about the existence and use of more advanced technologies, commonly called Advanced Public Transportation Systems (APTS). These answers were used to determine the extent to which these systems are being adopted and used at each agency.

Following up on the questionnaire results, a second phase of the research involved detailed site visits to a representative group of questionnaire respondents with more notable experiences. These site visits were intended to provide more qualitative information about the organizational and institutional issues surrounding information systems and technology use at each agency. Nine agencies were selected, primarily focusing on those respondent agencies that had some relatively novel APTS applications. This sample included agencies of diverse fleet sizes, service characteristics, and experiences with APTS technologies.

Survey Results

Collection, Maintenance and Use of Electronic Data

It appears that many agencies already have key data in an electronic format. As might be expected, larger agencies typically have more data types in an electronic format or data base. Route and schedule information is typically kept in some type of electronic format, whether in an off-the-shelf spreadsheet package or as part of routing and scheduling software. Most agencies also have electronic farebox data, allowing some measures of ridership and revenue to be tabulated virtually automatically on a daily basis. Other ridership data are often kept in electronic format to assist in development of Section 15 and other performance measures. A majority of agencies surveyed had routes, schedules, ridership and revenue (farebox) data in electronic format.

Other data types are less frequently kept in an electronic data base. Driver and vehicle availability may be kept electronically in the form of driver logs, vehicle maintenance logs, and dispatch records. However, this data is typically not in electronic format, except at some larger agencies where software is available to reduce the burden on dispatchers. Accident and crime data are also recorded electronically for easier reference at some of the larger properties, but are rarely kept on-line at smaller agencies. No agency currently has access to electronic data for traffic information.

The survey results also identified the functional unit that is responsible for data collection and/or maintenance at each of the transit agencies, by type of electronic data. Using these responses, it seems that at many of the larger agencies in California, there is some redundancy in data collection and maintenance. At several larger agencies, routes, schedules, farebox and ridership data are collected and maintained by more than one functional unit. Routes and schedules are often held by operations, service planning and customer information, while farebox and ridership information is also held by operations, service planning, and performance measurement. This suggests that similar types of data are being maintained in different units within the agency, and there may be duplication of effort in these tasks.

Use of New Information Technologies

Using the 30 survey responses, we observed the following applications of APTS technologies:

- 20 agencies have electronic registering fareboxes
- 16 agencies currently have or are considering a credit or debit card system
- 8 agencies have automatic vehicle location (AVL) or identification (AVI) systems
- 10 other agencies are currently considering AVL or AVI systems
- 4 agencies have the capability of signal priority for bus or light rail vehicles
- 1 agency has automated passenger counters on board its vehicles
- 14 agencies have silent alarms on board their vehicles
- 7 agencies have video cameras on board their vehicles for security and safety purposes
- 1 agency has video cameras in their heavy rail stations and associated parking lots

Our subsequent interviews at different transit agencies suggest a variety of strategies that agencies have to incorporate these new technologies. Generally, most of the agencies we talked with consider the adoption of these technologies as subservient to the larger mission and business goals of their agency. In these cases, technology advocates have of necessity made strong business cases for the adoption and use of these new technologies. This objective in technology adoption has been observed as a critical factor to the effective long-term adoption of these technologies.

At the same time, several agencies we visited could be classified as technology opportunists (in the literal sense of the word). In particular, many smaller agencies may be willing to experiment with new technologies if a significant opportunity arises. We found many smaller agencies have been approached by technology suppliers in California to serve as test sites for AVL systems. These agencies thus receive AVL service at a reduced (or at no) cost, and in turn provide valuable information to the corresponding product supplier. The three agencies we visited that were testing AVL systems seemed to be struggling to integrate the technology with the normal function of the organization. Our visits indicated that none of the three sites had a strategic plan for incorporating the new technology into their standard operating procedures. This under-utilization of the AVL technology at these sites may be attributed to both a lack of training of operations personnel in the use of the system, coupled with a low need (or low perceived benefit) for computer-assisted location and schedule monitoring capabilities.

Internal Data Coordination

To examine the issue of data coordination within the transit agency, the survey asked respondents which functional areas are using each type of electronic data. From these responses, it appears that the transit agencies in California are using a variety of data to perform functions associated with operations monitoring, service planning, performance measurement and traveler information. For many functions across all of these functional areas, routing and scheduling data appear to be key inputs to making effective decisions. Other data, such as ridership, farebox, and vehicle and driver availability data are also important for monitoring operations, planning service, and measuring system performance.

More importantly, it appears that there may be some opportunities for data sharing across functional areas in many transit agencies. Much of the data in electronic form, including routes, schedules, farebox and ridership data are used by functions in different functional areas. At larger transit agencies, different departments may exist for operations monitoring, service planning, performance measurement and traveler information. Given these conditions, there seems to be some opportunity for data sharing and integrated information systems within these transit agencies.

However, from the survey responses, there are mixed results on the use of common or shared data. Of the 12 larger agencies with more than 100 vehicles that responded to the survey, a clear majority do not have data in a common data base. The reason for separate data bases in these cases is most likely due to problems in transfer-ability between applications; i.e. significant differences in data definitions and formats that precludes sharing.

In response, some of the larger agencies have developed strategies to integrate data across applications. One strategy employed at OCTA has been to work directly with software and hardware vendors to create open data exchange across applications. In contrast to this more technical solution, other transit agencies have used organizational tools to manage existing hardware and software. As an example, San Diego Transit is leveraging existing hardware and software to enhance technical data integration. A high level of data coordination has been achieved through more direct communication between personnel and a clearly defined role of the MIS department in coordinating data integration.

Also, among other medium to large agencies, many have already implemented or are planning to implement local area networks (LANs) to improve data sharing and communication within the agency. At all of the smaller agencies (under 100 vehicles), the survey responses indicate that operations data are typically held in a common data base. This “common data base” typically means that the data are kept on a single personal computer or on an agency-wide network. Thus, when data are needed for particular functions, they can be easily retrieved from the computer in electronic form.

External Data Use and Coordination

A final area of concern in this research is the extent to which data are shared, or at least coordinated, across different transportation-related organizations. Generally, the survey results and the site interviews suggest a low perceived need for new information systems to improve the flow of data between transit agencies and other organizations. However, in the area of traveler information, there are significant initiatives now under way in both the San Francisco Bay Area and Southern California. In the Bay Area, the Metropolitan Transportation Commission (MTC) is now developing a regional database of transit agency routes, schedules and fares. This would provide travelers with easy access for transit information among the many transit operators in the 9-county MTC area, and will be integrated into the larger TravInfo operational test.

In Southern California, both the Los Angeles MTA and the non-profit Commuter Transportation Services (CTS) had developed complementary regional data bases of transit routes and schedules. In both cases, the organization collects route and schedule data from transit agencies throughout the region and makes that data available on-line. The CTS system, called Transtar, serves a number of smaller transit agencies primarily outside of Los Angeles County. The MTA system (Customer Computer Information System, or CCIS), which operates in a similar manner, serves most transit operators within Los Angeles County.

In Orange County, two projects are currently underway that enhance data coordination between the transit agency and local traffic managers. OCTA serves as the regional transportation planning organization for Orange County, and thus has interest in enhancing all modes of travel. Keeping with this goal, OCTA has initiated the TravelTIP project, designed to provide multi-modal travel information to residents and visitors in Orange County. Currently, several institutions will contribute to the traveler information data base: the cities of Anaheim and Santa Ana, Caltrans District 12, and OCTA. OCTA is also conducting the Transit Probe project jointly with Caltrans and the cities of Anaheim and Santa Ana. OCTA will be equipping about 43 vehicles on their fleet with a GPS-based AVL system, allowing real-time monitoring of both transit service as well as ambient traffic conditions. In this way, the AVL system will may provide real-time information on congestion and incidents on selected routes, and also demonstrates a vision for institutional cooperation and data sharing.

One clear message from these initiatives is that new information technologies may be a tool to enhance inter-agency data sharing, coordination and communication. The TravelTIP program in Orange County and the TravInfo project in the Bay Area suggest that multi-modal traveler information can be achieved through integrating transit data with real-time traffic surveillance information. Also, OCTA's Transit Probe project may enhance both transit and traffic management strategies through the shared resource of transit AVL data.

In addition, two different strategies for external data coordination emerge from these examples. For the CTS Transtar system and the MTC TravInfo project, a third party may facilitate data coordination across agencies. Common elements which seem to favor a third party in these cases include: 1) a lack of any one dominant transit agency in the region; and 2) a perceived need for better coordination of transit services covering diverse traveler origins and destinations; and, 3) a belief that the coordinated transit data base can be developed and operated without (or at a minimal) public subsidy. On the other hand, OCTA and the Los Angeles MTA have taken direct responsibility for developing the TravelTIP and CCIS programs, respectively. Such a strategy seems better suited to these agencies because they are such a dominant transit provider in their geographic regions.

Conclusions and Recommendations

Among transit agencies in California, there seems to be a large number of both existing and potential applications for information technologies. To this end, most agencies have data in electronic format, and many of the larger agencies are developing agency-wide computer networks to share data more easily. Also, sharing information across functional units within the organization seems to be an important objective at many agencies. Many agencies have risen to this challenge by aggressively pursuing data integration across applications, or at least in developing stronger organizational policies and programs to achieve integrated information systems. In addition, projects in development in the San Francisco Bay Area and in Southern California are bringing transit and traffic management agencies together to share data for traveler information and improved transportation system management.

Many new technologies are being implemented in a wide variety of transit environments. Many of the larger agencies in the state have the resources and capability to develop and implement the more well-established technologies such as AVL. At the same time, many of the smaller agencies are also acting as testbeds for various new technologies. Moreover, it is often the case that these smaller agencies have the organizational flexibility to innovate relatively quickly and stay on the cutting edge of technology. Yet, there appears to be a greater sense that many of the newer technologies are not being utilized to their greatest potential. It appears that in the midst of the growth in applications of new technologies in California, there is still room for improvement in using these tools in an efficient and effective manner.

There are several recommendations for Caltrans in facilitating the adoption and effective use of information systems and technologies in California:

- Caltrans should re-evaluate its role in facilitating data coordination among transit agencies and between transit and other transportation organizations.
- With its capabilities in traffic management, Caltrans should sponsor more research and development for the technical integration of transit and traffic management.
- Caltrans should facilitate communication between APTS technology developers and transit agencies throughout the state.
- Caltrans should support local agency officials to participate in standards development efforts.
- Caltrans should work with transit agencies in the state to establish dialog between transit operators regarding new information technologies.

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1. Introduction

The rapid development of computer and information technology over the past 20 years is now receiving increasing attention in transportation. Use of information systems and newer information technologies has grown considerably, in part due to recent programs in what is now called Intelligent Transportation Systems, or ITS. In public transit, newer applications of information technologies include local- and wide-area networks and other data sharing environments, geographic information systems (GIS), and ITS-related technologies (called Advanced Public Transportation Systems, or APTS). Many applications of these information systems and technologies in public transit have been envisioned, particularly for improved transit management, operations, passenger information, and vehicle maintenance.

At present, however, the rapid developments in the field of information systems and computation have made it difficult for many organizations to adapt to this new technology. For many transit agencies, the transition to the information age is not without its costs. As has been the case with other organizations, these information technologies may involve significant costs as well as substantial changes in the technical capabilities, operating procedures and organizational structure of a transit agency. These factors can have significant implications for the successful adoption and long-term utility of the new information systems and technologies.

Recent research in California supports this conjecture. Hansen et al. (1994) have examined many of the organizational and institutional issues associated with information technologies in public transit. Using several case studies in California and elsewhere, they identify several factors that may contribute to or detract from the decision to adopt new information technologies, including:

- Awareness and quantification of a problem
- Existing organizational attitudes toward newer technologies
- A person (or group) to support and promote the technology to the rest of the organization
- Awareness of alternatives
- Quantification of potential benefits of the alternatives
- Allocation of substantial managerial resources
- Opportunities to leverage development of information technologies with other technical system investments

Their research also included a broader survey of transit agencies, examining their attitudes and approaches to new technologies. The conclusions suggest that the newer technologies can be promoted through information and investment in these areas mentioned above.

In related research, Lo et al. (1993) and Hall et al. (1994) have examined the current technical and organizational environment in California for highway and arterial traffic management centers. Their research suggests that transportation agencies often are not eager to add functional capabilities through new information technologies. Also, personnel at these management centers generally do not have a broad vision for how these information technologies can improve their operations and management of the transportation system as a whole.

Keeping these issues in mind, it seems particularly timely and important to identify some of the potential opportunities and challenges for implementing new information technologies at transit agencies. To this end, the California Department of Transportation (Caltrans) commissioned this study to examine the current "state-of-the-practice" at transit agencies throughout the State of California. Such an inventory is intended to identify and assess:

- Current or planned applications of various information systems and technologies
- Potential application areas for new information systems and technologies
- The current environment for data collection, maintenance and sharing
- The current organizational climate with respect to new information systems and technologies

This research identifies and investigates the current technical and institutional framework for the use of data and information systems at transit agencies in California. In doing so, insight may be gained into the current status of information systems and new technologies across these agencies. Using this information, we develop recommendations to facilitate the adoption of new information systems and technologies at transit agencies, both in California and among similar properties around the country.

This report is organized as follows. Section 2 provides a review of related research in the areas of APTS and information systems in public transit. Section 3 describes the methodology for collecting information on the current state of the practice, highlighting a survey of transit agencies in California and related follow-up interviews and site visits. Results from the written survey are presented in Section 4, while impressions from the site visits are described in Section 5. Section 6 presents several conclusions and recommendations from this research.

2. Discussion of Related Research

The proposed research considers a number of different existing and on-going studies in the field of relevant information technologies and information systems in public transit, and in transportation more generally. For the purposes of this study, it is useful to differentiate between those studies that have examined new technologies for public transit and transportation, and perhaps separate these from greater discussion on the role of information systems within a transit organization. Thus, the first section describes some of the existing literature and on-going studies of the use of advanced technologies; i.e. specific technologies falling under the rubric of *advanced public transportation systems*, or APTS). The literature on the role of information systems at transit agencies is reviewed in the second section. A third section presents some conclusions based on this literature and presents some resulting implications for this research study.

2.1 Advanced Technologies in Public Transit and Transportation

2.1.1 Technical Capabilities and Implementation Experience

The past several years has seen substantial new interest in advanced public transportation systems, or APTS, both in the United States and around the world. In Europe, a significant research and development effort is proceeding with the DRIVE II program. Finn and Holmes (1995) provide an overview of the technologies and desired impacts of different operational tests in Europe that are part of DRIVE II. Their paper also presents a number of strategic issues facing public transit in Europe, and suggest that advanced technologies may be a means of improving the image of public transit and of reversing the trend of decreasing public transit ridership. Additional issues for European transit agencies, such as achieving a return on the capital investment in new technology and the impacts of new technologies on the operating procedures and practices, are also identified.

The US government has sponsored a number of studies to capture the technical capabilities and implementation experience with APTS. One of the more comprehensive studies of the capabilities and functions of APTS technologies was performed by Castle Rock Consultants (1991) as part of the National Cooperative Transit Research Program (NCTRP). Their study identified the state-of-the-art of existing technologies for vehicle monitoring, location, traveler and passenger information, fare payment, passenger counting, communications and vehicle control. They also identified many existing programs and operational tests of these technologies worldwide.

Also within the US, the Federal Transit Administration (FTA) has sponsored annual updates of current implementation practice with these APTS technologies. Studies have been published by Casey et al. (1991), Labell et al. (1992) and Schweiger et al. (1994). These studies have identified projects in the US and Canada are currently using or planning to use new technologies for vehicle operations (the so-called "Smart Vehicle"), passenger information ("Smart Traveler"), and multi-modal planning and operations ("Smart Intermodal"). A significant number of projects have been presented in these reports, primarily for the information of the public at large and of public transit operators who are interested in learning more about these technologies. Although these studies are not exhaustive, they provide significant insight into the real issues encountered in bringing advanced technology into the transit environment.

A more detailed review of existing APTS technologies was conducted by Khattak et al. (1993). This study reviewed the current availability of the APTS technologies, and sought to characterize these technologies based on: 1) basic technology elements, 2) potential users, and 3) potential beneficiaries. As a decision tool, the resulting taxonomy presents the potential value of each of the APTS technologies, and allows comparisons across different technologies. In addition, the study identified product vendors/suppliers across the country who are currently supplying many of the basic technologies for APTS applications.

The concepts of APTS information standards and systems integration have received attention in the US and abroad. Bourée et al. (1995) briefly describe the development of a European standard reference data model for information systems, called Transmodel. This development effort, also part of the DRIVE II program, has resulted in an established set of public transit terminology, functional areas, functions, and associated data. Transmodel is now under review for acceptance as a European reference model standard.

In the US, a comprehensive national Intelligent Transportation System architecture is currently being developed through a program administered by the US Department of Transportation (ITS America, 1994a). This ITS architecture identifies functional requirements, data flows, data bases, and key interfaces to perform a large set of activities at transit (and other transportation) agencies, using advanced technologies for information collection, processing, and distribution. Such an architecture defines how the technologies would work together to produce more efficient and effective transportation services. In conjunction with this national program, the FTA has sponsored the development of a more specific APTS architecture. This architecture, developed by Sandia National Laboratories (1994), identifies key functional areas at a transit agency that may use advanced technologies, and also describes the key APTS functions and data requirements for these functions. The functional areas addressed in the Sandia report include operations, service planning, maintenance and customer information.

A more detailed review of ITS functions requiring the use of spatial data is reported by researchers at the Oak Ridge National Laboratory (1994). Their research defines a set of 83 functions requiring spatial data, resulting in 116 specific requirements for spatial data bases for ITS applications. Major implementation issues identified in this research include:

- Need to connect real-time ITS-related data with (typically static) map data bases;
- Current lack of modeling and analytic tools in map databases for many ITS functions;
- Current lack of computational speed in geographic information systems (GIS) to allow support for real-time decision-making; and,
- Need for compatibility in data transfer between GIS and non-GIS applications.

This work has been complemented by detailed work on the specific functional and map database requirements for APTS services. A set of such requirements have been developed by the Map and Spatial Data Base Working Group, working under the APTS Committee at ITS America (1994b). That effort has produced a detailed transit spatial data template and, in related activities, has advanced a spatial data transfer standard for APTS applications (Watje and Okunieff, 1995). Several members of the working group are also working on a specification for an ITS location referencing *system* (Viggen Corporation, 1994), allowing sharing of spatial data across ITS applications based on compatible support for many location referencing *methods*.

2.1.2 Institutional and Organizational Issues

On the more institutional end, Schweiger (1995) examines the role of cooperative arrangements between transit and traffic management organizations to set up integrated transportation management centers. Such centers can serve to coordinate traffic and transit operations and to provide the traveling public with multi-modal information about many travel options. The study identified several case study regions in the country that have transportation management centers and examined the institutional and organizational issues associated with coordination between traffic and transit management. The study discovered that, while a good idea in principle, traffic and transit agencies had not pursued integration for either technical or institutional reasons, or simply because of differences in agency goals and objectives. However, a growing number of regions have developed or are planning to develop these integrated centers. Key areas for successful integration noted in this study include:

- Clear understanding of the need for patience and incremental planning in winning organizational and institutional support for an integrated center.
- Preservation of roles, responsibilities and authority of various parties through the mechanisms of inter-agency agreements.
- Respect for advanced technologies as a tool, but not a panacea, for integrating transit and traffic management activities.

In related research, Lo et al. (1993) and Hall et al. (1994) have examined the current technical and organizational environment in California for highway and arterial traffic management centers. The initial study by Lo et al. surveyed the current state of transportation management centers in California, examining the technical capabilities and resulting management, control, and information functions made possible through ITS technologies. This study was extended by Hall et al., who developed a model to characterize institutional cooperation and coordination in transportation system management. Through focus groups, the research explored agency managers' and operators' vision for future integration of traffic and transit management functions. The results of both studies suggest that transportation agencies may be enthusiastic about ITS technologies, but are often not eager to add additional functional capabilities and responsibilities that go along with these technologies. Also, personnel at these management centers generally do not have a broad vision for how these information technologies can improve their operations and management of the transportation system as a whole.

Finally, recent research by Hansen et al. (1994) has examined many of the organizational and institutional issues associated with information technologies within public transit agencies. Using seven case studies in California and elsewhere, they identify several factors that may contribute to or detract from the decision to adopt new information technologies, including:

- Awareness and quantification of a problem
- Existing organizational attitudes toward newer technologies
- A person (or group) to support and promote the technology to the rest of the organization
- Awareness of alternatives
- Quantification of potential benefits of the alternatives
- Allocation of substantial managerial resources
- Opportunities to leverage development of information technologies with other technical system investments

Their research also included a broader survey of transit agencies, examining their attitudes and approaches to new technologies. The conclusions suggest that the newer technologies can be promoted through information and investment in these areas mentioned above.

2.2 Information Systems in Public Transit

There has been only limited amount of comprehensive research into the role of information systems at transit agencies. Rather, most published studies focus on information system planning and design for a particular agency. Of the former, a preliminary investigation of the role of information systems in public transit is given by Elsherif et al. (1982). These authors examine the functional needs of transit agencies for service planning, operations, maintenance, finance, and marketing. Their methodology classifies decision-making in these areas as structured, semi-structured or unstructured, based on the level of human interaction and interpretation required for each specific function. Using this taxonomy, they assess the suitability of computer decision support systems and management information systems (MIS) for improving the efficiency of these functions. Such an assessment includes a review of the organizational structure, as well as the data requirements and necessary information systems, to perform these functions.

A number of studies more recently have focused on integrated information systems, evolving toward the use of common, shared data for transit information systems. A technical framework for information systems integration is presented in Wang and Madnick (1989). Their framework suggests three different types of connectivity for data: 1) physical, regarding electronic connection to data and associated computing resources; 2) logical, regarding data structures and formats for queries of data; and, 3) semantic, regarding the need for common data definitions and relationships. The relative level of integration of an information system may be evaluated in these three areas. Moreover, the use and sharing of data between applications can also be described using this taxonomy.

Beyond this technical framework, the benefits and institutional requirements of coordinated and integrated information systems development have been outlined by a number of authors. Dueker and Vrana (1995) have identified the benefits of sharing data and information at public agencies, and have codified these benefits in terms of:

- *Efficiency:* achieving the benefits of economies of scale in data collection, maintenance and use in analysis;
- *Effectiveness:* being able to provide new services or to provide new functions that enhance transit management and performance; and,
- *Enterprise:* improving the level of communication and information within the transit agency as a whole.

The authors continue by describing methods of achieving these benefits, including a case study at the Portland (Oregon) transit agency (Tri-Met).

Many of the studies described earlier are also transferable more generally into the realm of information systems in public transit. Most directly, a considerable effort has been launched in Europe as part of the DRIVE II program, and has been described in the work of Bourée et al. (1995). In the US, the ongoing work of the national ITS architecture program (ITS America, 1994a), Sandia National Laboratories (1994), and the APTS Map and Spatial Data Bases

Working Group (ITS America, 1994b) have made some very preliminary efforts at developing a common data model for transit applications.

As suggested by the work of the APTS Map and Spatial Data Bases Working Group, much of the recent research in the US has focused on standards for working with and sharing spatial data. This comes as geographic information systems (GIS) are taking a greater role as a computer-based decision support tool at many transit agencies and at public transportation and planning organizations. As a decision support tool, GIS applications have been implemented at many transit agencies over the past 10 years. Schweiger (1992) provides a nation-wide review of such GIS applications in public transit. Schweiger surveyed 46 transit agencies in the US and found 21 agencies using GIS for applications such as: facilities and land management, service planning, marketing and demand forecasting, map development and publishing, telephone customer information systems, and dispatching and scheduling for fixed-route and demand-responsive service. Key implementation issues for GIS identified in her research include:

- Inadequate funding, resources and training of personnel;
- Lack of effective data management to assure data quality;
- Inadequate staff and management support;
- Poor coordination across different units in the agency; and,
- Lack of compatibility and coordination with other (public) organizations.

A recent study by the Transit Cooperative Research Program (TCRP) (1994) describes the use of management information systems at seven larger transit agencies in North America. This study identified hardware, software, operating systems, and computer networking capabilities at these agencies. Also, the research suggests a number of issues that naturally arise in developing and integrating information systems at transit agencies. The report identifies and ranks 18 critical factors for success in MIS; to achieve long-term success, this research suggests that, most critically, an MIS should:

1. Support key strategic business purposes of the transit agency
2. Result from an appropriate organizational structure
3. Result from an agency-wide MIS planning process
4. Employ system development methods
5. Allow decentralized access to management tools
6. Centralize control over the MIS function

The high ranking of these six factors out of the list suggest that the organizational structure and the strategic goals of transit management are much more significant to success than more technical aspects of an information system, such as open architectures or technical support for the system. The TCRP study also identifies important barriers to MIS success, including:

- Organizational barriers to effective use of personnel and technical resources;
- Potential changes from existing practice (inertia);
- Lack of training of MIS and other agency staff; and,
- Lack of or inappropriate MIS funding.

Other research has looked at information systems and related applications at specific agencies. Several transit agencies have developed or are currently developing agency-wide standard data models ("enterprise models") and data bases for GIS applications. Initial investigation of opportunities and implementation issues for Portland (Oregon) Tri-Met is presented by Dueker et al. (1990), Dueker et al. (1991), Groff (1995) and Peng et al. (1995). These reports from the Portland experience identify significant advantages for data sharing within the agency, but achieving this goal requires overcoming several technical and organizational issues. These include:

- Ensuring data compatibility (data formats) across GIS applications;
- Enabling data compatibility (data definitions) between the GIS and other non-GIS computer applications; and,
- Facilitating coordination among many functional units in the transit agency, including MIS, service planning, operations, and customer information.

Seattle's Metro is also developing an agency-wide data model for GIS applications. This development effort began in the early 1990's and has so far resulted in a detailed analysis of user needs (Municipality of Metropolitan Seattle, 1992) and an alternatives analysis for the required information system (Municipality of Metropolitan Seattle, 1993). The user needs assessment identifies several current and potential programs at Metro that use GIS as a decision support tool. Following this assessment, the alternatives analysis describes several alternative programs to implement an agency-wide GIS and evaluates these alternatives based on costs, data requirements, hardware and software, and user support. An enterprise data model that is GIS-based is now being implemented at Metro.

2.3 Conclusions for Additional Research

Several important issues can be highlighted from this previous research. First, there are significant technical needs that often must be addressed in implementing information systems at a transit agency, including:

- A detailed assessment of user needs and functional and data requirements for specific applications;
- Assurance of data transferability between applications, both within the organization and with external organizations;
- Common data formats across applications, or at least relatively straightforward interfaces or translation between applications; and,
- Common data templates and definitions.

Also, the literature suggests that the ultimate adoption and success of these transit applications depend on the ability of the agency to coordinate functional and data needs across a broad range of functional units (e.g. operations, service planning, maintenance, etc.). There seem to be clear advantages to this coordination in terms of improving data consistency and eliminating redundancy in data collection and maintenance. Yet, significant effort is required on the part of the agency to reach this level of coordination.

Moreover, there has been only limited research into "enterprise" data models at transit agencies. Such models would directly address standard data definitions and functional uses on an agency-wide level. To date, the Europeans seem to have come a little further than the US, in that they seem to have a common data reference model that can serve as a standard for future implementation of transit information systems. In the US, work on this sort of a reference data model is still in the preliminary stages.

With all this in mind, it seems an opportune time to assess the technical and organizational issues of electronic data use and sharing in greater detail. To this end, Caltrans commissioned this study to take a broad inventory of information systems at transit agencies in California. Rather than performing a detailed case study of one agency's experience, this project is intended to examine the current state-of-the-practice at many different agencies. By conducting this inventory, insights may be gained to enhance both the initial adoption and the long-term use of information technologies and information systems at transit agencies. More specifically, this work is examining:

- Current or planned applications of various information technologies
- Potential application areas for new information systems and technologies
- The current environment for data collection, maintenance and sharing
- The current organizational climate with respect to newer information technologies

The research methods to investigate these issues are discussed in the following section.

3. Research Methodology

Based on these critical issues, it seems an opportune time to assess the technical and organizational issues of information systems and technologies at transit agencies. This research examines the issues associated with the use and sharing of data for functions associated with real-time operations monitoring, service planning, performance measurement and traveler information. Within each of these four areas, the technical and institutional capabilities and constraints were examined with respect to the following major issues:

1. The uses and management of data within the organization;
2. The level of coordination and sharing of data among various departments internally at each transit agency; and,
3. The level of coordination and organization associated with sharing of spatial data across transit agencies and other transportation-related agencies.

To examine these issues, a two-phase research method was employed, beginning with a written questionnaire and following up with telephone interviews and site visits. The following two sections highlight these two methods.

3.1 Written Questionnaire

For the written questionnaire, approximately 80 public transit agencies in California were identified. This set of agencies includes all agencies with known fleet sizes of 10 or more vehicles, and others for which no fleet size was known. A number of sources were used to compile this list, including membership lists from the California Transit Association, the American Public Transit Association, the Caltrans Office of Mass Transit, and the Federal

Transit Administration. At each of the agencies, a telephone contact was made, typically with personnel directly in charge of operations or service planning. A full list of contacts is included in Appendix A (Section 7). The preliminary telephone call also solicited the participation of these individuals in the survey, and a written questionnaire was sent to these contacts. This survey instrument is included as Appendix B (Section 8) of this report. More generally, the survey included over 50 questions, covering specific uses and needs for data and the current use of information systems and technologies. Generally the questions fall into one of the following broad categories:

- What data are collected?
- How are those data collected?
- How are those data maintained?
- How are those data used? I.e. what data are used to support different functions?
- What additional data are needed or desired?
- What data are in electronic format?
- What software and hardware exist to process and analyze these data?
- What coordination exists in data collection, maintenance and use within the transit agency?
- What data are shared with other (external) agencies?
- What newer technologies are used to enhance data collection and management?
- How are new technologies used to enhance existing transit services?

In its organization, the written survey was sub-divided into five sections. The first section asked about agency-wide data collection, storage, and maintenance. Answers to these questions provided a glimpse of whether data are collected automatically or manually, how frequently data are collected, and whether the data are shared among different departments through a common data base. Questions were also directed about what data are shared with other agencies, including other transit agencies, traffic and transportation planning agencies, other government agencies, private businesses and developers, and other rideshare coordinators. With these answers, a better picture of the current environment for data sharing across agencies and the need for data transfer standards could be examined.

The remaining four sections covered each of the four functional areas mentioned previously: operations monitoring, service planning, performance measurement and traveler information. These latter four sections contained more specific questions on the data, functions, hardware and software, and use of new information technologies within each functional area. Because many of the newer information technologies are intended to improve day-to-day operations and the level of service to the transit passenger, this study focused on the technical and organizational issues associated with operations (or level-of-service) data. Day-to-day operating data that most directly affect a traveler's trip were classified into the following categories: routes, schedules, fares, ridership, driver availability, vehicle availability, accidents, crime, and road traffic conditions. Table 3-1 presents general descriptions of these data that were provided as background for the questionnaire. Because of the diverse operating environments and likely information systems at the 80 target agencies, the data descriptions were intentionally vague and open-ended.

In addition to these definitions, Table 3-2 lists a set of functions that may be performed at a transit agency, again categorized by operations monitoring, service planning, performance measurement and customer information. These functions represent a composite from a number of recent reports, including Elsherif et al. (1982), ITS America (1994a,1994b) and the Oak Ridge National Laboratory (1994). In the corresponding section of the questionnaire, respondents were asked to identify both the specific functions they currently perform and the types of data (from Table 3-1) used to perform each function.

Table 3-1: Transit Operations-Related Data Categories

Routing data	Descriptions of a physical route and corresponding locations of terminals, garages, and intermediate stops; e.g. road names, addresses and distances, maps and other geographic referencing tools, network representation using links and nodes, etc.
Scheduling data	Descriptions of expected and actual travel times on particular routes or portions of a route; e.g. printed schedules (or timetables) for the public, network representations of travel times for various links, etc. This may also include descriptions of the fare charged for travel on particular routes (e.g., fare tables).
Farebox data	Description of revenues collected by route, by stop, or by particular groups of people; e.g. revenue by route or by stop/station, etc.
Ridership data	Records of unlinked and linked trips on routes, vehicle loads, passenger origins and destinations; e.g. on/off counts, passenger trip origin and destination, etc.
Driver availability data	Descriptions of crew schedules, assignment of shifts to each driver, and records of each person's daily and long-term absenteeism and driving record.
Vehicle availability data	Descriptions of vehicle schedules, assignment of runs to particular vehicles, and records of each vehicle's condition and maintenance log.
Accident data	Descriptions of incidents involving fatalities, injuries, and property damage accidents.
Crime data	Descriptions of crime-related incidents both on board the vehicle and in stations, stops, or parking areas.
Traffic condition information	Descriptions of traffic bottlenecks, planned and un-planned road work or other special events, non-transit-related accidents, and other congestion information.

Table 3-2: Transit Operations-Related Functions

Operations Monitoring
1. Monitoring driver performance
2. Monitoring vehicle condition
3. Monitoring vehicle location
4. Monitoring vehicle schedule adherence
5. Providing information to driver
6. Scheduling and routing to accommodate service requests (for demand-responsive service)
7. Dispatching vehicles (for demand-responsive service)
8. Directing on-route operations (for demand-responsive service)
9. Dispatching vehicles (for fixed-route service)
10. Directing on-route operations (for fixed-route service)
11. Monitoring passenger loads
12. Monitoring fare collection activities
13. Monitoring in-vehicle security/safety
14. Monitoring off-vehicle security/safety at stops or stations
15. Monitoring local traffic conditions

Service Planning
1. Analyzing schedule adherence data
2. Analyzing fare data
3. Analyzing passenger loads
4. Analyzing driver performance
5. Analyzing vehicle condition
6. Generating and modifying routes and stop locations
7. Generating and modifying route schedules
8. Generating and modifying vehicle schedules
9. Generating and modifying crew schedules
10. Analyzing demographic trends
11. Monitoring overall traffic patterns and transportation system performance

Performance Measurement and Reporting
1. Generating single day or day-to-day performance measures
2. Generating weekly, monthly, or quarterly performance measures
3. Generating long-term (annual or bi-annual) performance measures
4. Generating Section 15 data

Customer Information
1. Monitoring and responding to passenger comments and complaints
2. Disseminating routes and schedules information
3. Disseminating real-time vehicle and route status
4. Disseminating fare information
5. Disseminating ADA-required mobility information
6. Receiving incoming service requests (for demand-responsive service)

Additional questions in the survey asked about software and hardware used for data collection, processing, and dissemination. These included questions on the need for and use of various computerized decision support systems, e.g. for operations monitoring, scheduling, geographic analysis of travel patterns, etc. Also, the survey asked about the existence and use of more advanced technologies, such as automatic vehicle location or identification (AVL or AVI) systems, electronically registering fareboxes, electronic payment means (e.g. a stored-value "smart card" or debit card), passenger counters, signal priority equipment, etc. These answers were used to determine the extent to which these systems are being adopted and used at each agency.

Given the broad scope of the study, the final questionnaire was very long (20 pages) and on average took about 1 hour to complete. The questionnaire was fielded, first in a small pre-test at AC Transit in the San Francisco Bay Area and later, with significant revisions, to all 80 agencies on the contact list. Given the length of the survey, it was surprising that 30 agencies responded, giving a 37.5% response rate. The results from the survey are reported in Section 4.

3.2 Site Visits and Interviews

Following up on the questionnaire results, a second phase of the research involved detailed site visits to a representative group of questionnaire respondents with more notable experiences. Given the resources available for this phase of the research, nine agencies were selected for site visits, primarily focusing on those respondent agencies that had implemented some relatively novel information systems and/or technologies. The sample included agencies of diverse fleet sizes, service characteristics, service area demographics, and experiences with information systems and technologies. Table 3-3 identifies those agencies included in this phase of the research, as well as some of these agencies' distinguishing characteristics.

Table 3-3: Agencies for Site Visits

Name	Size	Service Environment	Functions Performed In-House	Services under Outside Contract	Jurisdiction
City of Napa	Small	Rural City and County	Administration	Fixed-Route Services	City
Foothill Transit	Medium	Suburban County	None	Management and Fixed-Route Services	Special Transit Zone
Golden Gate Transit	Medium	Suburban County	Management and Fixed-Route Services	Paratransit Services	Special District
Los Angeles County MTA	Large	Urban	All	None	County
Omnitrans	Medium	Suburban County	Management and Fixed-Route Services	Paratransit and Express Services	County
Orange County Transportation Authority	Large	Suburban County	Management and Fixed-Route Services	Paratransit and Express Services	County
Riverside Transit Agency	Medium	Suburban County	All	Paratransit and Express Services	County
San Diego Transit	Medium	Urban	All	None	County
Sonoma County Transit	Small	Rural County	Management Only	Fixed-Route Services	County

The site visits were intended to provide more qualitative information about the organizational and institutional issues surrounding information systems and technology use at each agency. In particular, the site visits allowed for direct verification of the written questionnaire responses and for questioning about coordination of data and information resources within and external to the transit agency. It also allowed us to identify agency attitudes and perspectives on information systems and newer APTS technologies. To facilitate conversation during each of these site visits, a set of follow-up questions was developed and sent via facsimile to the agency contact in advance of our meeting. These questions are shown in Table 3-4. While our site visits used these questions to facilitate discussion, they in no way limited the resulting range of topics during the interviews. The results of these interviews are presented in Section 5.

Table 3-4: Follow-up Questions for Site Visits

Operations

1. What is the standard procedure for guiding or directing a driver along a specific route?

2. What decision support tools (computers, radios, graphic displays, etc.) are used at the operations control center? Are there any tools for supervisors or dispatchers in the field?

3. What types of decisions are typically made by field supervisors? dispatchers? central control personnel?

4. What are the typical reasons for radio communications with vehicles? How busy is voice traffic over the radio?

5. What types of measures are used to correct service reliability problems (e.g. holding buses at time points, skip-stop service, re-routing of vehicles)?

6. How are emergencies and other incidents communicated to the proper authorities? E.g. from driver to central control, and from central control to police, fire, ambulance, etc.?

Service Planning

1. What computer-based support tools are used in service planning, e.g. for routing, scheduling, run cutting, etc.?

2. What data are used in these tools? Where do these data come from?

3. What type of computer platforms are in use in service planning?

Performance Monitoring

1. What types of performance measures are kept at the agency?

2. What unit within the agency is responsible for developing these performance measures? Does this vary by the type of measure; e.g. daily, weekly/monthly, and quarterly/annual measures?

3. How are these data collected and stored?

Customer Information

1. How are requests for information (e.g. routes, schedules) handled? Is there an automated information system, either over the phone, through a kiosk, etc.?

2. How is information given out about routes and schedules connecting with other services; e.g., paratransit to fixed route services, or connections to another agency's transit service?

3. How are requests for paratransit services recorded and processed?

4. To what extent are computers used to help get information to customers?

Table 3-4: Follow-up Questions for Site Visits (Continued)

Data Sharing

1. Is there any duplication of effort in collecting or maintaining data?

2. To what extent do each of the four areas share common information, either through paper or electronic means?

3. Do you have a local network or common computer system to share information between different departments?

4. Is there any interest in developing a common data base of operations-related information?

5. Is data shared with any outside agencies? What data is shared? And how is that data used within your agency?

6. If data is being shared, is this sharing done electronically or through some printed material? Is there interest in doing this electronically?

Newer Technologies

1. Has your agency considered using newer technologies, such as:
   - automatic vehicle location systems
   - passenger counting systems
   - electronic farebox systems
   - smart card systems
   - geographic information systems

2. What is the motivation behind considering or not considering these options?

4. Survey Results

This section presents the combined results from the survey questionnaire and the agency site visits described in Section 3. There was a lot of information gleaned from these survey activities, and this section provides a summary of major observations and particular noteworthy highlights. In presenting these results, this chapter summarizes the capabilities of the 30 agencies that responded to the written questionnaire and highlights particular innovations observed through the site visits.

The presentation of results begins at the level of specific functional areas within an agency. Section 4.1 describes the current climate for electronic data and for specific functions that use these electronic data, within each transit agency. To complement this analysis, Section 4.2 highlights the uses of APTS-related technologies to assist in each agency's operations, particularly as they are used for data collection, maintenance, processing and analysis. Section 4.3 then broadens the perspective to discuss what is being done at these agencies to integrate data sources, thereby reducing the costs associated with collecting and maintaining these data. In many cases, agencies have found significant efficiencies by connecting different functional areas at the agency. Finally, Section 4.4 describes some preliminary projects that explore sharing of electronic data with organizations external to the transit agency. In this regard, new information technologies are enhancing transit service provision and traveler information.

4.1 Electronic Data and Use of Information Systems

4.1.1 Electronic Data

One of the overarching concerns about the use of information systems at transit agencies is the extent to which electronic data and other information exists and is of value to the organization. The questionnaire asked respondents directly about what general categories of data, from Table 3-1, are used to perform the functions listed in Table 3-2, and what data of this is in electronic format. The following discussion identifies the current climate for collection, maintenance and use of electronic data among the survey respondents.

Table 4.1-1 shows the availability of data in electronic format for each of the data types, across the set of transit agencies that responded to the survey. From this simple summary, it appears that many agencies already have key data in an electronic format. These results also support a number of common assumptions about electronic data and their availability. First, as might be expected, larger agencies typically have more data types in an electronic format or data base. Virtually all of the agencies with over 40 vehicles reported having route, schedule and farebox data in some type of electronic format, whether in a spreadsheet package or as part of in-house or commercially available routing and scheduling software. Most agencies also have electronic farebox data, allowing some measures of ridership and revenue to be tabulated electronically on a daily basis. Ridership data were reported in electronic format at virtually all agencies. It is believed that these data are kept electronically to monitor transit agency performance, and to develop performance measures for local, state, and federal reporting requirements. Thus, a clear majority of all agencies, and virtually all agencies with fleet sizes of

40 or more vehicles, have routes, schedules, ridership and revenue (farebox) data in electronic format.

Our site visits confirmed the use of computer tools to manage and analyze routing, scheduling, ridership and farebox data. Even the smallest agencies visited, the City of Napa and Sonoma County Transit, used spreadsheets to maintain schedule and bus stop information. Sonoma County Transit also has all of its 21 routes coded into a geographic information system (GIS) to maintain bus route and stop information. All nine sites use electronic fareboxes to monitor revenues, and most made use of the same data to track route patronage at various times of the day. One curious exception to using farebox data for ridership tracking occurs at the Los Angeles County MTA, where it is difficult to track patronage through the farebox because of a large number of non-cash transactions (i.e. transfers and flash passes).

Other data types are less frequently kept in an electronic data base. Driver and vehicle availability may be kept electronically in the form of driver logs, vehicle maintenance logs, and dispatch records. However, as evidenced in Table 4.1-1, this data is typically not in electronic format, except at some larger agencies (200 or more vehicles) where specific hardware and software are available to track vehicles and drivers on a daily basis. Accident and crime data are also recorded electronically for easier reference at several of these larger properties, but are rarely kept on-line at the smaller agencies. No agency currently has access to electronic data for traffic information. As the latter three types of data (crime, accident and traffic information) are typically used infrequently, or perhaps on an exception basis, there seems to be little interest in collecting or maintaining these data as part of normal day-to-day operations.

Table 4.1-1: Agencies with Electronic Data

y	Number of Vehicles	Type of Data							
		Routing Data	Scheduling Data	Farebox Data	Ridership Data	Driver Availability Data	Vehicle Availability Data	Accident Data	Crime Data
County MTA	1700	Y	Y	Y	Y	Y		Y	Y
o Municipal Railway	1038	Y	Y		Y	Y	Y	Y	
ty Transportation Authority	847	Y	Y	Y	Y	Y			
	800	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
pid Transit District	637	Y	Y	Y	Y		Y		Y
	372		Y		Y				
ansit	323	Y	Y	Y	Y	Y	Y	Y	Y
Transit	298	Y	Y	Y	Y	Y	Y		
Public Transportation	213	Y	Y	Y	Y	Y			Y
	211	Y	Y	Y	Y		Y	Y	Y
Transit District	N/A		Y	Y	Y	Y			
nsit Agency	141	Y	Y	Y	Y			Y	
nas Transit	88	Y	Y	Y	Y				
a Metropolitan Transit District	74	Y	Y	Y	Y				
of California (Chico)	68	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
icipal Bus Lines	55	Y	Y	Y	Y			Y	Y
nty Transit	47		Y	Y	Y				
t	46	Y	Y	Y	Y			Y	Y
it Agency	40		Y	Y	Y	Y	Y	Y	
Transit Development Board	38	Y	Y	Y	Y				
ransit	36	Y	Y	Y	Y				
un Transit	35	Y	Y		Y				
ra Costa County Transit	29								
spo Regional Transit Authority	23			Y	Y			Y	
	17	Y		Y	Y				
ansit	12		Y	Y	Y	Y			
sit	10				Y				
a	9								
sit	8	Y	Y		Y				
n	3	Y	Y	Y	Y			Y	
of agencies	30	19	23	21	26	9	6	10	7

Key: Y indicates the agency has data in electronic format
N/A = Not Available

4.1.2 Functions Using Electronic Data

One of the overarching concerns about the use of information systems at transit agencies is the extent to which electronic data and other information is of value to the function of the organization. The survey instrument asked respondents directly about what functions they are performing and what general categories of data are used to perform these functions. From these answers, it is possible to identify data that might be generated in an electronic format for a specific application or shared electronically across different applications. This in turn suggest areas where electronic data standards may be necessary to enhance the market for decision support systems and related tools. From the 30 responses, Tables 4.1-2 through 4.1-5 list the categories of data used to perform the functions identified in Table 3-2. These tables include only data types which were cited by at least one-third of the agencies that reported performing each function.

Table 4.1-2 gives the data types used for monitoring operations. Many of the functions that might be performed frequently or continuously make use of routing and scheduling data, including: monitoring vehicle location and schedule adherence, providing instructions to drivers, dispatching and directing on-route operations. That is, route and schedule information appears to be very useful in performing these functions. The survey results in Table 4.1-2 suggest that these data can be in electronic format. However, in our site visits, we found these data occurred more often as a hard copy of the routes, bus runs and timetables at the dispatch or operations center.

Table 4.1-2: Data Used for Operations Monitoring Functions

Function	Number of Responses	Data Category	Number of Agencies Using Data	Number of Agencies Using Electronic Data
Monitoring driver performance	23	Accident	17	5
		Scheduling	13	8
		Driver Availability	10	3
		Routing	9	7
Monitoring vehicle condition	22	Vehicle Availability	14	5
		Accident	8	4
Monitoring vehicle location	18	Scheduling	11	11
		Routing	10	8
		Vehicle Availability	8	4
Monitoring schedule adherence	23	Scheduling	19	18
		Routing	10	8
Providing information to driver	18	Routing	12	8
		Scheduling	10	9
		Traffic Information	10	0
Scheduling and routing for demand-response services	15	Routing	8	6
		Scheduling	6	5
Dispatching demand-responsive vehicles	14	Routing	5	3
		Scheduling	5	3
		Vehicle Availability	5	2
Directing on-route operations, demand-response service	14	Routing	4	3
		Scheduling	4	4
Dispatching fixed-route vehicles	21	Vehicle Availability	12	4
		Scheduling	11	8
		Driver Availability	10	6
		Routing	9	8
Directing on-route operations, fixed-route service	18	Scheduling	15	12
		Routing	11	7
		Traffic Information	8	0
		Driver Availability	9	5
Monitoring passenger loads	21	Ridership	16	16
Monitoring fare collection activities	21	Farebox	21	18
Monitoring in-vehicle security	21	Crime	15	4
Monitoring security at stops	18	Crime	13	6
		Accident	6	5
Monitoring local traffic conditions	17	Traffic Information	13	0

Other operations monitoring functions may be performed on an exception rather than a continual basis: monitoring driver performance, passenger loads, vehicle condition, fare collection, traffic conditions, and system safety. From Table 4.1-2, such exceptional events typically require specific information to be relayed through the operations center. Vehicle and driver availability data, traffic information, ridership and farebox data are used to perform specific but perhaps infrequent functions. Many agencies in the survey mentioned that they keep such data in hard copy only rather than in electronic form. However, subsequent discussions with field personnel suggest that electronic data and computer decision support systems can be useful, depending directly on how frequently the operations center will perform each of these functions. Agencies with frequent problems with service reliability and security (e.g. in large urban areas of the state) expressed the greatest desire for decision support tools to respond quickly to transit and traffic incidents.

Table 4.1-3 shows the functions and respondents' data needs for service planning. As might be expected, routes, schedules and ridership data are critical for many of these functions. As noted in Section 4.1.1 and again in this table, these data are often in an electronic format, either in spreadsheets or as input to other software applications (e.g. for scheduling and run-cutting). It appears that performance of these service planning functions is often computer-intensive, allowing for considerable use of electronic data in conjunction with spreadsheet analysis, routing and scheduling software, and other computer-based decision support tools such as geographic information systems (GIS).

In many agencies, personnel in the area of operations or service planning are also responsible for measuring and reporting system performance. Table 4.1-4 indicates the data types that are used for these functions. As might be expected, the data used to measure efficient and effective transit system performance are based on system ridership, revenues, and service quality as measured by scheduled vehicle service hours and schedule adherence. Again, these measures are recorded electronically at many agencies. Farebox data is kept in electronic format by 20 agencies (about 69%), typically being derived from an electronic farebox (at 19 of these 20

Table 4.1-3: Data Used for Service Planning Functions

Function	Number of Responses	Data Category	Number of Agencies Using Data	Number of Agencies Using Electronic Data
Generating and analyzing schedule adherence data	22	Scheduling	19	16
		Routing	10	7
		Ridership	8	8
Generating and analyzing fare data	21	Farebox	18	12
		Ridership	12	12
Generating and analyzing passenger loads	23	Ridership	21	19
		Scheduling	9	7
		Farebox	9	9
Generating and analyzing driver performance	18	Accident	9	6
		Scheduling	7	6
		Driver Availability	6	2
Generating and analyzing vehicle condition	18	Vehicle Availability	10	3
Generating and modifying routes and stop locations	21	Routing	18	11
		Scheduling	16	15
		Ridership	12	11
Generating and modifying route schedules	21	Scheduling	18	16
		Routing	13	8
		Ridership	9	9
Generating and modifying vehicle schedules	20	Scheduling	15	15
		Vehicle Availability	13	6
		Routing	8	6
Generating and modifying crew schedules	20	Scheduling	12	12
		Driver Availability	9	2
		Vehicle Availability	7	3
Analyzing demographic trends	17	Ridership	11	10
Monitoring traffic patterns and system performance	15	Scheduling	12	10
		Routing	9	7
		Ridership	9	8
		Farebox	7	5
		Traffic Information	7	0

Table 4.1-4: Data Used for Performance Measurement and Reporting Functions

Function	Number of Responses	Data Category	Number of Agencies Using Data	Number of Agencies Using Electronic Data
Generating and analyzing day-to-day performance measures	22	Farebox Ridership Scheduling	16 16 11	15 16 9
Generating and analyzing weekly performance measures	22	Ridership Farebox Scheduling Accident	19 17 14 9	19 15 11 3
Generating and analyzing long-term performance measures	23	Ridership Farebox Scheduling Routing Accident	20 18 15 12 9	19 16 13 8 3
Generating and analyzing Section 15 data	21	Ridership Scheduling Farebox Routing Accident	16 14 14 10 9	16 13 13 7 2

agencies) and down-loaded daily to a local computer for storage and off-line processing and analysis. Also, bus mileage and other routing data are needed to analyze long-term performance trends; these data are typically kept electronically in spreadsheets, a GIS, or in other vehicle routing and scheduling software.

Finally, Table 4.1-5 indicates the data used to perform various customer information functions. As is typical, most transit customers are interested in learning about fixed-route and paratransit services through existing schedule, route and fare information. Thus, these data are perhaps used most frequently by a transit agency for customer information purposes. Other functions of a more "customer service" orientation require more specific kinds of data. When specific complaints are taken, this may be combined with route, schedule, driver and vehicle data to ensure appropriate corrective action. Also, routing data (e.g. as 3/4-mile "buffers" around fixed route service) are helpful in determining the eligibility of many passengers for ADA services. There were clearly those who supported use of computer-based information and decision support tools, especially at the larger fixed-route transit agencies. At the same time, the smaller agencies in this sample generally only have printed routes and schedules available to perform many of these customer information tasks.

Table 4.1-5: Data Used for Customer Information Functions

Function	Number of Responses	Data Category	Number of Agencies Using Data	Number of Agencies Using Electronic Data
Monitoring and responding to passenger comments	22	Scheduling Routing Driver Availability Vehicle Availability Traffic Information	17 15 11 10 9	13 9 4 3 0
Disseminating routes and schedule information	21	Scheduling Routing	19 17	16 11
Disseminating real-time vehicle and route status	18	Scheduling Vehicle Availability Routing	10 8 7	9 0 3
Disseminating fare information	20	Farebox	11	9
Disseminating ADA-required mobility information	19	Routing Scheduling Ridership Vehicle Availability	11 9 7 7	6 7 6 3
Receiving incoming service requests (demand-responsive services)	15	Scheduling Routing	7 5	6 5

4.1.3 Summary

There are several points that can be drawn from this information. First, it appears that the transit agencies in California are using a variety of data to perform functions associated with operations monitoring, service planning, performance measurement and customer information. For many functions across all of these functional areas, basic routing and scheduling data appear to be key inputs to making effective decisions. Other data, such as ridership, farebox, traffic conditions, and vehicle and driver availability data are also important for monitoring current operations and for planning service in the near- and long-term. Many of these latter types of data, as well as crime and accident data, are typically needed on an exception basis, but may be useful to support specific functions.

Second, it appears that many agencies already have key data inputs in an electronic format. Route and schedule information is typically kept in some type of electronic format, whether in an off-the-shelf spreadsheet package or as part of routing and scheduling software. Most agencies also have electronic farebox data, allowing some measures of ridership and revenue to be tabulated virtually automatically on a daily basis. Other ridership data are often kept in electronic format to assist in development of Section 15 and other performance measures. Driver and vehicle availability may also be in an electronic format, in the form of driver logs, vehicle maintenance logs, and dispatch records that may be kept in an agency-wide data base. Data for specific functions such as crime, accident, and traffic condition information may or may not be recorded in an electronic format, depending on the frequency of use of this information at each agency.

Finally, it appears that there may be some opportunities for data sharing across functional areas in many transit agencies. Many of the functions in operations monitoring, service planning, performance measurement and customer information use similar data types: routes, schedules, ridership, farebox, and vehicle and driver availability information. From the survey, many agencies are using these data across different functional areas, and the data are typically in some electronic format. Given these conditions, there seems to be some opportunity for data sharing and common information systems within these transit agencies. Moreover, to achieve such levels of integration, there may need to be data standards or at least open interfaces to enhance the sharing of these data. These opportunities are explored in Section 4.3.

4.2 Advanced Information Technologies

4.2.1 Summary of Applications

With the explosive growth of hardware and software capabilities over the past ten to fifteen years, one might expect a growing use of newer information systems in public transit. Several questions in the survey addressed the use of hardware and software for both data collection as well as data processing and dissemination. The following discussion highlights the findings regarding applications and interests in these information technologies.

One area of keen interest in the questionnaire and subsequent interviews is the use of newer technologies for data collection and aggregation. Based on the 30 responses to the written survey, Table 4.2-1 identifies reported use of many new technologies, including:

- 20 agencies (about 67%) have electronic registering fareboxes
- 16 agencies currently have or are considering a “smart” card or debit card system
- 8 agencies have automatic vehicle location (AVL) or identification (AVI) systems
- 10 other agencies are currently considering AVL or AVI systems
- 4 agencies have the capability of signal priority for bus or light rail vehicles
- 1 agency has automated passenger counters on board its vehicles
- 14 agencies have silent alarms on board their vehicles
- 7 agencies have video cameras on board their vehicles for security and safety purposes
- 2 agencies have video cameras in their rail stations and/or associated parking lots

These technologies present an interesting set of opportunities for transit agencies to collect data about their operations. These technologies can be used for collecting real-time data on current vehicle locations and schedule adherence as well as daily ridership and fare data for analyzing demand and revenues. Also, many of the technologies are useful for monitoring security and safety and responding to incidents that happen in the course of transit travel.

Table 4.2-1: Advanced Information Technology Applications

it Agency	Number of vehicles	Electronic farebox	Considering Smart Card or other electronic payment?	AVL / AVI	Traf sigr prior
ıngeles County MTA	1700		Y	Using	Y
Francisco Municipal Railway	1038	Y	Y	Using	Y
ge County Transportation Authority	847	Y	Y	Considering	
ransit	800	Y	Y	Considering	
Area Rapid Transit District	637	Y	Y	Using (Automatic train control system)	
rans	372			Using and Considering another system	
Diego Transit	323	Y	Y	Considering	
en Gate Transit	298	Y	Y	Considering	
Beach Public Transportation	213	Y			
trans	211	Y	Y	Considering	
County Transit District	N/A	Y	Y		
side Transit Agency	141	Y		Using	
erey-Salinas Transit	88	Y	Y		
ı Barbara Metropolitan Transit District	74	Y		Considering	
Vancom of California (Chico)	68				
ena Municipal Bus Lines	55	Y	Y	Using	
ma County Transit	47	Y	Y	Considering	
o Transit	46	Y	Y	Considering	Y
ne Transit Agency	40	Y	Y	Considering	
politan Transit Development Board	38	Y			
ı Vista Transit	36	Y			
eld/Suisun Transit	35		Y		
ern Contra Costa County Transit ority	29				
Luis Obispo Regional Transit Authority	23				
of Napa	17	Y	Y	Using	Y
Valley Transit	12	Y	Y	Considering	
ier Transit	10				
of Corona	9			Considering	
oc Transit	8				
of Auburn	3				

Table 4.2-1: Advanced Information Technology Applications (Continued)

ransit Agency	Number of vehicles	Sensors for passenger detection or counting	Silent alarms	Security
os Angeles County MTA	1700		Y	Video/CCTV in stops and/or stations
an Francisco Municipal Railway	1038		Y	Video/CCTV in stops and/or stations
)range County Transportation Authority	847		Y	
C Transit	800		Y	Video/CCTV monitors in buses
ay Area Rapid Transit District	637			Video/CCTV in parking lots and stations
amtrans	372		Y	
an Diego Transit	323		Y	
olden Gate Transit	298		Y	
ong Beach Public Transportation	213		Y	
)mnitrans	211			
orth County Transit District	N/A		Y	Video/CCTV in stops / stations
iverside Transit Agency	141		Y	
onterey-Salinas Transit	88			
anta Barbara Metropolitan Transit District	74			
TC/ Vancom of California (Chico)	68			
ardena Municipal Bus Lines	55	Y	Y	
onoma County Transit	47		Y	
allejo Transit	46			
unline Transit Agency	40		Y	
etropolitan Transit Development Board	38			Some experimentation with video
hula Vista Transit	36		Y	
airfield/Suisun Transit	35			Video/CCTV monitors in buses
astern Contra Costa County Transit uthority	29			
an Luis Obispo Regional Transit Authority	23			
ity of Napa	17			
imi Valley Transit	12			Video/CCTV monitors in buses
hittier Transit	10			
ity of Corona	9			
ompoc Transit	8			Video/CCTV monitors in buses
ity of Auburn	3			

4.2.2 Site Visit Results

Our site visits fleshed out a number of useful applications of new technology. Below, we describe particular observations in the following technology areas:

- Automatic Vehicle Location (AVL) or Identification (AVI) Systems
- Radio Data Systems
- Electronic Payment Mechanisms
- Customer Information

4.2.2.1 AVL/AVI

An AVL displays the location of vehicles on a computer generated map, allowing an operator to monitor the location of all vehicles more precisely than the current radio and supervisor monitoring. Through the use of an AVL, monitoring driver performance, vehicle condition and location, and schedule adherence can all be assisted directly. The interest in AVL among the agencies we visited was high. Four of the agencies we visited (City of Napa, Los Angeles Metropolitan Transit Authority, Riverside Transit Agency and Sonoma County Transit) have operating AVL systems, and the other agencies visited all were seriously considering or in the process of acquiring AVL systems.

The biggest impediment to acquiring an AVL system is clearly the cost. In response to the high capital costs associated with radio data systems, three of the four transit agencies we visited with AVL (Napa, Riverside and Sonoma) have chosen cellular-based communications systems rather than the more traditional radio data systems. By choosing a cellular-based technology, the transit agencies are able to operate the AVL system, primarily on an exception basis, for about a tenth the price of other communications technologies. The conclusion that can be drawn from the statements above is that a cellular-based AVL system is well suited for small and medium sized agencies because the capital costs will be small and the frequency of polling is low enough to justify the exception-based cellular transmission costs. Large systems would be interested in the more traditional radio systems because the number of vehicles diffuse the large initial capital cost and the enormous number of polls taken each day require little or no marginal transmission cost.

For the transit agencies with AVL the most important reason for having an AVL system was the ability to pinpoint the location of a vehicle in an emergency. Having the exact location of a vehicle can reduce the response time of emergency crews. Many AVL systems thus are linked with on-board silent alarms. Upon activation of the silent alarm, the AVL will begin transmitting location updates frequently and will visually appear on the dispatcher's screen in a noticeable fashion. The location and any future changes can then be radioed directly to supervisors and the authorities instantaneously.

From a reliability of service standpoint, knowing if a vehicle is way behind schedule or "running hot" (ahead of schedule) is important. Automating this function in a central location allows the dispatcher to contact coaches off schedule, find out what is going on, and take appropriate corrective action. The City of Napa was the only agency with an automated schedule adherence capability. On their vehicles, a dashboard readout alerts the driver when the vehicle is off-schedule. The feature is made possible through an on-board computer which contains the day's schedule for the vehicle, and then uses this data throughout the day to compare vehicle locations with the scheduled time points.

A particular problem that two (Riverside Transit Agency and Sonoma County Transit) agencies were having in obtaining schedule adherence data was due to the fact that polling of vehicles occurred at constant time intervals (RTA) or on an as-needed basis (SCT), not regularly at specific timepoints along the route as can be done with on-board vehicle computers connected to the AVL transponder.

The AVL system can also be used as a customer information tool. Should a vehicle be running off schedule, alerting telephone operators or the automated telephone information system can help customers avoid waiting or missing their bus. No agencies are currently employing their AVL for this purpose. On-vehicle information can also be transmitted to customers through an AVL-prompted auto enunciator system. As future American with Disabilities Act (ADA) requirements state that key timepoints, transfer locations and points of interest must be announced, such capabilities of an AVL are sure to be explored.

Finally, an AVL can be linked to fareboxes and passenger counters to give those technologies a geographic component to the data generated. These links have not been made at any of the agencies we visited. However Golden Gate Transit was very interested in exploring this capability, citing it as one of the main reasons for acquiring an AVL system.

4.2.2.2 Radio Data Systems

Communication between drivers and dispatchers is necessary for smooth operation of a transit system. The most common form of communication between the driver and dispatcher is through an audio radio system. Standard two-way radios are far and away the most common type of radio system in operation at the transit agencies we visited. One new technology called the Mobile Data Terminal (MDT) is available to allow transmission of data messages. Three agencies (Riverside Transit Agency, Omnitrans, and San Diego Transit) we visited have this technology operating on their vehicles. The MDT's on the vehicles typically have a thirty-character display and a numeric keypad. The driver can send canned messages to dispatch by pressing a number on the keypad. Dispatchers have the ability to send more complicated messages to all the drivers, to drivers on certain routes, or to a single driver. In general, at each of these three agencies the response to the MDT's has been positive and has helped clear the airwaves of more routine radio traffic.

The agencies that have AVL systems have expressed the desire to link the AVL with their radio systems. As it stands now a dispatcher must ask the computer to locate a calling vehicle. Having the computer automatically locate a calling vehicle would save time for the dispatcher. Knowing the exact location of a calling vehicle can also help the dispatcher make quick decisions. Both the Riverside Transit Agency and the Los Angeles Metropolitan Transportation Authority are in the process of linking their AVL and radio systems.

4.2.2.3 Electronic Fareboxes and Payment Mechanisms

All transit agencies we visited had electronic fareboxes. The common technology was the GFI farebox. The GFI farebox is capable of recognizing different fares by the amount of money deposited into the farebox. Special fares and passes require the driver to hit a button on the farebox which will notify the farebox that a special fare or pass has been paid. The GFI farebox can be probed at the end of the day to obtain ridership and revenue data.

Agencies we visited aggregate the data produced by the farebox to determine ridership per route and fare category. San Diego Transit had their GFI fareboxes linked to the bus odometers to get mileage counts for each bus. As a result, farebox data was used by vehicle maintenance in addition to the usual finance and planning departments. It was clear from our visits that the disaggregated data generated by the fareboxes were not being analyzed, apparently because the data generated by the farebox are in a format which is difficult to interpret at a disaggregate level. To get around this problem the transit agencies aggregate the data in order to get revenue information by route and run, however in the process lose a wealth of information on individual fares. In addition, the GFI farebox is a proprietary system, and as such is not easily linked with other electronics (e.g. AVL systems) on board the transit vehicle. However, out of all the agencies we visited, only Golden Gate Transit mentioned the possible linking of AVL and farebox as a capability they were exploring.

Largely because of the efforts of regional governments, (the Metropolitan Transportation Commission (MTC) in the San Francisco Bay Area and the Southern California Area Governments) many of the transit properties we visited were considering Smart Card or magnetic stripe technology for fare payment. There are two types of fare payment card, stored value and debit card from an account. Most transit agencies are considering the stored value card and not the debit card because the debit card involves the extra hassle of interaction with numerous financial institutions or a central clearinghouse to process fare payments. Smart Cards have the added ability to have other information stored on the card such as fare category, previous fare payment, and information about the card carrier. Magnetic Stripe technology, while having stored value, has only limited data storage capacity.

The MTC has been leading the Translink project which has been testing the magnetic stripe technology in use at Bay Area Rapid Transit (BART) on bus systems. Currently Central Contra Costa Transit Authority and BART Express buses are equipped to handle the Translink cards. Other Bay Area transit agencies we visited have considered magnetic stripe technology in light of the Translink project; however, it appears that this technology is likely to be abandoned in favor of a more sophisticated stored-value card.

In Southern California, Foothill Transit has just implemented a magnetic stripe card in connection with Culver CityBus and Montebello Bus Lines. The LAMTA, RTA and Omnitrans also were considering the Smart Card technology. Omnitrans viewed the rewards of Smart Card technology in a positive light, however, felt that the new fare media must not require passing through a farebox (i.e. it should be a contactless card) and must not complement, but rather replace all other existing fare media. This was deemed necessary to avoid too many diverse fare payment mechanisms.

4.2.2.4 Customer Information Systems

Providing information is a time and labor consuming job, therefore several computer tools have been created to make the job easier. Tools in this regard involve trip itinerary planning systems as well as automated schedule information. We review these two areas below

Trip Itinerary Planning

At all transit agencies a phone operator could be reached for assistance with itinerary and route planning. Riverside Transit Agency and Omnitrans have purchased the use of an itinerary planning program that is commercially available from Commuter Transportation Services (CTS) of Southern California. The software, called Transtar, allows the traveler to specify origin and destination, departure and/or arrival times, and parameters such as the least time in transit or the fewest number of transfers. After having entered this information into the computer for the traveler, the telephone operator receives a listing of transit options. The phone operator can then convey the best (deemed by the computer system) option to the traveler. Additional options can be generated until the traveler finds a transit option they are satisfied with. Also included in the output is fare information, transfer information and a map showing routes and transfer locations. At Riverside, the use of such computerized support tools has shortened the time of training a phone operator from several months down to a day and a half on the Transtar system.

Transtar is very powerful not only because of its itinerary planning capabilities but also because of the tremendous database it has to work from. Although not all transit agencies in Southern California use Transtar, the database does include full transit information from every transit provider in the Los Angeles metropolitan area. Therefore, a transit customer can call Omnitrans for information on a trip to Disneyland in Orange County or a trip to Los Angeles International Airport. San Diego Transit (SDT) has a customer information system that is very similar to Transtar. SDT's system can perform the same itinerary functions as Transtar and provide similar output, but covers only the San Diego metropolitan region.

OCTA has a similar itinerary planning system. OCTA's system was designed by Trapeze UMA and it works directly with Trapeze (the run cutting and scheduling package) when itinerary planning is performed. The system is limited only to OCTA's routes, and thus is unlike Transtar which has complete information on other transit agencies in the whole Southern California region.

Sonoma County Transit, the City of Napa and Golden Gate Transit do not have any advanced computer itinerary planning, relying solely on the telephone operator's knowledge of the service area and service provided. For these agencies, however, more sophisticated itinerary planning is not necessary because they are on the small end of transit operators. Both agencies may benefit if the Bay Area Metropolitan Transportation Commission gets its wish of having a region wide transit database and information hotline.

Automated Access to Schedules

The LAMTA also has a computer itinerary planner called Customer Information Computer System (CICS). However, unlike Transtar or San Diego Transit's itinerary planner, no phone operator is necessary to access the information. The traveler accesses the system directly through a touch-tone phone. The traveler must punch in the street address of both the origin and destination, which for long addresses is a lengthy process. Similar to Transtar, the customer information system contains transit information for all the municipalities in the 5-county area (Los Angeles, Ventura, San Bernardino, Riverside, and Orange); those outside the LAMTA's service area pay a small fee to have their information posted on the CICS. Foothill Transit, a spin off of the LAMTA, is also connected to the CICS for their customer information.

Through our site visit we did not determine whether customers preferred using the automated system. However a prior study of LAMTA's CICS determined that customers preferred getting information from human operators, that they understood the human operators more clearly than the automated responses, and that they made less errors in recording information from the human operators than from the automated responses.[1] But having the system helped reduce the amount of work performed by the customer information department.

San Diego Transit is testing an automated information system that would allow a traveler to input day, time, and route number, and receive a route schedule. The system will not be able to

[1] Emmanuel Le Colletter, Youngbin Yim, and Randolph Hall. Evaluation of the Transit Information System in Southern California. California PATH. August 1993.

perform more complicated itinerary planning, but the system is anticipated to handle 25% of the calls that currently come into customer information. Sonoma County Transit has their bus schedules recorded on the phone company's PressInfo service so that customers can obtain schedule information when the normal customer service department is closed. For ferry boat services, Golden Gate Transit (GGT) has set up a recorded message with the schedule and fare information. Customer information for bus services at GGT is still handled by phone operators, as it is believed that GGT customers prefer speaking with people on the other end of the telephone.

4.2.3 Strategic Role of New Technologies

Our subsequent interviews at different transit agencies suggest a variety of strategies that agencies have to incorporate these new technologies. As suggested by the recent TCRP study (1994), most of the agencies we talked with consider the adoption of these technologies as subservient to the larger mission and business goals of their agency. In these cases, technology advocates have of necessity made strong business cases for the adoption and use of these new technologies.

One salient example from our site visits is Foothill Transit in the greater Los Angeles area. One unique feature of Foothill Transit is that the management and administration, as well as all bus operations, are provided through private contract. This private sector "bottom line" interest means that Foothill's management is very focused on serving customers and providing them the best service possible. Translating this into new technology strategy, management has made the strategic decision not to pursue implementing an AVL system, fearing that such a technology may make bus operators too concerned with being on schedule, rather than taking time to provide a high level of customer service. More recently, Foothill management is promoting a magnetic stripe fare card that may be used at several transit agencies in the Los Angeles area, under the rationale that it improves convenience for Foothill patrons.

On the other hand, several agencies we visited could be classified as "technology opportunists." Intuition suggests that smaller agencies often do not have sufficient resources, and thus cannot make a strong business case, to support the adoption of new information technologies. As a result, they may be willing to experiment with new technologies if a significant opportunity arises. What we discovered in our site visits is that many such agencies have been approached by technology suppliers in California to serve as test sites for AVL systems. These agencies thus receive AVL service at a reduced (or at no) cost, and in turn provide valuable information to the corresponding product supplier. The Riverside Transit Agency is a test site of the Airtouch Teletrac system, Sonoma County Transit is a test site for Trimble Navigation's AVL system with cellular data communications, and the City of Napa is a test site for AVL software and hardware from 3M and another cellular data service provider.

At the same time, these three agencies seemed to be struggling to integrate the AVL technology with the normal function of the organization. Our visits indicated that none of the three sites had a strategic plan for incorporating the new technology into their standard operating procedures. In two of the three sites, the AVL computer and monitor were outside the normal work space of the dispatcher, and at all three sites the AVL was not in use at the time of our visit. This under-utilization of the AVL technology at these sites may be attributed to both a lack of training of operations personnel in the use of the system, coupled with a low need (or low perceived benefit) for computer-assisted location and schedule monitoring capabilities.

4.3 Data Coordination Within Transit Agencies

From the preliminary analysis of electronic data in Section 4.1, it appears that there may be some opportunities for sharing electronic data across functional areas within a transit agency. In this section, we review some of the survey results regarding: 1) the coordination of data collection and maintenance; and, 2) the use of integrated information systems to enhance the management of data, information and communication at each agency. These topics are pursued in the following sections.

4.3.1 Data Collection and Maintenance

Table 4.3-1 shows the functional unit that is responsible for data collection and/or maintenance at each of the transit agencies that responded to the written questionnaire, by type of electronic data. Several interpretations of these results are possible. First, it seems that at many of the larger agencies in California, there is some redundancy in data collection and maintenance. At several larger agencies, routes, schedules, farebox and ridership data are collected and maintained by more than one functional unit. Routes and schedules are often held by operations, service planning and customer information, while farebox and ridership information is also held by operations, service planning, and performance measurement. This suggests that similar types of data are being maintained in different units within the agency, and there may be duplication of effort in these tasks.

Another observation from Table 4.3-1 is that many agencies allocate the data collection and maintenance activities to different functional units, for a particular data type. For example, at some agencies, routing data are collected and maintained by personnel in operations; in other agencies, this task is performed by personnel in service planning. This suggests very different

Table 4.3-1: Functional Area Responsibilities for Data Collection and Maintenance

;jency	Number of Vehicles	Type of Data: Routing Data	Scheduling Data	Farebox Data	Ridership Data	Driver Availability Data	V Ava I
les County MTA	1700	SP	SP		SP	OM	
cisco Municipal Railway	1038	SP	OM SP		OM SP	OM	
ounty Transportation Authority	847	OM SP TI	OM TI	OM SP PM	SP PM	OM	
it	800	N/A	N/A	N/A	N/A	N/A	
Rapid Transit District	637	OM	OM PM TI	Treasury	SP		O
	372		OM SP PM TI		OM SP PM		
) Transit	323	OM	OM	OM	PM	OM	
ate Transit	298	SP	SP	OM SP	SP	OM	
ch Public Transportation	213	SP	SP	PM	SP	OM	
;	211	SP TI	OM SP TI	PM	SP PM		
ınty Transit District	N/A		OM TI	PM	PM TI	OM	
Transit Agency	141	OM	OM	OM	OM		
-Salinas Transit	88	OM	OM	PM	PM		
rbara Metropolitan Transit District	74	SP	SP	SP	SP		
com of California (Chico)	68	N/A	N/A	N/A	N/A	N/A	
Municipal Bus Lines	55	OM PM	SP	OM PM	OM SP PM		
County Transit	47		SP	OM SP	OM SP PM		
ansit	46	OM	OM	OM	OM		
ransit Agency	40		SP	PM	SP PM	OM	
an Transit Development Board	38	OM	OM	OM	OM		
ta Transit	36	OM	OM	OM	OM		
Suisun Transit	35						
Contra Costa County Transit	29						
Obispo Regional Transit Authority	23			OM	OM		
apa	17	OM		OM	OM SP PM		
ey Transit	12		SP	PM	PM	OM	
ransit	10						
orona	9						
Transit	8	OM	OM		OM		
uburn	3	OM	OM	OM	OM		

Key: OM = Operations Management N/A = Not Available
SP = Service Planning
PM = Performance Monitoring
TI = Traveler Information

organizational structures and allocation of responsibilities in this sample of transit agencies.

Particularly at the larger agencies, communication between departments may be further hindered by a number of both technical and institutional barriers. Both our site visits and the literature suggest that the barriers to effective data sharing may include:

- Lack of an electronic (physical) connection between computers in different areas of the agency.
- Differences in data definitions and semantics between different computer applications.
- Significant differences in the use of data that drives its frequency of collection and maintenance.
- Lack of management policies or operating procedures to coordinate information collection and maintenance.
- Lack of vision for the uses and capabilities of existing information systems.

4.3.2 Internal Data Coordination

From the previous discussions, it appears that there may be both opportunities and challenges for use of electronic data, common data bases and data sharing within transit agencies. To follow up these observations, the survey asked respondents whether electronic data appear in a common database, or whether data are maintained in separate data bases. The results are listed in Table 4.3-2. Perhaps most notable in this table is the fact that most of the larger agencies (over 100 vehicles), and even a few of the smaller agencies, are maintaining separate electronic data bases for routes, schedules, ridership, farebox, vehicle and driver availability data. As with the results of Section 4.3.1, this suggests that there may be room for greater coordination of data maintenance within agencies.

Table 4.3-2: Use of Common Data Bases for Operations Data

Agency Name	# of Vehicles	Common or Separate Database for Eac			
		Routing Data	Scheduling Data	Farebox Data	Ridership Dat
Los Angeles Metropolitan Transportation Authority	1700			Separate	Separate
San Francisco Municipal Railway	1038				
Orange County Transportation Authority	847	Common	Common	Common	Separate
AC Transit	800	N/A	N/A	N/A	N/A
Bay Area Rapid Transit District	637		Common		
Samtrans	372		Separate		Separate
San Diego Transit	323	Separate	Common	Common	Common
Golden Gate Transit	298	Separate	Separate	Separate	Separate
Long Beach Public Transportation	213	Separate	Separate	Separate	Separate
Omnitrans	211	Separate	Separate	Separate	Separate
North County Transit District	N/A		Separate	Separate	Separate
Riverside Transit Agency	141	Separate	Common	Common	Common
Monterey-Salinas Transit	88	Common	Common	Common	Common
Santa Barbara Metropolitan Transit District	74	Common	Common	Common	Common
ATC/ Vancom of California (Chico)	68	N/A	N/A	N/A	N/A
Gardena Municipal Bus Lines	55	Common	Common	Common	Common
Sonoma County Transit	47		Separate	Separate	Separate
Vallejo Transit	46	Separate	Separate	Separate	Separate
Sunline Transit Agency	40		Separate	Common	Common
Metropolitan Transit Development Board	38	Common	Common	Common	Common
Chula Vista Transit	36	Common	Common	Common	Common
Fairfield/Suisun Transit	35	Common	Common		Common
Eastern Contra Costa County Transit Authority	29				
San Luis Obispo Regional Transit Authority	23			Common	Common
City of Napa	17				**
Simi Valley Transit	12		Common	Common	Common
Whittier Transit	10				
City of Corona	9				
Lompoc Transit	8	Separate	Separate		Common
City of Auburn	3	Common	Common	Common	Common

** Disk to operations from dispatch

In addition, the questionnaire results also allow us to determine which functional units at each agency are using particular types of electronic data. These responses are listed in Table 4.3-3. There are several points that can be made from this information. First, it appears that the transit agencies in California are using a variety of data to perform functions associated with operations monitoring, service planning, performance measurement and traveler information. For many functions across all of these functional areas, routing and scheduling data appear to be key inputs to making effective decisions. Other data, such as ridership, farebox, and vehicle and driver availability data are also important for monitoring operations, planning service, and measuring system performance.

More importantly, it appears that there may be some opportunities for data sharing across functional areas in many transit agencies. Much of the data in electronic form, including routes,

schedules, farebox and ridership data are used by functions in different functional areas. At larger transit agencies, different departments may exist for operations monitoring, service planning, performance measurement and traveler information. Given these conditions, there seems to be some opportunity for data sharing and common information systems within these transit agencies.

However, from the survey responses, there are mixed results on the use of common or shared data bases. In Table 4.3-3, shading in a particular cell indicates that the electronic data are maintained in a common agency-accessible data base. Of the 12 larger agencies with more than 100 vehicles, a clear majority do not have data in a common data base. The reason for separate data bases in these cases is most likely due to problems in logical or semantic connectivity between applications; i.e., differences in data definitions, formats and structures. For example, the evidence above suggests that routing and scheduling data may be helpful for many different functions, but the form needed for each of those functions may vary. The form of the data needed

Table 4.3-3: Functional Areas Using Electronic Data

Agency Name	Number of Vehicles	Functional Units Using Electronic Data					
		Routing Data	Scheduling Data	Farebox Data	Ridership Data	Driver Availability Data	A
s County MTA	1700	OM TI	OM SP PM TI	OM PM TI	OM SP PM TI	OM TI	
sco Municipal Railway	1038	SP	OM SP PM		SP PM	PM	
unty Transportation Authority	847	SP PM TI	OM SP PM TI	OM SP PM TI	OM SP PM TI	OM PM TI	
	800	N/A	N/A	N/A	N/A	N/A	
apid Transit District	637	OM PM TI	OM SP PM TI	OM PM	OM SP PM		OM
	372		OM SP PM TI		OM SP PM TI		
Transit	323	OM SP PM TI	OM SP PM TI	OM SP PM	OM SP PM	OM SP PM TI	OM
e Transit	298	OM SP PM TI	OM SP PM TI	OM SP PM	OM SP PM TI	OM SP PM TI	OM
Public Transportation	213	OM SP TI	OM SP TI	OM PM TI	OM SP TI	OM	
	211	OM SP PM TI	OM SP PM TI	OM SP PM TI	OM SP PM TI		
ty Transit District	N/A		OM SP PM TI	OM SP PM TI	OM SP PM TI	OM PM	
ransit Agency	141	OM SP PM TI	OM SP TI	OM SP PM TI	OM SP PM		
alinas Transit	88	OM SP PM TI	OM SP PM TI	OM SP PM	SP PM		
ara Metropolitan Transit District	74	OM SP PM	OM SP TI	OM SP PM TI	TI		
om of California (Chico)	68	N/A	N/A	N/A	N/A	N/A	
unicipal Bus Lines	55	OM SP PM TI	OM SP PM TI	OM SP PM	SP PM		
ounty Transit	47		SP PM	OM SP PM	SP PM		
sit	46	OM	OM SP PM TI	OM SP PM	OM SP PM		
nsit Agency	40		OM SP PM TI	OM SP PM TI	OM SP PM TI	OM SP TI	C
Transit Development Board	38						
Transit	36	OM SP TI	OM SP TI	OM SP	OM SP		
isun Transit	35	OM			PM		
ntra Costa County Transit Authority	29						
bispo Regional Transit Authority	23			OM SP PM	OM SP PM		
a	17	OM SP TI		OM SP PM TI	OM SP PM		
Transit	12		OM SP PM TI	OM SP PM	PM	TI	
nsit	10						
ona	9						
ansit	8						
urn	3	OM	OM PM	OM	OM		

Key: OM = Operations Management
SP = Service Planning
PM = Performance Monitoring
TI = Traveler Information

Shading: Data exist in a common agency-accessible data base

N/A = Not Available

for a run-cutting and scheduling software may be different that that needed for customer information, and may differ from formats needed for long-range planning tools such as a GIS or transportation modeling software.

4.3.3 Data Coordination Strategies

In response, some of the larger agencies have developed strategies to integrate data across applications. One strategy, employed with moderate success at OCTA, has been to work directly with software and hardware vendors to create open data exchange across applications. Several applications have already been integrated into a common data model through a single software vendor (UMA Engineering, now Trapeze Software Inc.). OCTA uses Trapeze for fixed-route and Trapeze/QV for paratransit scheduling, run-cutting and crew assignment, and UMA's Customer Information software to provide route and schedule information to phone operators talking with travelers. OCTA uses a local area network (LAN) within the planning department to share data between Trapeze and Trapeze/QV in near real time. Also, a wide area network (WAN), connecting the planning department to the customer information center in a different town, is used to download schedule data to operators, usually once per day. As all three software tools were developed by the same company, the data may be easily shared across applications.

OCTA is also working with other software vendors to enhance data compatibility. OCTA has many applications running under Arc/Info, a geographic information system, and under EMME/2, a transportation modeling package, within the service planning department. Currently, OCTA is working with the makers of Arc/Info so that the spatial data model in

Arc/Info can also support EMME/2 and the UMA scheduling software. In this way, OCTA is leveraging newer hardware and software purchases to achieve data integration across applications.

In contrast to this more technical solution, other transit agencies have used organizational tools to manage existing hardware and software, under more limited resources. As an example, San Diego Transit is leveraging existing hardware and software to enhance technical data integration. The primary engine for data processing at San Diego Transit is an IBM AS/400 mainframe with a large network of local terminals. Direct connections to the mainframe are used in the accounting, administration, transportation, risk management, and purchasing departments. In addition to these typical MIS activities, all operations data is also maintained on the mainframe. The critical element in data coordination at San Diego Transit, however, is the use of other computer systems in other functional areas:

- Operations uses a MicroVAX, with weekly updates of data from the MicroVAX to the IBM mainframe;
- Scheduling and run-cutting software operate on a personal computer (PC) platform, but this data is uploaded to the mainframe once per pick; and,
- The customer information service runs off a network of PCs, downloading the schedule data from the IBM mainframe once per pick.

This level of data coordination, while fairly simple technically, has been achieved through more direct communication between personnel and a clear role of MIS in coordinating this integration. More specifically, the success of data integration at San Diego Transit is due to several organizational factors, including: 1) a clearly articulated data management policy; 2) strong support for MIS at higher levels of management; and, 3) strong business relationships between key staff in each of the affected departments. Nonetheless, maintaining consistent and timely data requires diligence on the part of the MIS and other data processing staff.

Among other medium to large agencies, many have already implemented or are planning to implement LANs to improve data sharing and communication within the agency. Agencies we visited that have already implemented such networks include Riverside and Foothill Transit, while the Los Angeles County MTA and Golden Gate Transit are now developing and installing local networks. At all of the smaller agencies (under 100 vehicles), the survey responses indicate that operations data are typically held in a common data base. From the site visits at Sonoma County Transit and the City of Napa, this “common data base” typically means that the data are kept on a single personal computer or on an agency-wide network. Thus, when data are needed for particular functions, they can be easily retrieved from the computer in electronic form, and local area networks are not considered to be worthwhile investments.

In summary, there appear to be opportunities in the data sharing environment at many transit agencies in California. The survey results suggest there is some data types that are collected and maintained by multiple functional units within several transit agencies. To improve data consistency and to reduce possible duplication of effort in maintaining this information, a common data base or data model may be useful for routes, schedules, farebox and ridership data. Larger agencies seem to be moving toward integrated data systems, but with differing strategies to balance organizational and technical constraints. At agencies such as OCTA, technical software and hardware integration is possible. At agencies with more limited resources such as San Diego Transit, more significant organizational coordination for MIS integration is necessary. Many agencies now implementing agency-wide networks (LANs or other systems) may consider some combination of technical and organizational strategies to facilitate data coordination.

At the same time, it appears that the organizational policies and management approaches are the critical link in affecting the level of data integration. In the examples cited above, OCTA has changed its information technology procurement specifications to get open and compatible software and hardware. This in turn is supported by management goals of reducing unnecessary duplication of data maintenance and processing. The San Diego Transit example, on the other hand, shows that management practices can successfully integrate information systems, even when technical options are severely limited. From these examples and others in our site visits, we may echo the previous research in noting that technology itself is only a tool to enhance data and systems integration. Rather, the key element to achieve this level of integration is the level of management support and dedication to this goal in both procuring and operating the information systems.

4.4 External Coordination (Across Agencies)

A final area of concern in this research is the extent to which data are shared, or at least coordinated, across different transportation-related organizations. The information systems and architectures proposed under ITS suggest a significant amount of data sharing between transit agencies and other organizations (ITS America, 1994a; Sandia, 1994). However, there has not been much investigation of the current state-of-the-practice in this area, with the notable exception of Schweiger (1995). Below we review our findings on similar activities in California, beginning with information sharing with transit-related agencies and then similar arrangements with other transportation management organizations.

4.4.1 Data Sharing with Transit-related Agencies

First, data sharing directly between transit agencies was reported by 15 of the 30 agencies responding to the questionnaire. Typically, much of this information exchange involves sharing printed routes and schedules with other agencies, with the stated intention of coordinating transfers between routes or for customer information. However, site visits and interviews with several agencies suggest that coordination of services is done on an ad-hoc basis, and is often tied to particular passenger comments or complaints. There seems to be minimal data sharing for transfer coordination by any transit agency in California.

Other purposes of information sharing, such as for traveler information or for performance comparison among peer agencies, seems to be relatively rare, done only where institutional relationships between transit agencies are cooperative. Our observations suggest that such data sharing occurs among many of the medium-sized transit agencies (100-500 vehicles), whose operations and ridership may be more sensitive to local coordination, particularly in suburban areas of the state.

Data sharing with other transportation organizations, such as traffic managers and other public agencies, was reported by a small minority of transit agencies in the written survey. Moreover, such data flows are relatively infrequent and often do not involve the use of electronic data. As a result, there is little technical need for physical connectivity between transit agencies and other organizations. The survey results and the majority of site interviews suggest a relatively low perceived need for new information systems to improve the flow of data between transit agencies and other organizations.

However, in the area of customer information and travel planning, there are significant initiatives now under way in both the San Francisco Bay Area and the greater Los Angeles region. In the Bay Area, the Metropolitan Transportation Commission (MTC) is now developing a regional database of transit agency routes, schedules and fares. This would provide travelers with easy access for transit information among the many transit operators in the 9-county MTC area. Moreover, this regional transit data base will be part of the TravInfo operational test, to begin in Spring 1996. In that experiment, the MTC will coordinate real-time dissemination of both transit and traffic information. More specifically, the MTC will oversee a third party contractor who will be responsible for collecting route and schedule data from transit agencies, maintaining that data in a central data base, and disseminating that information to travelers, to the media, and to any value-added information resellers.

Similar arrangements for customer information are also being established in Southern California. At the time of this survey, both the Los Angeles MTA and the non-profit Commuter

Transportation Services (CTS) had developed complementary regional data bases of transit routes and schedules. In both cases, the given organization collects route and schedule data from transit agencies throughout the region and then makes that data available on-line. The CTS system, called Transtar, serves a number of smaller transit agencies primarily outside of Los Angeles County. As examples, both Riverside Transit and Omnitrans provide route and schedule data to the Transtar system; phone operators at these agencies then use computers, connected through a modem to the CTS data base, to query for traveler itineraries. The MTA system (Customer Information Computer System, or CICS), on the other hand, serves most transit operators within Los Angeles County. Besides serving the MTA, smaller agencies such as Foothill Transit are served through modem connections to the CICS.

In Orange County, two projects are currently underway that enhance data coordination between OCTA and local traffic managers. OCTA serves as the regional transportation planning organization for Orange County, and thus has interest in enhancing all modes of travel. Keeping with this goal, OCTA has initiated the TravelTIP project, designed to provide travel information to residents and visitors to Orange County regarding automobile and transit options. Currently, there are several institutions that will provide data for the traveler information data base: the cities of Anaheim, Irvine and Santa Ana; Caltrans District 12; and OCTA. Real-time traffic condition information from these sources would be combined with (at least) static transit route and schedule information in a central data base. This information would then be disseminated to the public through telephone, television, kiosks and perhaps also radio. In addition, OCTA's direct connection to real-time traffic information may also be used to monitor and control on-street transit operations.

OCTA is also conducting the Transit Probe project jointly with Caltrans and the cities of Anaheim and Santa Ana. OCTA will be equipping 43 vehicles on their fleet with a GPS-based AVL system, allowing real-time monitoring of transit service as well as ambient traffic conditions. In this way, the AVL system may provide real-time information on roadway speeds and incidents on a few selected routes. This project provides a demonstration of the utility of a transit-based AVL system for traffic monitoring, and also demonstrates a framework and vision for institutional cooperation and data sharing. Also, the Transit Probe project will dovetail into TravelTIP, providing real-time transit information for the TravelTIP data base.

One clear message from these initiatives is that new information technologies may be a tool to enhance inter-agency data sharing, coordination and communication. The TravelTIP program in Orange County and the TravInfo project in the Bay Area suggest that multi-modal traveler information can be achieved through integrating transit data with real-time traffic surveillance information. Also, OCTA's Transit Probe project may enhance both transit and traffic management strategies through the shared resource of transit AVL data.

At the same time, it appears that the technical tools are indeed subservient to the institutional relationships in achieving system coordination. In Orange County, there is already a strong and healthy relationship between the transit and traffic managers. As a result, the new technologies support and strengthen these institutional relationships. On the other hand, the MTC has had some difficulty in bringing together the transit and traffic managers in the Bay Area, because such institutional relationships are not nearly as strong as in southern California. In spite of the significant technical capabilities promised through the TravInfo and Regional

Transit Data Base projects, the technology does not appear to substitute for stronger direct relationships between institutions.

In addition, two different strategies for external data coordination and cooperation emerge from these examples. For the CTS Transtar system and the MTC TravInfo project, a third party has stepped in to enhance data coordination across agencies. Common elements which seem to favor a third party in these cases include: 1) a lack of any one dominant transit agency in the region; and 2) a perceived need for better coordination of transit services covering diverse traveler origins and destinations; and, 3) a belief that the coordinated transit data base can be developed and operated without public subsidy. On the other hand, OCTA and the Los Angeles MTA have taken direct responsibility for developing the TravelTIP and CICS programs, respectively. Such a strategy seems better suited to these agencies because they are such a dominant transit provider in the geographic region of interest.

4.4.2 Data Sharing With Other Transportation-related Organizations

The external transportation related organization which transit agencies share with the most is the city (19 of 29 transit agencies) and county governments (17 of the 29 agencies). The city and county governments are often subsidizing the transit services and therefore require feedback on performance. These performance indicators include ridership, revenue, and other levels of service as measured by service frequency (from schedules) and geographic coverage (from routes). The transit agencies are also interested in land use and development data, typically held at the government planning offices, that might be useful for service planning and marketing. This data typically includes employment and census data, land use and GIS profiles.

Data sharing with businesses and developers is performed primarily by large-sized transit agencies, with some sharing at medium-sized agencies and very little sharing at small-sized agencies. The data which is exchanged revolves around service forecasts given to developers and businesses in order to encourage future land use and joint development. Other businesses, such as sporting and cultural events, share data for planning special events services. When you look at data sharing with businesses and developers by urban, suburban and rural transit agencies, we see a similar situation as when we break it into size grouping. Urban transit agencies indicated much data sharing with businesses and developers, while suburban transit agencies shared some information and rural transit agencies had almost no data exchange.

One would assume that transit agencies would be involved in data exchange with traffic centers based on their mutual goals of getting people to their destinations in the shortest time possible. With the exception of the OCTA Transit Probe project (still in development), we found that there is very little data exchange between traffic centers and transit agencies. What little sharing there was, occurred at large- and medium- sized transit agencies. The most common data type shared was road closures and construction schedules which the traffic center provided to the transit agency. A couple medium sized transit agencies did indicate that they gave traffic centers route information and future plans. Smaller-sized transit agencies indicated almost no interaction with traffic centers, the only interaction was to receive road closure and detour information.

The final question about data exchange between transit agencies and transportation related organizations was related to the transit agencies data exchange with employer-based rideshare coordinators. Like traffic centers, rideshare coordinators share a common goal with transit agencies, i.e. to transport people in a more efficient manner. What the surveys indicated to us was that large- and medium- sized transit agencies had much more contact with ridesharing agencies than did small-sized transit agencies. The most common data exchange involved routing and scheduling data, primarily for marketing purposes. It was not clear from our surveys, however, the means by which such marketing is done.

In summary, then, it appears that there is relatively little regular exchange of data between transit agencies and other transportation-related organizations. Of particular concern is whether the current lack of communication between transit and traffic management in most parts of the state can continue. As the need for integrated transportation system management grows, this type of communication may be more vital, as suggested by Schweiger (1995). With the considerable abilities of traffic management in the state, this transit connection may more additional attention.

5. Conclusions and Recommendations

The results of Section 4 indicate a number of important insights into the technical and institutional climate for information technologies in California that are highlighted below in Section 5.1. In addition, Section 5.2 gives specific recommendations for Caltrans in facilitating new information technology adoption and use.

5.1 Summary and Conclusions

With the continued rapid development of computer and information technologies, the needs for electronic data and for effective data sharing will likely grow substantially. Among transit agencies in California, there seems to be a large number of both existing and potential applications for information systems and technologies. Technically, many agencies are currently developing new information systems. Most agencies have data in electronic format, and many of the larger agencies are developing agency-wide computer networks to share data more easily. Such networks allow physical connectivity, and may lead to better logical and semantic connectivity as information systems evolve in the future.

At the same time, there are a lot of areas where electronic data are not being used to their fullest potential. Many different functional units are collecting and maintaining their own data, and often this information is not easily physically or logically connected with other important functions at the organization. At many agencies, new APTS-related information technologies are not being fully integrated to the functions and needs of the organization. Technologies such as AVL and integrated fare payment (smart cards or other stored value media) seem to be of high interest, but many agencies have not fully thought through the potential uses and value of these technologies. In addition, route, schedule and ridership data are not frequently shared between operations, service planning, and customer information, especially at the larger agencies in the state.

Nonetheless, sharing information across functional units within the organization seems to be an important objective at many agencies. Many agencies have risen to this challenge by aggressively pursuing data integration across applications, or at least in developing stronger organizational policies and programs to achieve integrated information systems. There seem to be a variety of technical and non-technical approaches to achieve data integration, depending on the level of hardware and software available at each agency and the strength of communication within each organization. Management policies, however, appear to dominate the underlying technical solutions as a means to achieve integration of these information systems.

In addition, new projects in development in the San Francisco Bay Area and in Southern California are bringing transit and traffic management agencies together to share data both for traveler information and improved transportation system management. The TravInfo project in the Bay Area and the TravelTIP project in Orange County represent significant strides in providing both traffic and transit information to the public in a "one-stop-shopping" format. In addition, the Transit Probe project in Orange County may allow both a transit agency (OCTA) and various traffic agencies in the county to share real-time information on traffic conditions on local arterials and freeway segments.

Also, this study has confirmed key elements of success suggested by many previous studies: that integrated information systems are a result of a concerted effort by transit management to use information systems and technologies to enhance the mission of the agency.

The site visits bear out the fact that information systems have been used successfully in California to meet a variety of agency objectives, such as: 1) improving customer service; 2) managing data and information resources more effectively; 3) enhancing communications within a transit agency; and, 4) improving coordination and communications among different transportation organizations. Clearly, more research into effective management strategies for transit information systems is necessary. Nonetheless, many agencies have used new APTS technologies, LAN and WAN systems, and computerized traveler information systems to achieve better customer service and more efficient management.

At the same time, a critical technical issue that seems to emerge from this research is the need for logical and/or semantic compatibility of data. Both the existing literature and this research point to a strong need for an integrated data model to avoid data redundancy and inconsistency and to enhance data sharing for transit applications. Such a data model would facilitate the integration of information systems within transit agencies and would enhance the ability of transit agencies to share data with other (external) organizations in the future.

5.2 Recommendations

Based on these observations, there are several recommendations for Caltrans in facilitating the adoption and effective use of information systems and technologies in California. These are identified and outlined below.

- **Caltrans should re-evaluate its role in facilitating data coordination among transit agencies and between transit and other transportation organizations.**

Under some circumstances, a third party such as Caltrans can play an important role in providing traveler information and in enhancing inter-agency communication and data exchange.

This is especially true in areas of the state where there is only limited interaction between transit agencies, and there is no clear agency to take a leadership role in the adoption and use of new technology. In this regard, Caltrans can continue to provide funding and technical support and, where appropriate, direct management of such inter-agency agreements.

- **With its capabilities in traffic management, Caltrans should sponsor more research and development for the technical integration of transit and traffic management.**

Caltrans should leverage existing projects and activities to improve the coordination of traffic and transit management. Multi-modal traveler information systems like TravInfo and TravelTIP provide a good initial base to develop and implement advanced traveler information systems throughout the state. However, additional coordination in system management is necessary. This will involve the development of technical systems to integrate traffic and transit data for traveler information, as well as traffic and transit management and control systems to manage the transportation system more effectively.

- **Caltrans should facilitate communication between APTS technology developers and transit agencies throughout the state.**

Several transit agencies in the state have already been approached by technology developers in the state about testing new products. California seems to be a real leader in both the testing and adoption of new transit technologies: AVL systems, smart cards, and integrated traveler information systems are all getting a significant start in the state. Moreover, many of these systems are products of industries within California. Caltrans should facilitate greater dialog between transit agencies and various technology development organizations in the state, such as: Project California, the California Alliance for Advanced Transportation Systems (CAATS), Calstart. We might suggest the following example actions:

- Sponsor a session at the Transit California annual meeting on APTS technologies;
- Sponsor a session at the CAATS annual meeting with local implementors doing the presentations; Organize meetings between the CAATS leadership and Caltrans Division of Mass Transit and Transit California.
- Distribute this report and other related PATH cross-cutting surveys in APTS both the technology suppliers as well as the transit agencies in the state.

- **Caltrans should support local agency officials to participate in standards development efforts.**

With the need for technical systems standards highlighted by the efforts of Sandia (1994), the National ITS Architecture (ITS America, 1994a) and the APTS Committee at ITS America (1994b), local transit operators should participate heavily in the development of information and data standards. With the extensive experience with APTS technologies at agencies throughout the state, Caltrans should financially support local information systems professionals to participate in standards development efforts.

- **Caltrans should work with transit agencies in the state to establish dialog between transit operators regarding new information technologies.**

Continually through our research, we were approached by transit agency staff to share results of our study, together with the specific experiences at other agencies. As a major point of contact with the many transit agencies in the state, Caltrans can play a role in setting up information-sharing meetings throughout the state. Such focus groups can serve as opportunities to showcase existing projects, as well as highlight strategic directions in the state. We recommend Caltrans coordinate at least regional meetings (e.g in Northern and Southern California), and perhaps a state-wide meeting, to allow operators to share their experiences with information systems and new APTS technologies. Such activities should work in cooperation with the Caltrans Office of New Technology, the Division of Mass Transit, and Transit California.

6. Appendix A: List of Contacts

The following pages give the contacts, in alphabetical order by transit agency.

Robert Garside, Assitant General Manager - Operations
Alameda-Contra Costa Transit District (AC Transit)
1600 Franklin Street
Oakland CA 94612
510-891-4854

Carol White
Butte County Public Works Department
7 County Center Drive
Oroville CA 95965
916-538-7681

Walter Stringer, Manager of Operations
Caltrain (Joint Powers Board)
P.O. Box 3006
San Carlos CA 94070
415-508-6355

Tom Brush, Operations Manager
Central Contra Costa Transit Authority
2477 Arnold Industrial Way
Concord CA 94520
510-676-1976 x404

Lynn McEnespy, Transportation Coordinator
Chico Area Transit System
City of Chico Transportation
P.O. Box 3420
Chico CA 95927
916-895-4876

David Feinberg, Administrative Assistant
City of Arcadia Dial-A-Ride
City of Arcadia
240 W. Huntigton Drive
Arcadia CA 91007
818-574-5435

Gary Griffenhagen, Transportation Officer
City of Barstow Dial-A-Ride
City of Barstow
220 E. Mountain View
Barstow CA 92311
619-256-3531 x3268

William Gustafson, Transportation Coordi
City of Chula Vista
276 Fourth Avenue
Chula Vista CA 92010
619-691-5260

Daniel Gomez, Transportation Director
City of Commerce
Commerce Transportation Department
2535 Commerce Way
Commerce CA 90040
213-887-4419

Chet Wior
City of Corona
815 W. Sixth Street
Corona, CA 91720
909-279-3521

Kathi Hubert, Deputy City Manager
City of El Cajon
200 E. Main St.
El Cajon CA 92020
619-441-1776

Paula Faust, Administrative Assistant
City of La Mirada
P.O. Box 828
La Mirada CA 90638
310-943-0131

Fred Cavanah, Transportation Director
City of Modesto
P.O. Box 642
Modesto CA 95353
209-577-5298

Celinda Dalgren, Transit Planner
City of Napa
c/o Napa Transit
720 Jackson St.
Napa CA 94558

Mike Harrod
City of Norwalk
12700 Norwalk Blvd.
Norwalk, CA 90650
310-929-2677

Bob Myers
City of Torrance Transit System
20500 Madrona Ave.
Torrance CA 90503
310-618-6266

Mark Wall, Transit Manager
City of Visalia Public Transit
City of Visalia, Transit Division
707 W. Acequia
Visalia, CA 93291
209-738-3305

Susan Chow, Director of Transportation
City of Whittier Transit Department
City of Whittier
13230 Penn Street
Whittier CA 90602
310-945-8260

Steve Cunningham, Deputy Transportation Director
Culver City Municipal Bus Lines
9815 Jefferson Blvd.
Culver City CA 90232
310-202-5731

Geannie Krieg, Marketing and Planning
Eastern Contra Costa County Transit Auth
801 Wilbur Ave
Antioch CA 94509
510-754-6622

Lynnette Donner, Operations Manager
El Dorado Transit Agency
P.O. Box 286
Placerville CA 95667-0286
916-642-4942

Kevin Doughton, Transportation Planner
Fairfield/Suisun Transit System
City of Fairfield
1000 Webster Street, Room 411
Fairfield CA 94533
707-428-7590

Birgip Gabig, Deputy Executive Director
Foothill Transit Zone
100 N. Varranca Ave., Suite 100
West Covina CA 91791
818-967-2274 x226

George Grandison, Operations Manager
Fresno Area Express
2223 G Street
Fresno CA 93706
209-498-4032

Jeff Webster, General Manager
Fresno County Rural Transit Agency
2100 Tulare Street, Suite 619
Fresno CA 93721
209-233-6789

Tom Whittle, Transit Director
Gardena Municipal Bus Lines
City of Gardena
15350 South Van Ness Ave.
Gardena, CA 90249
213-321-0165

Chester Moland, Director of Operations and Planning
Golden Empire Transit District
1830 Golden State Ave.
Bakersfield CA 93301
805-324-9874

Helen Haas, Passenger Relations
Golden Gate Transit
1011 Anderson Dr.
San Rafael CA 94901
415-257-4563

Jerome Kuykendahl, Manager of Service Planning
Golden Gate Transit
1011 Anderson Dr.
San Rafael CA 94901
415-257-4465

Humboldt Transit Authority
133 V Street
Eureka, CA 95501
707-443-0826

Ron Hughes, Transportation Manager
Kings County Area Public Transit Authority
Kings Area Rural Transit (KART)
1400 W. Lacey Blvd.
Hanford CA 93230
209-582-3211 x2690

Nancy Malone, Operations Supervisor
Laguna Beach Transit
City of Laguna Beach
505 Forest Ave.
Laguna Beach CA 92651
714-497-0746

Vic Sood, General Manager
Livermore-Amador Valley Transit Authority
1362 Rutan Court, Suite 100
Livermore CA 94550
510-455-7555

Tracy Powers
Lompoc Transit System
1300 W. Laurel
Lompoc CA 93436
805-736-7666

Dick Stillwell
Long Beach Transit
P.O. Box 731
Long Beach, CA 90801
310-591-8753

Jim Okazaki, Chief of Transit Programs
Los Angeles City Department of Transport
1200 N. Spring St.
Los Angeles CA 90012
213-485-2278

Byron Lee, Executive Assistant
Los Angeles Metropolitan Transportation Authority
425 S. Main St.
Los Angeles CA 90013
213-972-4407

Steve Turner, Manager of Operations
Mendocino Transit Authority
241 Plant Road
Ukiah CA 95482
707-462-5765

Cathi Cole, Operations Manager
Montebello Municipal Bus
3100 S. Greenwood Ave.
Montebello CA 90640
213-887-4600

Doran Barnes, Planner
Monterey-Salinas Transit
1 Ryan Ranch Road
Monterey CA 93940
408-899-2558

Jim Andrew, Interim Transit Manager
Morongo Basin Transit Agency
71747 Twenty Nine Palms Hwy
Twenty Nine Palms CA 92277
619-367-5637

Sherry Bertoli, General Manager
Napa Transit
720 Jackson St.
Napa CA 94558
707-257-9517

Noe Valdez
National City Transit
2100 Hoover Ave.
National City, 91950
619-474-7505

Leslie Blanda, Manager of Service Planning
North San Diego County Transit District
311 S. Tremont
Oceanside CA 92054
619-967-2828

Steve Hartert, Director of Marketing
Omnitrans
1700 W. Fifth Street
San Bernardino CA 92411
909-889-0811 x122

Glenn Campbell, Senior Planner
Orange County Transit District
550 South Main St.
P.O. Box 14184
Orange CA 92613-1584
714-560-5712

Jeff Briltz
Placer County Minibus
City of Auburn
1225 Lincoln Way
Auburn, CA 95603
916-823-4211 x145

George Sparks, Administrator
Pomona Valley Transportation Authority
2120 Foothill Blvd., Suite116
La Verne CA 91750
909-596-7664

Ray Deryee, Operations
Redding Area Bus Authority
760 Parkview Ave
Redding CA 96001
916-225-4174

Frank Baker, Coordinator
Richmond Paratransit
330 25th Street
Richmond, CA 94804
510-307-8030

Cis Leroy, Operations and Planning
Riverside Transit Agency
P.O. Box 59968
Riverside, CA 92517
909-684-0850

Ron Toonen, Transit Operations
Roseville Transit Services
2005 Hilltop Circle
Roseville CA 95678
916-774-5709

Ronald Ahrendt, Scheduling Manager
Sacramento Regional Transit District
P.O. Box 2110
Sacramento CA 95812-2110
916-321-2932

Kendal C. Karnes
San Diego County Transit System
9335 Hazard Way, Suite 104
San Diego CA 92123
619-694-3000

R.A. Murphy
San Diego Transit Corporation
100 16th St.
P.O. Box 2511
San Diego CA 92112
619-238-0100

Langley Powell, CEO
San Diego Trolley
1255 Imperial, Suite 900
San Diego CA 92101
619-595-4949

James T. Gallagher
Assistant General Manager, Operations
San Francisco Bay Area Rapid Transit District
101 8th Street
Oakland, CA 94607
510-464-6060

Kathy Gilbert
San Francisco Municipal Railway
949 Presidio, Room 224
San Francisco, CA 94118
415-923-6252

Tony McCaulay
San Joaquin Regional Transit District
1533 East Lindsay St.
Stockton CA 95205
209-948-5566

Alan Cantrell, CEO
San Luis Obispo Regional Transit Authority
1150 Osos St., Suite 206
San Luis Obispo CA. 93401
805-781-4465

Danny Ours, Operations Manager
San Mateo County Transit District (SamTrans)
1250 San Carlos Ave.
San Carlos CA 94070
415-508-6414

Brad Davis, CEO
Santa Barbara Metropolitan Transit Distric
550 East Cota St.
Santa Barbara CA 93103
805-963-3364

Bill Capps
Santa Clara County Transportation Agency
Service Development
3331 N. First Street, Bldg. B
San Jose, CA 95134-1906
408-321-7059

Ian McFaddan, Operations
Santa Cruz Metropolitan Transit District
1200 River St.
Santa Cruz CA. 95060
408-423-0319

Bobbie Albright, Operations Manager
Santa Maria Area Transit
314 West Cook #7
Santa Maria CA 93454
805-928-5624

George Reynoso
Santa Monica Municipal Bus Lines
1660 7th Street
Santa Monica CA 90401
310-451-5444

Betty Beck, Supervisor
Santa Rosa Transit
555 Stoney Point Road
Santa Rosa CA 95401
707-543-3925

Ray Turpin
Simi Valley Transit
2929 Tapo Canyon Road
Simi Valley CA 93063
805-583-0393

Bryan Albee
Sonoma County Transit
355 West Robles Ave.
Santa Rosa, CA 95407
707-585-7516

Frank Schroder, Scheduling Manager
L.A. County M.T.A.
425 South Main
Los Angeles CA 90013
213-972-6931

Ray Grosclaude, Director of Transportation
Sunline Transit Agency
32-505 Harry Oliver Trail
Thousand Palms CA 92276
619-343-3456

Lauren Mende
Transit Assist Joint Powers Agency
P.O. Box 949
Los Gatos CA 95031
408-395-2010

Guia DelRosario
Vallejo Transit System
1850 Broadway
Vallejo CA 94589
707-648-4666

Martie Dote, Senior Planner
Yolo County Transit Authority
1495 East Street, Suite A
Woodland CA 95776
916-661-0816

Darlene Fuller, Director of Transit Operati
South Coast Area Transit
P.O. Box 1146
Oxnard CA 93032
805-487-4222

Thomas Larwin, CEO
Strand Express Agency
1255 Imperial Ave, Suite 1000
San Diego CA 92101
619-231-1466

Ron Myers, Transportation Analyst
City of Thousand Oaks
2100 Thousand Oaks Blvd.
Thousand Oaks CA 91362
805-449-2100

Wilson Lee
Union City Transportation
34009 Alvarado-Niles Road
Union City, CA 94587
510-471-3232 x409

Charles Anderson, CEO
Western Contra Costa Transit Authority
601 Walter Ave
Pinole CA 94564
510-724-3331

Keith Martin, Transit Manager
Yuba City Transit Agency
1612 Poole Blvd.
Yuba City CA 95993
916-674-7882

7. Appendix B: Survey Instrument

<u>Transit Operations Data and Information Survey</u>

We are conducting a survey of the operations data and information needs of transit agencies within California. In this survey, we focus specifically on the data and information that is needed for day-to-day operation and longer-term service planning for each transit agency. This survey is intended to supply a much-needed inventory of the current state of practice in California and to assist in identifying ways of improving data collection and use.

Throughout the survey, we will refer to operations data/information as quantitative information in the following categories:

- **Routing data**: descriptions of a physical route and corresponding locations of terminals, garages, and intermediate stops; e.g. road names, addresses and distances, maps and other geographic referencing tools, network representation using links and nodes, etc.

- **Scheduling data**: descriptions of expected and actual travel times on particular routes or portions of a route; e.g. printed schedules (or timetables) for the public, network representations of travel times for various links, etc. This may also include descriptions of the fare charged for travel on particular routes (e.g., fare tables).

- **Farebox data**: description of revenues collected by route, by stop, or by particular groups of people; e.g. revenue by route or by stop/station, etc.

- **Driver availability data**: descriptions of crew schedules, assignment of shifts to each driver, and records of each person's daily and long-term absenteeism and driving record.

- **Vehicle availability data**: descriptions of vehicle schedules, assignment of runs to particular vehicles, and records of each vehicle's condition and maintenance log.

- **Ridership data**: records of unlinked and linked trips on routes, vehicle loads, passenger origins and destinations; e.g. on/off counts, passenger trip origin and destination, etc.

- **Accident data**: descriptions of incidents involving fatalities, injuries, and property damage accidents.

- **Crime data**: descriptions of crime-related incidents both on board the vehicle and in stations, stops, or parking areas.

- **Traffic condition information**: descriptions of traffic bottlenecks, planned and un-planned road work or other special events, non-transit-reated accidents, and other congestion information.

We are interested in learning how your organization collects this data and how it may be used within the transit agency. For this survey, we have focused on the following areas where this data could be used:

1. Operations monitoring
2. Service planning
3. Performance measurement and reporting
4. Traveler information

Our survey has a “General Information” section, followed by a more detailed section in each of these four areas.

We are also interested in learning whether you may be receiving (or interested in receiving) similar types of data from other organizations, such as: other transit agencies, carpool and vanpool organizations, other para-transit agencies, traffic managers, and emergency service providers (fire, police, etc.). Please answer the following questions to the best of your knowledge; if they do not apply to your agency, simply write NA in response. If the answers to any question vary by the type of service (e.g. fixed-route versus demand-responsive) or by mode (e.g. bus versus rail), please indicate these differences in your answers as much as possible.

Thanks for your prompt completion of this survey. We will be happy to share the survey results and common experiences and observations with you, most likely during the late spring of 1995. Thank you again for your help!

Background Questions

Agency Name : ____
Address: ____
____
____
Phone Number: ____
Fax Number: ____
Number of vehicles by Mode: (enter 0 or NA if mode is not operated)

_____ Bus
_____ Contracted Bus
_____ Trolley Bus
_____ Light Rail
_____ Commuter Rail
_____ Heavy Rail
_____ Paratransit
_____ Contracted Paratransit
_____ Other: _____________________

Total Number of Employees:______

Respondents of Sections (If all the same, fill in name and title for General Questions only)

General Questions:
Name and Title:____
Operations Monitoring:
Name and Title:____
Service Planning:
Name and Title:____
Performance measurement and reporting:
Name and Title:____
Traveler Information:
Name and Title:____

General Questions

1.) Which functional areas are responsible for collecting and maintaining the listed operations data? (Check all that apply)

	Operations Monitoring	Service Planning	Performance Measurement	Traveler Info
Routing Data:	______	______	______	______
Scheduling Data:	______	______	______	______
Farebox Data:	______	______	______	______
Driver Availability Data:	______	______	______	______
Vehicle Availability Data:	______	______	______	______
Ridership Data:	______	______	______	______
Accident Data:	______	______	______	______
Crime Data:	______	______	______	______
Traffic Information:	______	______	______	______
Other:____________	______	______	______	______

2.) How does your agency collect the operations data (If using an automatic system please note the technology and supplier)?

- Routing Data:
  Manually?(Y/N):_______How?____
  How frequently? __Continuously __Daily __Weekly __Monthly __Annually __Other:_______

  Automatically? (Y/N):_______
  Technology?____
  How frequently? __Continuously __Daily __Weekly __Monthly __Annually __Other:_______

- Scheduling Data:
  Manually?(Y/N):_______How?____
  How frequently? __Continuously __Daily __Weekly __Monthly __Annually __Other:_______

  Automatically? (Y/N):_______
  Technology?____
  How frequently? __Continuously __Daily __Weekly __Monthly __Annually __Other:_______

- Farebox Data:
  Manually?(Y/N):_______How?____
  How frequently? __Continuously __Daily __Weekly __Monthly __Annually __Other:_______

  Automatically? (Y/N):_______
  Technology?____
  How frequently? __Continuously __Daily __Weekly __Monthly __Annually __Other:_______

- Driver Availability Data:
  Manually?(Y/N):_______How?____
  How frequently? __Continuously __Daily __Weekly __Monthly __Annually __Other:_______

  Automatically? (Y/N):_______
  Technology?____
  How frequently? __Continuously __Daily __Weekly __Monthly __Annually __Other:_______

- Vehicle Availability Data:
  Manually?(Y/N):________How?____
  How frequently? __Continuously __Daily __Weekly __Monthly __Annually __Other:________

  Automatically? (Y/N):________
  Technology?____
  How frequently? __Continuously __Daily __Weekly __Monthly __Annually __Other:________

- Ridership Data:
  Manually?(Y/N):________How?____
  How frequently? __Continuously __Daily __Weekly __Monthly __Annually __Other:________

  Automatically? (Y/N):________
  Technology?____
  How frequently? __Continuously __Daily __Weekly __Monthly __Annually __Other:________

- Accident Data:
  Manually?(Y/N):________How?____
  How frequently? __Continuously __Daily __Weekly __Monthly __Annually __Other:________

  Automatically? (Y/N):________
  Technology?____
  How frequently? __Continuously __Daily __Weekly __Monthly __Annually __Other:________

- Crime Data:
  Manually?(Y/N):________How?____
  How frequently? __Continuously __Daily __Weekly __Monthly __Annually __Other:________

  Automatically? (Y/N):________
  Technology?____
  How frequently? __Continuously __Daily __Weekly __Monthly __Annually __Other:________

- Traffic Condition Information:
  Manually?(Y/N):________How?____
  How frequently? __Continuously __Daily __Weekly __Monthly __Annually __Other:________

  Automatically? (Y/N):________
  Technology?____
  How frequently? __Continuously __Daily __Weekly __Monthly __Annually __Other:________

- Other: _________________
  Manually?(Y/N):________How?____
  How frequently? __Continuously __Daily __Weekly __Monthly __Annually __Other:________

  Automatically? (Y/N):________
  Technology?____
  How frequently? __Continuously __Daily __Weekly __Monthly __Annually __Other:________

3.) How is operations data stored and maintained at your agency? (Check all that apply)

- Routing Data:
  __Electronic form __Paper ___Both __Not kept __Other:________________
  If the data is in electronic form, what software is used?________________________________
  If the data is in electronic form, how often is the data updated?__________________________

- Scheduling Data:
  __Electronic form __Paper ___Both __Not kept __Other:________________
  If the data is in electronic form, what software is used?________________________________
  If the data is in electronic form, how often is the data updated?__________________________

- Farebox Data:
  __Electronic form __Paper ___Both __Not kept __Other:________________
  If the data is in electronic form, what software is used?________________________________
  If the data is in electronic form, how often is the data updated?__________________________

- Driver Avaliability Data:
  __Electronic form __Paper ___Both __Not kept __Other:________________
  If the data is in electronic form, what software is used?________________________________
  If the data is in electronic form, how often is the data updated?__________________________

- Vehicle Availability Data:
  __Electronic form __Paper ___Both __Not kept __Other:________________
  If the data is in electronic form, what software is used?________________________________
  If the data is in electronic form, how often is the data updated?__________________________

- Ridership Data:
  __Electronic form __Paper ___Both __Not kept __Other:________________
  If the data is in electronic form, what software is used?________________________________
  If the data is in electronic form, how often is the data updated?__________________________

- Accident Data:
  __Electronic form __Paper ___Both __Not kept __Other:________________
  If the data is in electronic form, what software is used?________________________________
  If the data is in electronic form, how often is the data updated?__________________________

- Crime Data:
  __Electronic form __Paper ___Both __Not kept __Other:________________
  If the data is in electronic form, what software is used?________________________________
  If the data is in electronic form, how often is the data updated?__________________________

- Traffic Condition Information:
  __Electronic form __Paper ___Both __Not kept __Other:________________
  If the data is in electronic form, what software is used?________________________________
  If the data is in electronic form, how often is the data updated?__________________________

4.) For the data types listed above that are used by more than one functional area, is the information contained in a common agency-wide database or does each functional area maintain a separate database?

	Common	Separate	Other (describe)
Routing Data:	______	______	__________________________
Scheduling Data:	______	______	__________________________
Farebox Data:	______	______	__________________________
Driver Availability Data:	______	______	__________________________
Vehicle Availability Data:	______	______	__________________________
Ridership Data:	______	______	__________________________
Accident Data:	______	______	__________________________
Crime Data:	______	______	__________________________
Traffic Condition Info:	______	______	__________________________

5.) Does your agency share operations data with other local or regional transit agencies?

Yes / No (If No, Proceed to question 9.)

6.) If you do share operations data with other transit agencies, what operations data do you share?

	Information Given	To Which Transit Agencies
Routing Data:	Yes / No	______________________________
Scheduling Data:	Yes / No	______________________________
Farebox Data:	Yes / No	______________________________
Ridership Data:	Yes / No	______________________________
Other: _________________	Yes / No	______________________________

	Information Received	From Which Transit Agencies
Routing Data:	Yes / No	______________________________
Scheduling Data:	Yes / No	______________________________
Farebox Data:	Yes / No	______________________________
Ridership Data:	Yes / No	______________________________
Other: _________________	Yes / No	______________________________

7.) Is there any operations data that you do not currently receive but would like to receive from other transit agencies?

Yes / No (If No, Proceed to question 9.)

8.) If yes, what operations data would you like to receive and from what particular transit agencies?

Data:	Agency:
____________________	________________________________
____________________	________________________________
____________________	________________________________
____________________	________________________________
____________________	________________________________

9.) Does your agency share operations data with other transportation-oriented organizations?

	Gives Information	Receives Information
Local Government:	Yes / No	Yes / No
County Government:	Yes / No	Yes / No
Businesses:	Yes / No	Yes / No
Developers:	Yes / No	Yes / No
Traffic Control Centers:	Yes / No	Yes / No
Rideshare Coordinators:	Yes / No	Yes / No
Other: _______________	Yes / No	Yes / No

10.) If you share or receive operations data with local or county government, which offices do you exchange operations data with, what data is shared, and how is the data used within your agency? (E.g. geographic and census information)

Office:	Data:	Use:
__________	________________	____________________________
__________	________________	____________________________
__________	________________	____________________________
__________	________________	____________________________

11.) If you share or receive operations information with businesses or developers, which businesses or developers do you share with, what operations data is shared, and how is the information you receive used within your agency?

Business:	Data:	Use:
___________	___________________	__________________________________
___________	___________________	__________________________________
___________	___________________	__________________________________
___________	___________________	__________________________________
___________	___________________	__________________________________

12.) If you share or receive operations information with traffic control centers, what operations data is shared, and how is the data used within your agency? (E.g. current traffic conditions, planned road work)

Data:	Use:
________________	____
________________	____
________________	____
________________	____

13.) How do you learn about special events and road closures?

___ Call to/from state or local transportation officials
___ Radio
___ Drivers/Route Supervisors
___ Other (please describe:) ____________________________

14.) If you share or receive operations information with rideshare coordinators, what operations data is shared, and how is the data used within your agency?

Coordinator:	Data:	Use:
___________	___________________	__________________________________
___________	___________________	__________________________________
___________	___________________	__________________________________
___________	___________________	__________________________________

Operations Monitoring

15.) What data is used to perform each of the following operations monitoring functions? Indicate all that apply using the letters from below, or NA if none apply.

1. Monitoring driver performance:________
2. Monitoring vehicle condition:________
3. Monitoring vehicle location:________
4. Monitoring vehicle schedule adherence:________
5. Providing information to driver:________
6. Scheduling and routing to accommodate service requests (demand-responsive service): ________
7. Dispatching vehicles (demand-responsive service) :________
8. Directing on-route operations (demand-responsive service) :________
9. Dispatching vehicles (fixed-route service) :________
10. Directing on-route operations (fixed-route service) :________
11. Monitoring passenger loads:________
12. Monitoring fare collection activities:________
13. Monitoring in-vehicle security/safety:________
14. Monitoring off-vehicle security/safety (stops/stations) :________
15. Monitoring local traffic conditions:________

Information types:
A = Routing data
B = Scheduling data
C = Farebox data
D = Driver availability data
E = Vehicle availability data
F = Ridership data
G = Accident data
H = Crime data
I = Traffic information
J = Other:____

16.) Does your agency have an electronic farebox system on line?

Yes \ No (Skip to question #18)

If yes, on what modes? ______________________________

17.) What operations information is being generated by the electronic farebox?

___ Passenger loads by Route or by Stop/Station
___ Fare revenues by Route or by Stop/Station
___ Other: ____________________________

18.) Has your agency considered a Smart Card or other electronic payment technologies?

Yes \ No (Skip to question #20)

If yes, on what modes? ____________________________

19.) If your agency has considered or are converting to Smart Card or similar electronic fare payment technology, what operations data do you expect to be generated by the new technology?

___ Passenger loads by Route or by Stop/Station
___ Fare revenues by Route or by Stop/Station
___ Other: ___________________________

20.) What type of capabilities are you currently using for passenger safety monitoring?

___ Video/CCTV monitors in buses
___ Video/CCTV in bus stops and/or stations
___ None
___ Other: ______________________

If yes, on what modes? ____________________________

21.) Are there silent alarms ("panic buttons") for drivers on some or all of the vehicles?

Yes \ No

If yes, on what modes? ____________________________

22.) Which part of your agency receives emergency calls from drivers?

____

23.) How are emergency calls passed on to the appropriate agencies (police, etc.)?

____

____

____

24.) Are you using or considering using an Automatic Vehicle Location (AVL) or identification (AVI) system?

___ Using AVL/AVI (See question 25)
___ Considering AVL/AVI (Skip to question 26)
___ Not using or considering AVL/AVI (Skip to question 27)

What modes are using or considering AVL/AVI? ___________________________

25.) If you are using an AVL/AVI system, which technology are you using?

___ Signpost
___ GPS
___ Dead Reckoning
___ Other:______________________________ (Skip to question 27)

26.) If you are considering using an AVL/AVI system, which technology are you looking into, or have decided on?

Looking Into	Decided On	
___	___	Signpost
___	___	GPS
___	___	Dead-Reckoning
___	___	Other:___________________________

27.) What communication technology between vehicles and the operations center are you using? (E.g. Trunked Radio, Standard two-way radio, etc.)

____

____

28.) Does your agency have equipment in vehicles and along routes to allow traffic-signal pre-emption or priority?

___ Yes
___ No, but we have looked at the idea or are currently examining this capability
___ No, and we have not investigated this capability at all

If yes, on what modes? ___________________________

29.) Do your agency's vehicles have sensors for passenger detection or passenger counting?

___ Yes
___ No, but we have looked at the idea or are currently examining this capability
___ No, and we have not investigated this capability at all

If yes, on what modes? ___________________________

30.) Is a Geographic Information System (GIS) used for real-time operations monitoring?

___ Yes
___ No, but we have looked at the idea or are currently examining this capability
___ No, and we have not investigated this capability at all

If yes, what software is used? ______________________

We now refer to your answers given for questions (5)-(14) on operations data you may receive from other transportation agencies. Please refer to those answers when filling out questions 31 and 32.

31.) For each of the information types listed that you receive from other transit agencies, in what ways do Operations Monitoring use them?

Routing Data:____

____

Scheduling Data:____

____

Farebox Data:____

____

Ridership Data:____

____

Other:___________: ____

____

32.) For the listed data types, how important is shared operations data (from other transit agencies only) to Operations Monitoring?

Routing Data:
Very Helpful 5 4 3 2 1 Slightly HelpfulN/A

Scheduling Data:
Very Helpful 5 4 3 2 1 Slightly HelpfulN/A

Farebox Data:
Very Helpful 5 4 3 2 1 Slightly HelpfulN/A

Ridership Data:
Very Helpful 5 4 3 2 1 Slightly HelpfulN/A

Other: ______________________________
Very Helpful 5 4 3 2 1 Slightly HelpfulN/A

Service Planning

33.) What information is used to perform each of the following service planning functions? Indicate all that apply using the letters from below, or NA if none apply.

1. Generating and analyzing schedule adherence data: ________
2. Generating and analyzing fare data: _______
3. Generating and analyzing passenger loads: _______
4. Generating and analyzing driver performance: _______
5. Generating and analyzing vehicle condition: _______
6. Generating and modifying routes and stop locations: _______
7. Generating and modifying route schedules: _______
8. Generating and modifying vehicle schedules: _______
9. Generating and modifying crew schedules: _______
10. Analyzing demographic trends: _______
11. Monitoring overall traffic patterns and transportation system performance: _______

Information types:
A = Routing data
B = Scheduling data
C = Farebox data
D = Driver availability data
E = Vehicle availability data
F = Ridership data
G = Accident data
H = Crime data
I = Traffic information
J = Other:____________________________________

34.) Do you use software for developing route or other service timetables?

Yes / No

If yes, what software is used? _______________________________

35.) What data are used for developing timetables? (e.g. network travel times, desired headways, etc.)?

____

____

36.) What data are used for the placement of bus stops? (e.g. demographic data, existing ridership data, physical route descriptions, etc.)

____

____

____

37.) Does your agency support fixed-route service, demand-responsive service, or do you support both?

__ Fixed-Route
__ Demand Responsive
__ Both

38.) What software is being used for vehicle and crew scheduling (If Any)?

Fixed-Route:_______________________________
Demand-Responsive:__________________________

39.) Does your agency have flat fares, graduated fares, or zonal fares?

__ Flat	Modes:____________________
__ Graduated	Modes:____________________
__ Zonal	Modes:____________________
__ Other:__________	Modes:____________________

40.) Does Service Planning use a Geographic Information System (GIS)?

___ Yes
___ No, but we have looked at the idea or are currently examining this capability
___ No, and we have not investigated this capability at all

If yes, what software is used? ________________________________

We now refer to your answers given for questions (5)-(14) on operations data you may receive from other transportation agencies. Please refer to those answers when filling out questions 41 and 42.

41.) For each of the information types listed that you receive from other transit agencies, in what ways does Service Planning use them?

Route Information:____

____

Schedule Information:____

____

Farebox Information:____

____

Ridership Information:____

____

Other:__________ ____

____

42.) For the listed data types, how important is shared operations data (from other transit agencies only) to Service Planning?

Routing Data:

Very Helpful	5	4	3	2	1	Slightly Helpful	N/A

Scheduling Data:

Very Helpful	5	4	3	2	1	Slightly Helpful	N/A

Farebox Data:

Very Helpful	5	4	3	2	1	Slightly Helpful	N/A

Ridership Data:

Very Helpful	5	4	3	2	1	Slightly Helpful	N/A

Other: ____________________________

Very Helpful	5	4	3	2	1	Slightly Helpful	N/A

Performance measurement and reporting

43.) How does your agency put together Section 15 data for each of the given data categories? (Skip to question 44 if not applicable)

Route Data:
__Electronic form __Paper __Both__Other:________________________

Schedule Data:
__Electronic form __Paper __Both__Other:________________________

Farebox Data:
__Electronic form __Paper __Both__Other:________________________

Ridership Data:
__Electronic form __Paper __Both__Other:________________________

Accident Data:
__Electronic form __Paper __Both__Other:________________________

Crime Data:
__Electronic form __Paper __Both__Other:________________________

44.) What information is used to perform each of the following performance measurement and reporting functions? Indicate all that apply using the letters from below, or NA if none apply.

1. Generating and analyzing single day or day-to-day performance measures: ________
2. Generating and analyzing weekly and/or monthly performance measures: _________
3. Generating and analyzing long-term performance measures: ________
4. Generating and analyzing Section 15 data: ________

Information types:
A = Routing data
B = Scheduling data
C = Farebox data
D = Driver availability data
E = Vehicle availability data
F = Ridership data
G = Accident data
H = Crime data
I = Traffic information
J = Other:____________________________________

45.) Does Performance Measurement and Reporting use a Geographic Information System (GIS)?

___ Yes
___ No, but we have looked at the idea or are currently examining this capability
___ No, and we have not investigated this capability at all

If yes, what software is used? ______________________________________

We now refer to your answers given for questions (5)-(14) on operations data you may receive from other transportation agencies. Please refer to those answers when filling out questions 46 and 47.

46.) For each of the information types listed that you receive from other transit agencies, in what ways does Performance Measurement and Reporting use them?

Route Information:____

____

Schedule Information:____

____

Farebox Information:____

____

Ridership Information:____

____

Other:___________: ____

____

47.) For the listed data types, how important is shared operations data (from other transit agencies only) to Performance Measurement and Reporting?

Routing Data:

Very Helpful 5 4 3 2 1 Slightly Helpful N/A

Scheduling Data:

Very Helpful 5 4 3 2 1 Slightly Helpful N/A

Farebox Data:

Very Helpful 5 4 3 2 1 Slightly Helpful N/A

Ridership Data:

Very Helpful 5 4 3 2 1 Slightly Helpful N/A

Other: ______________________________

Very Helpful 5 4 3 2 1 Slightly Helpful N/A

Traveler Information

48.) What information is used to perform each of the following traveler information functions? Indicate all that apply using the letters from below, or NA if none apply.

1. Monitoring and responding to passenger comments and complaints: _________
2. Disseminating routes and schedules information: ________
3. Disseminating real-time vehicle and route status: ________
4. Disseminating fare information: ________
5. Disseminating ADA-required mobility information: ________
6. Receiving incoming service requests (demand-responsive service): _________

Information types:
A = Routing data
B = Scheduling data
C = Farebox data
D = Driver availability data
E = Vehicle availability data
F = Ridership data
G = Accident data
H = Crime data
I = Traffic information
J = Other:_____________________________________

49.) Please check all the listed passenger information capabilities that your agency has?

___ Printed routes and schedules
___ Phone service to an operator
___ Phone access to automated, menu-driven information
___ Kiosks
___ In-Station message displays
___ On-board message displays
___ Other: ____________________________

50.) Is new information disseminated to these areas manually or automatically (i.e. electronically)?

- Printed routes and schedules
  Manually?(Y/N):________How Frequently?____
  Automatically? (Y/N):_______ How Frequently?____
- Phone service to an operator
  Manually?(Y/N):________How Frequently?____
  Automatically? (Y/N):_______ How Frequently?____
- Phone service to automated information
  Manually?(Y/N):________How Frequently?____
  Automatically? (Y/N):_______ How Frequently?____

- Kiosks
  Manually?(Y/N):________How Frequently?____
  Automatically? (Y/N):________ How
  Frequently?____

- In-Station message displays
  Manually?(Y/N):________How Frequently?____
  Automatically? (Y/N):________ How
  Frequently?____

- On-board message displays
  Manually?(Y/N):________How Frequently?____
  Automatically? (Y/N):________ How
  Frequently?____

- Other: _________
  Manually?(Y/N):________How Frequently?____
  Automatically? (Y/N):________ How
  Frequently?____

51.) Does Traveler Information use a Geographic Information System (GIS)?

___ Yes
___ No, but we have looked at the idea or are currently examining this capability
___ No, and we have not investigated this capability at all

If yes, what software is used? ____

We now refer to your answers given for questions (5)-(14) on operations data you may receive from other transportation agencies. Please refer to those answers when filling out questions 52 and 53.

52.) For each of the information types listed that you receive from other transit agencies, in what ways does Traveler Information use them?

Route Information:____

____

Schedule Information:____

____

Farebox Information:____

____

Ridership Information:____

____

Other:____________: ____

____

53.) For the listed data types, how important is shared operations data (from other transit agencies only) to Traveler Information?

Routing Data:

Very Helpful	5	4	3	2	1	Slightly Helpful	N/A

Scheduling Data:

Very Helpful	5	4	3	2	1	Slightly Helpful	N/A

Farebox Data:

Very Helpful	5	4	3	2	1	Slightly Helpful	N/A

Ridership Data:

Very Helpful	5	4	3	2	1	Slightly Helpful	N/A

Other: ______________________________

Very Helpful	5	4	3	2	1	Slightly Helpful	N/A

8. Appendix C: Descriptions of Site Visits

The following pages provide a summary of each of the site visits, in chronological order:

- Golden Gate Transit
- Sonoma County Transit
- Los Angeles County Metropolitan Transportation Authority
- San Diego Transit
- Omnitrans
- Riverside Transit Agency
- The City of Napa and Napa Valley Transit
- Orange County Transportation Authority
- Foothill Transit

Summary of Visit to Golden Gate Transit

We visited Golden Gate Transit on March 31, 1995 to follow up on the survey they returned as part of this project. We had initially contacted Alan Zahradnik, a Senior Planner at Golden Gate Transit who filled out our survey, about the visit. He arranged for a meeting at the main offices in San Rafael, and brought together a large group of people for our meeting. We estimate that about 15-20 people participated in the meeting, but on a more rotating basis, so that there was generally no more than about a dozen Golden Gate people in the room at any one time. The meeting began about 1:30 p.m. and lasted until about 3:15. What follows is a more or less chronological accounting of the discussion; fortunately, this proved to be a reasonably well-structured meeting.

Operations

We began by discussing real-time operations monitoring. Communication between the operations center and buses is done primarily on an exception basis, with most exceptions involving significant traffic tie-ups over the Golden Gate Bridge or on Highway 101. The buses generally are running pretty close to on time otherwise, and passenger safety and security are a very rare problem at this agency. Thus, even though the agency has silent alarms on the buses, most of the alarms that do come in are false alarms, e.g. when the driver accidentally bumps the switch.

There are no graphical displays or other similar tools to help the staff at the operations center; most of the time they just work with paper maps and run sheets. Because service reliability is pretty good, there is not much need for significant real-time monitoring or for real-time control actions. At times, buses will hold at time points or at the four transfer centers in the network, but these are generally initiated by the drivers themselves or by supervisors in the field (i.e. not by people at the operations center).

Golden Gate has considered the use of an AVL system, but not really for the purposes of operations monitoring. With the high level of service reliability, the people at the operations center "basically know where the buses are." An AVL system would be used locally on the bus, simply to record locations associated with fare payment in the electronic farebox system.

Service Planning

Service planning at Golden Gate is, at least in their opinion, under-valued. This is because the fixed-route service is generally aimed at commuters into and out of San Francisco, and the geography of Marin and Sonoma counties largely defines routes, or at least key travel corridors. This limits the opportunity for significant route and schedule changes, and the service has not changed all that much in the 20 years of the agency. Currently, service is not really changing much in Marin county, but is struggling to match some significant growth of population and employment into Sonoma county.

[As a note, there are some HOV lanes and park and ride lots along Highway 101; however, these are operated and maintained by Caltrans. We got the sense through the discussion that relations between Golden Gate and Caltrans are not very cordial.]

Much of the data that originates in service planning is in spreadsheets - e.g. routes, schedules, vehicle runs, etc. Simple spreadsheet models are used to generate schedules and vehicle runs. For the most part, information from service planning is disseminated on paper, not electronically. The exception would be the schedules themselves, which are often relayed to other units, or other organizations (e.g. the MTC), electronically.

Service measures, such as ridership, headways, and schedule adherence, are collected using traffic checkers on each route. These checks are done weekly for the heavily-traveled routes and quarterly for the less popular routes. The MTC has also recently audited Golden Gate and had them institute a program for checking bus on-time performance. This requires additional checkers at designated time points on a quarterly basis.

Ridership counts are used for compiling Section 15 data; these are also supplemented by information from on-board surveys and checkers on vehicles to do origin-destination counts. A policy that has been instituted since the beginning of Golden Gate's bus service is that drivers must record the fare type and county of origin for each boarding passenger. This is manually input to an electronic farebox next to the driver on the bus.

Golden Gate Transit does maintain a GIS, containing bus stops and routes, primarily for maintenance and engineering. It is also used by service planning to assess potential new transit markets. This is done by geo-coding responses to the ferry and bus on-board surveys, and through license plate matching of drivers traveling over the bridge. The origins of these potential travelers are mapped in the GIS, allowing service planning to examine bus routes to best match these markets.

<u>Customer Information</u>

There are a number of means of getting information to customers at Golden Gate. There are kiosks in the 4 main transfer centers and at the ferry terminals (Larkspur and San Francisco); these are complemented by printed material. There are also a bus stop signs throughout the service area, although these generally do not have a whole lot of information: most just have a route number and a phone number for more information, but some have the approximate bus headway as well.

Beside the usual printed routes and schedules, the main effort in customer information is a bank of telephone operators. Golden Gate has 14 operators that work from 6 a.m. to 9 p.m., disseminating information from printed routes and schedules. The operators also have access to a bus stop list, allowing them to give customers information about the nearest bus stop. Ferry operations also has an "automated attendant" (i.e. touch-tone phone menus) for route and schedule information. This is generally not considered feasible for the bus system, as there is the perception that customers would rather talk with an operator than work with a machine.

Management Information Systems

A multi-year project is just beginning to upgrade the management information systems. The effort seems to have gained momentum recently as the service planning area has begun looking into newer computerized scheduling software (e.g. RUCUS and Trapeze). It is generally believed that there is not a whole lot of duplication of effort or of data input at the agency. However, it is also believed that computerized schedules then could receive wider dissemination and use if they were connected to a local area network. In addition to more commercial scheduling and dispatching software, Golden Gate is also looking at customized or in-house software for generating Section 15 data, recording employee work hours, printing schedules, etc. In this way, about 50% of the software put on this new information system would be commercial off-the-shelf (COTS) software, and about 50% custom or in-house work.

At this preliminary stage of the project, only a limited amount of data is available on the local network, including electronic farebox information, schedules, Section 15 data, and bridge traffic counts. In addition, MIS is now working toward setting up a wide-area network to connect the bridge, ferry, and bus operations centers.

Data Sharing

Only a limited amount of information sharing with other agencies is going on at Golden Gate. The customer information service only provides information on Golden Gate services, and will give someone only the MUNI or BART information number if they want information on connecting services (e.g. in San Francisco). They do circulate paper copies of routes and schedules both internally and with other operators. Currently, there is a project led by the MTC to develop a Bay Area-wide transit route and schedule database, and Golden Gate has been participating in that by sending both printed and electronic copies of routes and schedules to the MTC.

Paratransit Service

Golden Gate works cooperatively with the Marin County Transit District to provide paratransit service (including ADA-required service) in Marin. This service is currently provided under contract to Whistlestop Wheels. There have been several more innovative activities on this front recently, including:

- Current development of a request for proposals (RFP) for a computer-aided dispatch (CAD) and service scheduling software; and,

- Development of a coordinated Bay Area-wide database of ADA clients, certifying their eligibility for ADA services.

There is also interest in procuring paratransit CAD and scheduling software that will be compatible with similar systems that may (in the reasonably near future) be bought for the fixed-route operations. Cynthia Petersen from the Planning Department, who works in the paratransit area, asked me for references of other agencies in our survey that have paratransit CAD and scheduling software, to assist in developing their RFP. We have since sent her five such references, including:

1. Evelyn Freeman, Long Beach Transit
2. Lisa Ives, SamTrans
3. Tina Wu, Omnitrans
4. Bryan Albee, Sonoma County Transit
5. Roberta Gardella, OUTREACH (Santa Clara County)

Summary of Visit to Sonoma County Transit

This memo provides a brief summary of a visit to Sonoma County Transit (SCT) in Santa Rosa on April 21, 1995. We spent a couple of hours interviewing Bryan Albee, the senior planner at SCT, and then took a brief tour of the facilities. The discussion below focuses on the interview with Mr. Albee, which (at least loosely) followed a draft set of questions we had sent to him before the meeting. This memo begins with a brief description of SCT's operating environment, and then characterizes what is going on more specifically in operations, service planning, performance monitoring, and customer information.

SCT Operating Environment

Sonoma County Transit began service in July 1981 with a single route and a single bus; today, service includes 21 routes and 40 buses. SCT also operates 4 park and ride lots throughout the county. For the most part, SCT provides inter-city service within Sonoma County. However, SCT also offers local bus services under contract from the cities of Cotati, Rohnert Park, Windsor, Sebastopol, and Sonoma. Operations and some capital purchases are funded directly by local tax moneys and state TDA funds; federal dollars are only used for capital purchases alone (coming from FTA Section 9, Section 18 - Rural, and Section 26 - Research).

SCT is a contract operation. Currently, there are 10 employees on the county payroll; these are primarily in planning, marketing, and management positions. The operation itself has been contracted to ATC/Vancomm since 1989. Operators are organized in a union, but the private contractor is not required to hire these employees as part of their contract. The agency has now changed contractors twice, and, as might be expected, each time there has been pressure from the union to become a fully public agency. However, the current contracting arrangement seems to be going well, and the contractor seems cooperative with the union.

The service provided by SCT overlaps a little with some other operators. Most notably, some of the SCT routes run through the town of Santa Rosa, and in some cases overlap with service provided by Santa Rosa Transit (a fully public operator). There is a free transfer program between the two operator, on which SCT estimates it loses $30,000 to $40,000 a year. SRT is especially sensitive to SCT's operation within Santa Rosa. SRT has been unwilling to allow SCT buses to stop at their bus stops. The transit mall in Santa Rosa has also been a bone of contention between SRT and SCT. SRT is worried that SCT bus operations will disrupt the over-crowded mall. SCT, on the other hand, would like to have several of their buses arrive and leave concurrently so that transferring between buses will be easy. Golden Gate Transit (GGT) also operates within Sonoma county and is in contact with SCT. Again, SCT does most of the adjustments when it comes to coordination with GGT. SCT attempts to adjust service to facilitate transfers to and from GGT. Representatives from all three transit providers in Sonoma county meet on a regular basis.

Coordination of transfers with other operators, such as Santa Rosa Transit and Golden Gate Transit, is made a little more difficult by the fact that SCT does not run fixed headways. That is, while buses operate on specific schedules, their headways are not constant during the day. To improve coordination of services, planners from these three agencies get together once or twice a year to swap notes on services and ridership patterns.

SCT also interacts a little bit with the MTC, as their TDA money must come from Caltrans through the MTC. However, the operating environment at SCT is substantially different from other Bay Area agencies, so that only limited interaction with the MTC is desired. This is perhaps reinforced by recent requirements by the MTC to improve productivity at SCT. On the other hand, the MTC has helped SCT and other operators in the Bay Area in coordinating ADA services and tracking passenger ADA eligibility in the region. SCT is also keeping an eye on the MTC's Translink fare integration project, but is somewhat wary of value in the MTC's effort to develop a regional data base of transit routes and schedules.

Interaction with Caltrans is limited to being a recipient of federal and state-wide funds for capital improvements. SCT receives about $200-300k per year in federal Section 18 funds for capital improvements and Section 9 funds for other facility improvements. In addition, for a small telecommuting project at Sonoma State College, SCT is receiving research grant funds through Section 26(a). Finally, SCT has received some moneys from the Bay Area Air Quality Management District (BAAQMD), in the form of vehicle registration fees, to pay for compressed natural gas (CNG) buses. Some of the federal and BAAQMD funds are also being used to put in a CNG plant in the bus lot.

Mission of Agency

SCT's mission is to provide county residents with alternative modes of transport to the single occupant vehicle. This statement is reflected in two programs currently being carried out. The first program is construction of park and ride lots that serve more car-poolers than transit passengers. The second program is a telecommuting center sponsored by SCT on the campus of Sonoma State University. The telecommuting center can be used by workers who choose not to commute to San Francisco or Oakland. A telecommuter can use the center up to two days a week. The center appears to be an unqualified success and SCT is planning on extending the funding for the project.

Operations

Operations runs fairly smoothly at SCT. When new drivers are brought into the system, each spends about 1 month learning all the routes in the system. For every service day, the driver is given a set of direction sheets to keep with his/her bus, as well as a "paddle" with his/her daily work assignment. Work pieces are bid on a seniority basis. The drivers, two roving supervisors, and the dispatcher are all union personnel.

These drivers provide the main lifeline for the dispatcher at the main office. Information on incidents, re-routes, road closures, etc. is typically relayed through these drivers. The radio system is generally used to report these sorts of problems, as well as periods when a bus is significantly behind schedule. In the past 1-2 years, SCT has installed a new radio system that allows drivers to contact each other (i.e. other buses) directly, easing the communications load on the dispatcher. SCT also has 2 roving supervisors with radios to handle re-routes and monitor service. In general, incidents and emergency situations are pretty rare, even though there are silent alarms on the buses for fast response in these cases.

Operations has also been looking into an AVL system since 1990. In 1993-94, a research project determined that GPS-based systems were relatively expensive. Instead, SCT was approached by Trimble Navigation to tie an AVL system into the Cellular One cellular telephone system. In this way, the vehicles have GPS transponders, but the information from these transponders is conveyed using cellular telephone back to the dispatch center. In the future, this cellular system could be tied to in-terminal kiosks, or used in conjunction with mobile data terminals for real-time trip scheduling and routing for paratransit services.

The buses still require a GPS receiver, but communication costs are covered through the local cellular network. As a result, the cost of equipping the full fleet is a mere $150k, much less than the $1-1.5 million projected with the conventional AVL system. As cellular air time is pretty expensive ($0.38 per call for polling), vehicle location reports are polled as needed, rather than on regular time intervals, by the dispatcher. Currently, SCT has 2 buses equipped with this AVL system, but is planning to expand to the full fleet in the next several months with the help of $125k of Section 18 funds arriving in July. With only two vehicles equipped, the AVL system is currently used very, very infrequently -- the PC running the software was off during our tour.

Service Planning

SCT has a number of tools to help with service planning. Bus stops and routes are currently in a GIS, although the GIS is under-utilized for the most part. The GIS is used for determining the ADA service area and for determining nearest bus stops for ADA-certified passengers. Mileage calculations are also taken from the route layouts in the GIS.

In-house spreadsheets are used for creating route schedules and vehicle schedules (including inter-lining), as well as generating service hours for the contractor. As commercial packages do not perform well on routes with continuously varying headways, and because there are only a relatively small number of routes at SCT, this spreadsheet model seems to be sufficient. The contractor (ATC/Vancomm) is responsible for creating driver run cuts. The schedules and run-cuts are updated in August and January, although August typically involves greater changes than January. This is due in part to some school services in Rohnert Park and Cotati. Finally, the biggest constraint on scheduling often seems to be the transit mall in Santa Rosa, which has limited capacity (2-3 buses at a time) for SCT.

Data collection is done through several means. GFI electronic fareboxes are used on all buses, and are maintained by ATC/Vancomm, who generate monthly reports from the farebox data. Because SCT operates a zone fare system, the driver must punch in the fare type into the electronic farebox when the fare is paid. The farebox also generates a time-stamp on the farebox data, but it is very difficult to get any useful origin-destination or passenger trip information from these data. Rather, the contractor is only able to report daily ridership by route. Road supervisors and some traffic checkers do annual surveys of passenger trips on all routes. This task is very time-consuming for small operators like SCT, especially given the large geographic area covered in Sonoma County.

Passenger complaints or comments on the service generally come to SCT staff first and then are communicated to the contractor. There is an incentive program for the contractor, up to $10k per quarter, based on a number of service measures, including on-time performance, driver courtesy, cleanliness, etc. Thus, there is clearly an incentive for the contractor to keep the number of passenger complaints down.

Performance Monitoring

Several different parts of the organization are responsible for monitoring performance. The contractor is responsible for generating daily route ridership figures from the electronic farebox, and also must generate a set of quarterly progress reports recording a wide set of performance indicators. In addition, costs and revenues are recorded by SCT personnel directly. Both sets of performance measures are reported to a broad audience, including the SCT Board of Supervisors, the MTC, the FTA (Section 15 data), and in the Short-Range Transit Plan (SCT's annual report and 5-year plan).

Customer Information

SCT has 3 people at their main office to handle customer information requests. This service, on an 800 number, operates from 7 am to 6 pm on weekdays, and currently handles about 300 calls per day. As SCT does not operated fixed headway service, the calls to information are particularly important for trip planning and determining appropriate transfers. Operators have schedule and fare information, as well as printed route maps with bus stops, at their fingertips. In addition, there is an e-mail link within the building so that the dispatcher may inform these operators of service disruptions or exceptions.

Some of the calls for information come through a local "PressInfo" telephone system; this service is a single telephone number in Sonoma County that allows direct access to many county-wide public services. Customers needing connecting service information for Golden Gate or Santa Rosa Transit are given the other agency's phone number. In addition, calls for paratransit service come in through SCT, where they are checked to meet ADA eligibility requirements, and then passed on to the non-profit operator in Santa Rosa.

Schedules are distributed to over 600 sites in the county, including being posted at 125 passenger shelters (out of 900 total bus stops). Newspaper ads, flyers and direct mailings have been done in the past. Other school promotions, Elvis sightings, and special events promotions are part of the marketing picture.

Summary of Visit to Los Angeles County MTA

We conducted a site visit to the Los Angeles County Metropolitan Transportation Authority (MTA) last Monday, April 24, to learn more about the MTA's operations and use of information systems and technologies. We spoke first with Dr. Ashok Kumar and then with Frank Schroder, both of the Scheduling and Operations Planning department. Dr. Kumar directs the MTA's data collection and technical system support for service planning and scheduling, while Mr. Schroder manages the development of routes and schedules more directly. Unfortunately, we were unable to connect with either Byron Lee or Larry Kozner in operations, or with Doug Anderson in the customer information department; both were unavailable for this visit. This memo begins with the conversation with Mr. Schroder, as it provides a good introduction to the MTA.

MTA Service and Scheduling

The MTA provides transit services for a wide area of Southern California, ranging from Long Beach in the south, Riverside and San Bernardino in the east, Ventura and Santa Clarita to the north, and Santa Monica to the west. Most of the 200 routes (covered by about 1700 buses) for the bus service run in a grid-like pattern, north-south and east-west. This has the added complication that trips not running in these directions generally have to make a transfer at some point. Fares were traditionally based on a two-zone system, but this has since been scrapped in favor of a single common fare for local and limited bus service. For these routes, a monthly pass is also available; the pass can also be used for the rail system. Express routes have distance-based fares, depending on how much of the route is run in closed-door service.

The light rail line (the Blue Line), which opened in 1990, runs from Long Beach up to central Los Angeles. The Red Line opened in 1993, and currently runs for only a small portion of downtown (4 miles), although this line is to be expanded. The Green Line is set to open later in 1995; there has been much public controversy about the construction delays and the availability of operating funds for this line. All rail fares are flat fares, as with the bus system. There are no barriers on any of the rail lines, and thus, fares are on the honor system. There was some effort last year to move to zone-based fares, especially for the Blue Line. A lawsuit followed, saying that it unfairly hurt monthly pass users, which effectively stopped this proposal.

The MTA has operating agreements with many of the other cities in its jurisdiction to provide transit service. Examples include Santa Monica, Torrance, Foothill, Long Beach, etc. The level of service and schedule coordination with these operators, however, is limited. More typically, coordination of service and schedules is done in response to passenger complaints or comments, rather than a more active role by the agencies themselves. As an example, relations with Foothill are strained based on the lawsuit filed by the Foothill communities to replace MTA service with private contract service. One MTA route stops directly at the jurisdictional boundary with Santa Monica; through-traveling passengers must disembark there and board a waiting Santa

Monica bus to continue their trip. With Torrance and Long Beach, the MTA has more cordial relationships; these operators have managed to work out cooperative agreements to share services where necessary.

Mr. Schroder indicated that generating schedules for 3 rail lines and 200 bus routes is a pretty complicated matter. The MTA is currently using Mini-Scheduler by SAGE, running on an IBM mainframe, to do scheduling on the bus routes. However, this task must be checked and supplemented manually, as many of the routes have schedules to accommodate short turns (running only part of the route), inter-lining (buses switching from one route directly to another), and branching. As a result, much of the scheduling effort is still done manually. Apparently, the MTA is considering purchasing HASTUS-BUS; according to Mr. Schroder, it handles these routing complexities much better than Mini-Scheduler. HASTUS-BUS may also automate some scheduling of the rail lines; these are currently done completely by hand.

The MTA's schedules are kept on the company-wide IBM mainframe; this can be accessed by the operations and customer information departments. However, with so many users in the organization, the mainframe often runs very slowly, thus hindering access to these electronic data. More typically, these other departments use printed copies of routes and schedules.

The MTA updates its schedules twice annually, once in August and again in January. From these schedules, HASTUS is used to generate run-cuts for vehicles and drivers (also on the IBM mainframe). There are 13 bus garages (called "divisions"), and the picks for a driver's work are performed at this division level during these same two periods per year. Drivers wishing to switch divisions can do so only if work opens up between picks at another division; even then, this open work is given out based on seniority.

Data Collection

Dr. Kumar made some comments about data collection at the MTA. The MTA has electronic fareboxes, but that data is not really useful for service planning. First, the electronic farebox does not record passengers who carry passes (no swipe is required) or printed transfers. Thus, fare payment types and passenger boardings cannot be effectively determined from the farebox data. The MTA currently employs on-board checkers to do ridership and fare counts. These checkers are scheduled to cover each route in the system once per year on a weekday, and once every four years for a weekend day. This task has been made more difficult by cuts in the checking staff: the staff of 48 was recently cut down to 26. Each of the checkers has a hand-held computer to record ons, offs, locations, times, and fares. These data are then downloaded from these computers to the IBM mainframe. From there, the data are used to examine bus schedule adherence, ridership, and fare revenue patterns.

Data collection on the rail system is even harder, given that there is no barrier and the fare payment is based on the honor system. Checkers often circulate with the transit police to do on-board counts and fare checks, but this is rare. Thus, little information on fare payment and ridership for the rail system is known.

Operations

Both Mr. Schroder and Dr. Kumar talked about several things going on in operations. In particular, the MTA is currently installing a new radio system called TRS (Transit Radio System) that will be connected to a signpost-based AVL system. This project has been around since the early 1990's, and is somewhat of a boondoggle in the organization due to technical problems with the radio and signpost systems. Nonetheless, the new system should allow the MTA to collect more data on schedule performance and bus running times to help with scheduling.

The MTA also has a large set of transit operations supervisors (TOS's) to manage daily operations. These TOS's include so-called radio dispatchers, who are located at the operations center, and a host of field supervisors, who are responsible for road calls, accident investigations, and monitoring service. Currently, the 9-channel radio system is only used for exception reporting, meaning an incident or the bus is more than 10 minutes behind schedule. The MTA also has silent alarms on its buses. However, both the radio dispatchers and field supervisors are dependent on several large volumes of printed schedules and time points to determine bus locations during such events. The problems with such a system were highlighted during a recent shooting on board a bus: both the field supervisors and radio dispatchers were unable to locate the bus, thus hindering a quick response to the incident.

Customer Information

The MTA also has a Customer Information Computer System (CICS), which is an automated telephone information system. The CICS includes all municipalities in the 5-county area (Los Angeles, Ventura, San Bernardino, Riverside, and Orange); those outside the MTA's service area pay a small fee to have their information posted on the CICS. Currently, the system uses U.S. Census DIME files to generate landmarks and street addresses. The user must punch in the street address of both the origin and destination, using a touch-tone phone; this can be a very time-consuming process for the traveler. From this input, a lookup table in the CICS cross-references these to the DIME files, and a trip itinerary is generated. At present, there is not a separate GIS running for customer information.

Summary of Visit to San Diego Transit

We visited San Diego Transit on May 9, 1995 to follow up on their survey response. The meeting was set up by Mr. Richard Murphy, Vice President of Operations. Several other people at the agency were also in attendance: Mark Lothian, Manager of Customer Information; Larry McGonagle, Manager of Transportation Services; John Peacock, Manager of Data Processing; and Bill Bennett, Scheduler. The meeting began around 10:00 a.m. and lasted about two and one-half hours, including a brief tour of the customer information area and the radio room. The conversation focused on San Diego Transit's information systems and general operations.

Background

San Diego Transit has existed for a long time as the bus transit operator in the greater San Diego metropolitan area. Their operations were largely autonomous (under the City's jurisdiction) until 1985, when they were made a subsidiary corporation beneath the San Diego Metropolitan Transit Development Board (MTDB). The MTDB was created by the state of California in 1976 to develop a fixed guideway system in San Diego, and the planning, development, and operation of San Diego Trolley was their major project. At present, the MTDB is basically a short-range (2-10 years) transit planning agency with no direct operating authority. However, they have several subsidiary corporations that operate the transit service: San Diego Transit (local and express bus), San Diego Trolley, and a paratransit administration.

As a result, San Diego Transit is primarily an operating agency, with very limited longer-term planning. The MTDB, on the other hand, primarily does the medium-term service planning (hours of operations, service levels, route frequencies/headways, etc.). In addition, the MTDB and its subsidiaries are under the jurisdiction of the San Diego Association of Governments (SANDAG), which is responsible for long-term transportation planning for the region (much like the MTC in the Bay Area). As far as we know, SANDAG has jurisdiction over all of San Diego County, while the MTDB is limited to the greater San Diego metropolitan area (excluding North County).

San Diego Transit has a separate board of directors, although with the MTDB, the board's responsibilities are fairly diluted: they have control over matters of the general manager, labor relations, and some advisory role over the agency's budget. As far as service goes, San Diego Transit has a service area covering a population of 2.2 million, and carries 33 million passengers annually on about 260 peak vehicles (312 total). Currently, about 50% of operating funds are recovered through the farebox, with another 45% from the state and 5% from the federal government.

Operations

The centerpiece of operations at San Diego Transit is a Motorola trunked data radio system that is connected to a MicroVAX. The radio system connects transit buses, field supervisors, operations supervisors (dispatchers) and communications supervisors (in the radio room). The communications and operations supervisors have terminals directly connected to the MicroVAX that allows automatic logging of radio events, including direct data links to connect bus, driver, route and run information to log records. The communications and operations supervisors have access to Thomas Brothers geographic/mapping data for determining routes and locations of buses (although there is no vehicle location system at present). There is a tape drive connection between the MicroVAX and the central IBM AS/400 mainframe; transfers are made between systems on a weekly basis.

In addition, the field supervisors have mobile data terminals (MDTs) in their cars, and have the capability of transmitting messages (voice or data) directly to buses or back to the central radio room. The trunked radio system allows specific data and voice messages to be broadcast to all units or to specific vehicles (e.g. a single vehicle or all vehicles on a particular route).

In total, radio traffic is fairly light, amounting to about 200-250 calls per day, and can be easily handled by the 1-2 people in the radio room on weekdays. Most of these calls involve problems with equipment, wheelchair access, transfers to other lines, buses running behind schedule (e.g. more than 10 minutes), etc. The radio system does allow prioritization of calls to three levels (Code Blue, Accidents, Normal).

There seems to be a rather low level of supervisory personnel. We were told that the current ratio is about 30 operators per one supervisor, which is lower than typical transit industry standards. As a result, the supervisory personnel spend most of their time responding to road calls or other equipment problems, route detours, and other real-time incidents. These activities take up about 99% of their time, leaving little time for performance monitoring or other less critical activities.

Buses are equipped with silent alarms ("Code Blue"). A radio signal sent to the communications supervisors allows them to call up the vehicle number, driver, route, run, and nearest time points. From there, the communications supervisors will direct field supervisors and local police (if necessary) of the incident and the above information. Generally, response times are on the order of a couple of minutes. Most such incidents (80-90%) are handled by transit personnel, without the need for external help. The MTDB has been deliberating over hiring a police force to handle incidents. The main benefits of having an in-house police force are: relief of road supervisor activities and a more visible safety aspect on the buses.

San Diego Transit has electronic fareboxes and was one of the first such agencies with these back in the 1970's. Normal fares and transfer slips are logged automatically by the GFI farebox, while special fares (passes, etc.) are input by the driver. This data is used to determine riders by different fare categories and route loads. The farebox is also connected to the odometer to get mileage counts for each bus. As a result, many departments at San Diego Transit use the data (e.g. finance, vehicle maintenance, etc.) via daily reports. However, there is still a pressing question about how to manage the reams of data that come out of the electronic farebox.

The agency is interested in pursuing an AVL system with a new radio system, passenger counters (for 20-30% of the vehicles) and a system for automated ADA announcements. Such an AVL system would certainly aid in doing real-time performance monitoring. However, the capital funding is currently not available for this system, primarily because of difficulty in obtaining the local 20% share.

Customer Information

San Diego County is covered by two major transit organizations: the North County Transit District and the Metropolitan Transit System (MTS), the latter being run by the MTDB. The MTS also includes other operators, including Chula Vista Transit, National City Transit, etc., that offer services in the MTDB's jurisdiction. For the MTS region, San Diego Transit manages a regional transit traveler information system (RTTIS), an integrated system containing timetables and route information from all transit operators in the MTS. The RTTIS is owned by San Diego Transit, and the costs of operations are divided among operators in the MTS based on the number of calls for each agency in the MTS.

The RTTIS revolves around a trip planning system developed by Tidewater Consultants, which is currently being updated. This computerized system allows the traveler to specify an origin and destination, departure or arrival time. From this, the computer displays up to 6 transit options, including access and egress distances, routes, fares, transfers, etc. Geographic data in the RTTIS is based on US Census DIME files. Currently, the information works through a human operator (there are 15 full-time operators at present). Customer information also has a speaker so that messages about real-time operations from the radio room can be broadcast to all the phone operators. In addition, the upgrade will allow the operator to FAX the trip planning information directly from the operator terminals to a traveler's location. In addition, an automated voice response will be included as part of the updated system.

The data for the RTTIS comes out of traditional scheduling software. However, because that data includes only major time points and not all bus stops, there is a fair amount of work to convert the schedules that come off the mainframe into a suitable format for the RTTIS. This is especially problematic without some graphics capabilities to identify and locate bus stops. Thus, the RTTIS is not directly connected to the IBM mainframe.

On a different note, San Diego Transit is currently experimenting with an automated information system that allows the traveler to input day, time, and route #, and receive a route schedule. This is anticipated to handle about 25% of the calls to customer information. There are currently some minor technical glitches in the system, but this should be up and running by the end of June. As anticipated, the system will provide 1-second response times for information lookups.

The MTDB is also considering a regional traveler information system to display transit services for all trolley stops and major transfer points with the bus system. The difficulty is integrating this with carpooling and ridesharing coordinators in the San Diego region to provide full region-wide information services. In addition, there is currently a lack of available funding for capital for this system.

Scheduling / Run Cutting and Bidding

San Diego Transit was one of the first five agencies in the US to use the RUCUS software for vehicle scheduling and run cutting. Currently, they are using G-Sched by Teleride-Sage, which handles both run cutting and scheduling. This software runs on a PC, and is transferred to the IBM mainframe through a floppy disk. The MTDB provides peak and off-peak headways, but generally does not get involved in the specific schedules. Scheduling and run-cutting are also made a little easier since the peak to base ratio is rather small at San Diego Transit: about 1.1-1.2 to 1. About 52% of the riders occur in the peak period.

The data processing group at San Diego Transit has developed software in-house to handle operator picks and bidding. This software, connected to the mainframe, uses the schedule and run-cut information coming out of the Teleride-Sage software to display daily runs. Operators then may use the computer to select division, days off, and individual runs. Under this process a driver could have different runs on different days. This form of bidding has resulted in better attendance because drivers feel they have more control over their destiny and feel more responsible to the routes. The extra board is kept small by this process and on any day a person can bid to take available runs for a day during the week. This information is then automatically registered in the mainframe, for use by other applications. A pick for 522 operators can be performed in about 8 hours; picks occur every January, June and September.

As mentioned above, MTDB and SANDAG are responsible for longer-term service planning. More specifically, SANDAG handles passenger counts and ride checks every 18 months or so, and that data is shared with the MTDB for their planning purposes. Section 15 and other state data reporting requirements are thus handled directly by SANDAG and the MTDB.

Data Processing

The primary engine for data processing at San Diego Transit is an IBM AS/400 mainframe, which has at present over 140 local terminals. More direct connections to the mainframe are for the Accounting, Administration, Transportation, Risk, and Purchasing departments. While all the operations data is also maintained on the mainframe, many of the operations-related areas at the agency use other computer systems:

Operations:	MicroVAX	Weekly updates
Customer Information:	Network of PCs	Update once per pick
Scheduling:	PCs	Update once per pick

Thus, maintaining consistent and timely data requires a bit of diligence on the part of the data processing staff.

Summary of Visit to Omnitrans

We visited the offices of Omnitrans in San Bernardino on May 16, 1995 to follow up their survey response. Our main point of contact is Tina Wu, who is a transportation planner at Omnitrans; her current boss (interim manager/consultant) is Jim Andrew. We talked for a while with Jim and Tina, then visited with other members of the staff who are directing different areas. In total, we spent a little over three hours at Omnitrans; the visit was lengthened simply because we visited with a large number of people. Below is a brief summary of our visit.

Background

Omnitrans provides fixed-route bus service and contracts out for express and paratransit service in the southwest corner of San Bernardino County, centered on the city of San Bernardino. This service area includes a population of about 1.2 million, of which about 40% are on some form of public assistance (welfare) among the elderly, disabled, and poor working class. As a result, there are a large number of transit-dependent people in the service area. This is also reflected in the fact that services and ridership patterns are uniform throughout the day -- there is very little "peaking" of demand or service.

The agency began in 1976, and has grown to about 123 buses operating over 33 routes, with a planned increase of 26 new buses coming in the next fiscal year. In this mode of expansion, Omnitrans has been working to cover their large service area; they are now trying to increase service levels (i.e. frequencies and hours of operation) within those markets. In particular, they have recently added Sunday service on a number of routes, and have decreased headways to 10-15 minutes on several heavily-traveled routes. San Bernardino city and county have been expanding with people and jobs over the past decade, and Omnitrans is trying to stay on top of this growth. Omnitrans served about 7 million passenger trips in 1994, and expects a 20% growth in ridership in 1995.

As mentioned above, Omnitrans contracts for local paratransit service, particularly for the elderly and disabled, as well as in areas that are not served by fixed-route service (e.g. Redlands, Yucaipa, Mentone, etc.). Their ADA paratransit service, Access, is complemented by dial-a-ride and dial-a-cab services. These services are operated and managed directly by the contractors, including handling of customer information and ride requests.

Omnitrans is officially a Joint Powers Authority, and as such is governed by a locally appointed board (one member from each of the 20 cities Omnitrans serves) and general manager. Funding of transit services is achieved through federal moneys and state TDA funds. There is also dedicated sales tax revenue (0.25%) in San Bernardino County (Measure I) that is dedicated to transportation for the elderly and disabled. The local air quality management district (AQMD) also provides some funding, and farebox revenues account for just over 20% of operating expenses. Omnitrans is under the jurisdiction of the San Bernardino Association of Governments (SanBAG) who in turn is under the Southern California Association of Governments, SCAG.

Service Planning

The service planning department is responsible for collecting data on system performance and for providing short-range planning. Data collection is performed by a group of 5 checkers who use hand-held computers to record ons, offs, vehicle schedule adherence at bus stops, etc. The tool for this data collection is a hand-held unit made by On-Board, which can be programmed to prompt the checker at particular bus stops on a route. [However, the data input (bus stops and time points) as well as the data output (loads by route segment, etc.) from the On-Board units are not entirely compatible with the G-Sched scheduling software, so this interfacing problem remains.] Route checks are done once a year; one checker is permanently assigned to collecting Section 15 data. Field supervisors have a quota of 32 time/schedule checks per week, although this can hardly be called a random sample for analyzing system performance.

Data from the hand-held computers is downloaded to a PC in service planning. The computer capabilities are based on IBM-compatible PCs, and no networking or linking of PCs is in place; there is some initial thoughts about creating a local area network in the planning department. Nonetheless, this data from the planning department is electronically and physically separated from the operations department, which handles scheduling. The paratransit service is contracted out directly, and the three contractors each collect and maintain their own records on service performance.

There seems to be only minimal interest in the service planning department about using the wealth of data from the electronic farebox or the planned AVL system (see the Operations section below). The only potential data item that was mentioned during the interview was using the farebox system for route and off-route (out of revenue service) mileage for Section 15 purposes.

Omnitrans does not currently have a GIS in house, although they are planning on acquiring Arc/Info-PC and ArcView 2.0 in the next fiscal year. This will be done in conjunction with a similar capability coming on line at SanBAG, and in cooperation with the GIS capabilities of SCAG. The street network already exists at the San Bernardino County planning offices. A significant challenge to these GIS efforts will be keeping the data timely and consistent, given the rapid changes in land use and demographics in the county. Omnitrans is currently contracting with a local firm (San Bernardino Geographic Information Management Services) to determine eligibility for ADA services.

Omnitrans currently has a contract with Booz-Allen to review their fare media and pass program. Currently, Omnitrans offers several fare products, including regular fares, quarter fares ($0.25), senior and disabled fares, monthly flash passes, tickets for students and seniors, and tear-off transfers. Some thought has been given to integrating fare media with something like a smart card (proximity card); this would simplify the fare payment process and may allow effective identification of the passenger and fare type based on data stored in the card.

In general, the underlying philosophy at Omnitrans about new technologies is a “wait-and-see” approach. That is, given the rapid changes in technologies and products out there, they would rather not waste a lot of time, effort, and money on technologies that may not be longer-term winners, both technically and for the bottom line of the agency.

Customer Information

For customer information, we talked with Leslie Henderson in the marketing department. Omnitrans is connected to the Transtar program. Commuter Transportation Services (CTS) of Southern California, the LA area’s non-profit ridesharing agency, has developed this commercially-available software that provides trip plans and itineraries for travelers. This computerized system allows the traveler to specify an origin and destination, departure or arrival time. From this, the computer displays several transit options, including routes, fares, transfers, etc. Geographic data in Transtar is based on US Census DIME files. The information is kept centrally at CTS; Omnitrans has a modem connection to CTS and has several terminals for information operators. Omnitrans pays a monthly fee for this service, and in turn provides data on routes and schedules to CTS.

[It is noted that many transit operators in Southern California are hooked in to the Transtar system. However, several large operators, such as the MTA and OCTA, are not directly tied in. In these cases, CTS obtains and maintains their data so that operators on the Transtar system do have access to OCTA and MTA schedules. At the same time, the level of support and reliability for those schedules (MTA and OCTA) is not as high. SCAG is currently putting together a regional transit database of routes and schedules, also for traveler information purposes. There is also a rumor that SCAG will be taking over the CTS Transtar software.]

Operations

We also spoke with Cindy Peterson, the director of operations. The most notable project going on currently at Omnitrans is the installation of a new radio data system. Omnitrans has received 3 licenses in the 450 MHz range, of which one channel will be for data and the other two for voice. They are currently undergoing acceptance testing, software development and personnel training for use of the system. The main element on board the vehicle is a transit control head (TCH), which prompts the driver for their shift, route, run, and ID. The TCH automatically records vehicle mileage. The TCH acts as a mobile data terminal, allowing coded messages to be sent automatically between the bus and the radio/control center, such as: silent alarms, wheelchair lift reports, transfer requests, priority request to talk, etc.

Dispatchers at the control center can also contact specific buses directly, either through voice or text. Similar capabilities are being installed in the supervisory vehicles. Radio (voice and data) contact thus can be achieved directly from field supervisors and dispatchers to particular buses. At present, though, all radio contact from the buses must go through the dispatchers.

Omnitrans has two levels of supervisory personnel: dispatchers and field supervisors. The former handle both the radio traffic (relatively noisy at present) and the equipment and operator assignments. The latter are responsible for monitoring service, responding to road calls and other incidents, disciplinary action on operators, and some security. Both types of personnel have a paper copy of route schedules and maps. At present, such information is not likely to be put into electronic form on the new radio data system; while this may be considered useful, it is not considered any faster for the dispatchers or supervisors.

Omnitrans is also planning to implement an AVL system on its entire fleet. Currently, Omnitrans is developing an RFP for such a system. In the system specifications, the AVL system (likely to be GPS- or Differential GPS-based) is anticipated to be compatible with the new radio data system. In addition, a graphic user interface or GIS capability is also necessary for the dispatcher; this is likely to be designed with the help of an outside consultant. Other hooks in the AVL spec should allow tie-in to an automatic stop annunciation system (for ADA) and automatic passenger counters. However, the AVL will likely not be interfacing with the signboard or the electronic farebox.

In terms of real-time monitoring of service, Omnitrans has relatively low-frequency service (15- to 60-minute headways) and only a minimal problem with traffic congestion during the peak periods. As a result, the agency enjoys a 95% on-time performance record. In this respect, one may be left to wonder on the value of the proposed AVL system for schedule adherence and performance monitoring.

The operations department handles vehicle scheduling and run-cutting. Omnitrans is a beta test site for G-Sched by Teleride-Sage. Schedules from Riverside Transit, the LA County MTA, Metrolink, and Foothill Transit are all used to develop reasonable schedules. Particular changes to the schedule have been added recently to meet Metrolink service to central San Bernardino; unfortunately, Metrolink has not been quick to share schedule changes with Omnitrans. Omnitrans also has cooperative service agreements with each of the agencies listed above regarding transfers, use of passes, provision of particular services, etc.

Omnitrans is also considering implementing a paratransit computer-aided dispatch (CAD) system, such as PASS, which integrates paratransit scheduling with GIS capabilities. As much of the paratransit functions are controlled by the contractors, there is some back and forth with them on the need and desire for such a system. Omnitrans maintains the database of ADA-certified clients, and passes this along (on paper) to the contractor. Ride requests are then handled directly by the contractor, who processes these requests Rides Unlimited software. This software has no GIS or graphical interface, which makes it difficult to check the reasonableness of certain paratransit trips.

Summary of Visit to Riverside Transit Agency

We visited the offices of the Riverside Transit Agency (the RTA) on May 16, 1995 to follow up their survey response. Our contacts at the RTA include Cis Leroy, who completed the survey, Fina Clemente, who organized our visit, and Steve Oller, who was our main contact for this site visit. Mr. Oller is the Director of Transportation at the RTA. We spent most of the afternoon talking with Mr. Oller, and we met several other members of the staff as we toured most of the facility there. In total, we spent a little over three hours at the RTA; below is a brief summary of our visit.

Background

The RTA is the main transit operator for the western portion of Riverside County, including the city of Riverside. The RTA operates fixed-route services as well as a paratransit/dial-a-ride service over about 2500 square miles. In total, the RTA operates slightly over 100 buses, with over 60 large buses (20 fixed routes), 32-35 small buses (6 additional fixed routes), and a paratransit fleet of 50-60 vans [We am unsure whether these paratransit vehicles are in fact owned by the RTA or the service contractor]. The RTA works closely with other regional operators (Omnitrans, Orange County Transit Authority (OCTA), LA MTA, and Metrolink). Some of the regional Inland Empire Connection services are operated by contractors by agreement with other transit agencies. The service from Riverside to Orange County was recently reduced in half because OCTA stopped funding it.

The RTA falls under the jurisdiction of the Riverside County Transportation Commission (RCTC) and the Western Riverside Council of Governments. These agencies establish transportation policies for the region and do some of the longer-range transportation planning for the RTA. Funding for service comes through the usual federal (Sections 3, 5, 9, and 18) and state (TDA) sources; the RTA has been trying to wean itself from federal operating assistance for some time now. The grants manager at the RTA is a so-called "whiz" with several irons in the fire, including CMAQ and other alternative funding arrangements. With all these funding arrangements and political oversight, the RTA has a number of reporting requirements and responsibilities. These oversight agencies include: the FTA, RCTC, the 18-member (14 elected and 4 appointed) board of directors, SCAG (through the RCTC), and Caltrans (for Section 18 funds).

Data Processing

The RTA has a Novell network running on PCs with a client-server architecture. There are currently 40-50 terminals at the RTA's operations center that are on this local-area network (LAN). The agency itself has gradually migrated from 50/50 Mac and PC to a mostly PC environment; currently, only the marketing department has Macs. There is some thought that in the next year or so, a relational database tool will be put on the network, such as Microsoft Access, to enhance the use of schedule and routing data within the organization.

Operations

The RTA currently has an AVL system up and running (since June 1992). The RTA uses the PacTel Tele-Trac system. For a cost of $20/month per unit, the RTA receives 1000 peak and 1000 off-peak locations (per month). The Tele-Trac system works off of a simple unit in the vehicle; the PacTel repeaters get data transmissions from these units to triangulate the vehicle's position. In this way, the position of a vehicle can be known at the operations center with a fairly high degree of accuracy, *without using the traditional radio channel(s)*. The Tele-Trac system also includes silent alarms.

The RTA has Tele-Trac units installed on 86 vehicles, and has 29 units on the shelf / ready to go. The units are polled every 11 minutes; there is also a hook in the software to do polling upon certain events (e.g. radio contact). At present, Tele-Trac also supports mobile data terminals (MDTs) in 5 supervisory vehicles at a slightly higher cost ($28/month per unit for canned text; $38/month per unit for free text). The Tele-Trac system also includes software running on a PC and graphics, including mapping capabilities based on the Thomas Guide (distances, address matching, etc.). The current disadvantage of the Tele-Trac system is that the polling is done at a constant time interval rather than at specific locations; this means that it is very difficult to get schedule adherence data at various time points in the network..

The RTA uses a Johnson radio system (not Motorola) running a standard 2-way system in the 900 MHz area. The system lacks much of the functionality of a Motorola system, but has proven to be sufficient for the RTA's needs. The maintenance shops are also connected to the radio system to respond to road calls, etc.

Drivers are responsible for ADA announcements, keying in data to the electronic farebox, and changing overhead signs. Operator paddles and daily registers are generated off the network run cuts and are downloaded daily for dispatch purposes. The RTA is also now considering a semi-automatic annunciator system for stop announcements that would only require the driver to hit a switch before each stop. The GFI farebox system is downloaded to a PC daily, and from there, data is aggregated and placed on the network for analysis: determining ridership by trip and by fare type, etc. The RTA is considering other fare media, such as TRIM units, smart cards or debit cards, etc., although these ideas seem to be slated for a long-term wish list.

The paratransit contractors primarily run their own shows (ride requests, scheduling, and dispatch) under contract to the RTA. In general, trips are scheduled a day in advance, but some service is on 1-2 hours lead time. Currently, the RTA is installing MDTs on their paratransit fleet to assist drivers in making appropriate pick-ups and drop-offs. For a couple of services, the RTA handles ride requests, scheduling and dispatch. In the latter cases, the RTA is bringing in a computer-aided dispatch (CAD) system, from Multisystems, on the LAN to handle scheduling of services. The CAD system includes a GIS to assist with curb-to-curb service delivery; this GIS is based on USGS TIGER files and a Thomas Brothers map database. Also, the RTA does their own ADA certification using a GIS; they claim to be pretty tough on customers in making sure ADA customers are truly eligible.

Service Planning/Transportation

Data collection for time checks are supposed to be done by field supervisors, although these are not really done in any comprehensive manner, and are not entirely at random in the network. Interns are also responsible for ride checks, from which Section 15 data is derived. Each route is given a complete check every 3 years.

There are a number of computer tools that seem to be in use for service planning and operations. The RTA is currently installing bidding and driver/vehicle dispatching software from Multisystems. This software gives the agency the capability of converting the run cuts into bid sheets and daily rosters; the software also handles operator time-keeping and payroll. Currently, the RTA (i.e. Mr. Oller) is using simple Lotus 1-2-3 spreadsheets to do scheduling and run-cutting. The spreadsheets produce statistics on vehicle miles and hours as well as driver miles and driver hours. The schedules are generally only updated once per year, although there are three bids/picks per year.

There is clearly some "folklore" involved in setting these schedules; with 26 routes, Mr. Oller clearly understands some of the subtle nuances of transfers, O-D patterns, traffic congestion, etc. of each route. There is money in the next fiscal year's budget to purchase scheduling and run-cutting software such as Trapeze; its compatibility with the bid software from Multisystems is very much in question at this point. The current spreadsheets take some manual manipulation to put into the appropriate format for the bid software.

Schedules are coordinated for transfer services, especially with Metrolink in downtown Riverside. The RCTC has a seat on the Metrolink board, which means that the RTA and Metrolink have a relatively symbiotic relationship. About 4-5 bus routes at the RTA also connect with other operators (OCTA, Omnitrans, etc.), and service on these routes is reasonably well-coordinated (although through an ad-hoc and "folklore" process).

The RTA also uses GIS for service planning, although the uses to date are somewhat limited. Data is shared with the RCTC and with the County of Riverside. It is hoped that the RTA can begin to use the GIS as a tool for longer-term service planning. This is especially important in an area such as Riverside, as the RTA and county would like to maintain "livable communities" and transit-friendly development into the next century.

Customer Information

For customer information, we talked with Scott Richardson in the marketing department. The RTA, like Omnitrans, is connected to the Transtar program. Actually, the RTA is a beta site for the software, and has been using the software since 1988. Commuter Transportation Services (CTS) of Southern California, the LA area's non-profit ridesharing agency, has developed this commercially-available software that provides trip plans and itineraries for travelers. This computerized system allows the traveler to specify an origin and destination, departure or arrival time. From this, the computer displays several transit options, including routes, fares, transfers, etc. Geographic data in Transtar is based on US Census DIME files. The information is kept centrally at CTS; the RTA has a modem connection to CTS and 4 terminals for information operators. All agencies pay a monthly fee for this service, and in turn provide data on routes and schedules to CTS.

[It is noted that many transit operators in Southern California are hooked in to the Transtar system. However, several large operators, such as the MTA and OCTA, are not directly tied in. In these cases, CTS obtains and maintains their data so that operators on the Transtar system do have access to OCTA and MTA schedules. At the same time, the level of support and reliability for those schedules (MTA and OCTA) is not as high. SCAG is currently putting together a regional transit database of routes and schedules, also for traveler information purposes. There is also a rumor (from Mr. Richardson) that SCAG will be taking over the CTS Transtar software on July 1.]

Summary of Visit to Napa

We visited Celinda Dahlgren at the City of Napa on June 20. Ms. Dahlgren works within the Department of Public Works for the City of Napa; in this role she oversees the transit service in the City of Napa (the Valley Intracity Neighborhood Express, or VINE) as well as Napa Valley Transit (NVT) service between Calistoga and Vallejo. We talked with her a little more about the information systems and technologies at these two agencies. However, some of the details are a little sketchy either because of the fast pace of the interview and/or because Ms. Dahlgren is not intimately involved in the technical details of these technologies.

Background

The City of Napa coordinates the VINE and NVT services; in practice, this means that Ms. Dahlgren and her assistant are responsible for higher-level service planning functions (i.e. routes, policy headways, and schedules through an outside consultant) and contract oversight. Both the VINE and NVT are operated by a single contractor; however, from the city's perspective, the two are administered separately (e.g. different costs, performance requirements, budget, etc.). In total, there are 19 buses in the VINE and NVT fleet.

VINE has been operating since 1972, and receives operating funds from both the Federal Transit Administration (Section 9) and the City of Napa TDA funds. At present, there are 5 routes on the VINE, with an annual operating budget of about $2 million supporting about 660,000 trips. The nerve center of the VINE is the downtown transit center, where a "pulse" timed transfer system allows all five routes to converge every 30 minutes. The dispatchers (also part of the contractor team) operate at this transit center.

NVT has operated a single route connecting Calistoga and Vallejo since 1991. The operating funds for NVT are provided through a population-based formula from each of the municipalities in the valley. Initial expectations were to recover 15% of the operating funds through the farebox; the true figure is now somewhere around 19-22%. Capital funds are provided from this same pool and also from federal Section 3 funds. Ridership has experience double-digit (percentage) growth in every month since the service began. For the single NVT route, monthly ridership recently broke 10,000, and the annual ridership will likely break 100,000 this year. Of this ridership, over 40% are commuters, which is a higher percentage than might be expected for this service.

At present, there are multiple and largely independent transit services operating in Napa County, including the VINE, NVT, a county-run paratransit service, a subsidized taxi service (dial-a-ride), and small bus service in American Canyon and other towns. As an example of the autonomy of these services, the oversight for NVT is provided by each separate municipality in Napa Valley. There is currently a study, sponsored by the MTC, investigating the feasibility of merging transit services in the Valley into a single joint powers board.

The VINE and NVT have reporting requirements to each of the municipalities they serve. In addition, because of funding mechanisms, these agencies are also accountable to the MTC (for RTIP funds) and Caltrans (for STP, TDA, and Section 9 funds). They are also connected by modem to the MTC's ADA database. As with other communities, they do their own certification for ADA eligibility in the Napa valley, but this data is shared with other operators in the Bay Area through the MTC's database.

Information for Operations and Service Planning

The VINE and NVT have a number of means of collecting and using data for operations and service planning. These include:

1. Driver reports, filled out manually, that contain passenger boardings and fares paid by run, revenue hours and revenue miles, and significant deviations (> 10 minutes) from schedule;

2. Electronic fareboxes, recording route, run, and fares by type of fare;

3. Manual checkers for Section 15 passenger-mile estimates; and,

4. An automatic vehicle location system.

The first three methods are reasonably straightforward. The driver reports are compiled daily and are input in Quattro-Pro spreadsheets for later analysis. Based on these reports, monthly, quarterly, and annual system progress reports are generated. The electronic fareboxes are also down-loaded daily using electronic probes at the maintenance garage. Passenger-mile statistics are collected quarterly by manual checkers; Ms. Dahlgren expressed some dismay at this effort, simply because the statistics are not useful for her and are very expensive to collect. All of this data is kept on a local area network (LAN), connecting the maintenance garage, the dispatching office at the transit center, and the administrative offices at the City of Napa Department of Public Works (i.e. for Ms. Dahlgren and her assistant).

The VINE and NVT have had an automatic vehicle location (AVL) system since March 1995. A product supplier, 3M, approached these agencies about being a beta test site for an AVL product they were developing, and offered free use of the system in return. The system uses GPS receivers on board each of the buses, and an on-board computer displays to the driver whether he/she is running on, ahead, or behind schedule. Data for the bus computers is downloaded to the bus every morning via a short-range wireless device at the bus garage; the same device is used to upload computer records at the end of the day. One piece of data that is uploaded and downloaded is the polling method for the bus; according to Ms. Dahlgren, the level of polling may be based on frequency (e.g. every 5 or 10 minutes) or on location (on/off route, at particular time points, etc.).

Software on the LAN is used to show vehicle locations, schedule adherence, run number, vehicle number, driver, route mileage, etc. In this way, the dispatchers can track the vehicles in real time. Communication between the vehicles and the dispatch center is performed using a cellular data network (either Cellular One or GTE MobileNet). A special clearance from the state public utilities commission was obtained to operate this cellular network. Charges for the cellular system are thus based on a per-packet (i.e. "burst") basis, rather than the usual per-minute charges for voice communication, yielding significant cost savings over typical cellular communications.

Additional hooks to the AVL system include an automatic signal priority system (replacing the older manually-generated messages to local signals) and silent alarms. According to Ms. Dahlgren, one of the main motivations for the AVL system was to automate the valley's signal priority system, as there were often problems with drivers forgetting to reset the signals after receiving the pre-emption.

There is currently no thought to integrating the AVL with the electronic farebox. However, Ms. Dahlgren indicated that she will receive federal Section 3 funds to connect the AVL system to an automatic voice annunciation system for ADA purposes. Automatic passenger counters may also connect with the AVL system, but there are no definite plans at this point to introduce this capability in the near future.

Other Technologies

Ms. Dahlgren identified some need for a security system on board the buses; this need is heightened by the fact that over 35% of the passengers on the VINE are younger (and presumably more mischievous) students. On her wish list was a means of getting video images from the buses to the dispatch center, so that dispatchers could keep an eye on activities on a bus. However, given the technical difficulties of getting video over the communication system, she is now investigating the use of simple on-board cameras.

The VINE and NVT have looked at compressed natural gas as a fuel option for their bus fleet, but was considered infeasible due to high costs of a CNG plant, retro-fitting the maintenance garage, and other physical plant requirements. In another area, the maintenance shops are running a Prototype EMS computer software to do maintenance record-keeping, including inventory, bus maintenance records, etc.

Summary of Visit to Orange County Transportation Authority

We visited the Orange County Transportation Authority (OCTA) on Thursday, July 6, 1995. Our meeting was coordinated by Shirley Hsiao, a senior transportation planner at OCTA who had facilitated their response to our questionnaire. She had us meet with several people across different departments, and our full visit lasted over five hours. For the ease of organization, each section below describes various interviews we had during the day.

Background

OCTA is the second largest agency (second only to the Los Angeles Metropolitan Transportation Authority) which we have visited during our site visits with over 500 buses and over 300 paratransit vehicles. OCTA is responsible for all of the transportation needs within Orange County, this includes fixed-route bus transit, demand-response paratransit, highways (in conjunction with Caltrans), and the road network. During our visit we only spoke to people from the transit division (fixed-route and paratransit).

GIS and long-range planning

We began the day talking with Ms. Hsiao about OCTA's long-range planning and analysis tools. At present, OCTA is developing a geographic information system (GIS) as an integrating data analysis tool for a variety of applications. The GIS itself is an Arc/Info system running on a set of inter-networked IBM 6091 workstations; data is distributed over this set of (5-6) workstations. In the future, a client-server architecture may be implemented for storing the large volumes of data for the GIS. In this case, the GIS applications run off of a Thomas Brothers base map.

The OCTA has tried to use the GIS to generate and analyze some long-term planning information. In particular, OCTA currently has an interface between Arc/Info and EMME/2, a travel and transit demand modeling package. GIS is seen as a tool for data analysis, while packages such as EMME/2 are useful for network assignment in long-term planning. In addition to EMME/2, OCTA is currently exploring an interface to a similar modeling package called Tranplan, which is used by most other transportation planning organizations in Southern California. In this regard, OCTA is currently coding in the Tranplan traffic analysis zones (TAZs) and zone connectors into their GIS. It is hoped that Arc/Info can serve as an integrating platform to connect EMME/2, which has good transit modeling capabilities, with Tranplan, which has better highway modeling capabilities.

OCTA is employing a summer intern to input manually their routes and schedules into the GIS. At the same time, OCTA is talking with the makers of Trapeze, the routing and scheduling software, about an interface to Arc/Info. This would then have the advantage of electronically (and possibly automatically) coordinating the GIS-based data analysis with up-to-date routes and schedules. As evidenced by the summer intern and the large size of OCTA's bus operations, this would be a considerable time savings to the agency.

OCTA already has a considerable amount of data in their GIS. This includes (as examples): recent ride check and other Section 15 data; worksite survey on travel patterns from the Southern California Air Quality Management District; a recent on-board survey; land use data; and, paratransit pick-up and drop-off records. However, most of this data has come directly from other sources; Ms. Hsiao's group has little budget for additional data collection efforts. Some of the transit projects which they have performed using the GIS are a worksite survey, tracking the walking distance to/from stops along routes, land-use analysis, light and commuter rail planning, park-and-ride demand forecasting, and route structure analysis. We were also shown briefly a traffic signalization project which had been performed on the GIS.

Advanced technology applications

We also met with Dean Delgado, a senior transportation analyst who leads OCTA in projects relating to so-called intelligent transportation systems (ITS). He is currently involved with two projects: the Orange County TravelTIP and the Transit Probe project. The TravelTIP project is designed to provide travel information to residents and visitors to Orange County regarding their transportation options. Information will include current traffic conditions and at least static transit route and schedule information. This information would then be disseminated by telephone, television, kiosks, and perhaps also radio.

The TravelTIP project was identified for early implementation by the ITS Master Plan for the county several years ago. As may be implied, there are a significant number of institutions involved in providing this database of traveler information: the cities of Anaheim, Irvine and Santa Ana; Caltrans District 12; and OCTA. At present, a team headed by Rockwell is about halfway through the system design; this initial phase should be completed by February 1996. As the TravelTIP is funded 80% through the federal ITS program through the FHWA, there is currently some question about whether there will be sufficient funding to bring the project to implementation (slated for 1997).

The transit probe project involves a cooperative agreement between OCTA, Caltrans, and the cities of Anaheim and Santa Ana. Basically, OCTA will be equipping 43 vehicles on their fleet with a GPS-based AVL system, allowing monitoring of transit service characteristics as well as some measure of ambient traffic conditions. In this way, the AVL system may be used to monitor transit operations and also provide real-time information on speeds on arterial roads and freeways, at least on some selected routes. This project provides a demonstration of the utility of a transit-based AVL system for traffic assessment, as well as a framework for institutional cooperation and data sharing in Orange County. The probe project may also dovetail nicely into the TravelTIP, providing real-time transit information, and also may lead to a full implementation of AVL across the full vehicle fleet at OCTA.

Radio and communications

Mr. Frank Lonyai then took us on a tour of the Garden Grove bus facility, including the communications room and vehicle maintenance facilities. In terms of communications, OCTA has standard two-way radios on both the fixed-route and paratransit operations. There is a project now underway to replace these radio systems; a consultant is now doing a needs analysis and will shortly make recommendations. Issues that have come up so far include the need to accommodate AVL and other data needs, as well as the overall cost of the radio system.

The fixed-route system operates five 800-MHz channels. A single channel is used for data communications, and is based on vehicle polling every three minutes. The data channel polls the vehicles for any request-to-talk or silent alarm situations; in addition, each bus regularly transmits the vehicle ID, run number, operator ID, and route. The remaining four fixed-route channels are divided up into: one channel for north-south routes, one channel for east-west routes, one auxiliary backup channel, and one channel for support vehicles (maintenance, field supervisors, etc.). A computer at Garden Grove provides some "intelligence" in allocating the radio channels across users.

All fixed-route radio communications are handled through two repeaters; radio messages are carried from the vehicles to the repeaters via microwave, and from the repeaters to the radio room via standard phone line. In an emergency, a backup radio system could operate directly from the radio room at Garden Grove. At a separate division, the paratransit service (ACCESS) uses a set of five radio channels in the 500-MHz region of the spectrum. Their allocation of channels is similar to that for the fixed-route service, but they operate with eight repeaters (rather than 2) simply because of their larger service area.

Operators requesting to speak with a radio supervisor must tap their microphones at one of three priority levels: request to talk, priority request, or silent alarm. The supervisors may then use the bus run number and route to look up bus locations and schedules for a given call. Silent alarms average about 1-2 real calls per month; accidental tripping of the switch accounts for 70-75 such "alarms" per month, mostly in the maintenance yard.

There is currently a project to connect the three divisions (Garden Grove, Irvine and Anaheim) on a wide-area network with the main administration building (downtown Orange). This would allow a consistent set of static schedules, driver assignments, runs, etc., and would also allow management personnel at the administration building to receive information on real-time operations.

Fleet and maintenance management

OCTA has instituted a fluids management program that uses a short-range RF interface to get a vehicle ID and a mileage count as it enters the fluids area. At that time, the appropriate pumps for that vehicle are activated. The system then automatically records the amount of fluids used, allowing for automated accounting of fluid use and of vehicle performance and fluid maintenance. This has proven helpful in reducing the manpower associated with maintenance reporting, and also helps in verifying that vehicles were maintained to appropriate levels for warranty claims. A modem allows garages to share this vehicle and fluids data several times per day.

OCTA also has contracted with SAIC to develop software and hardware for automating the collection of vehicle condition information. At present, OCTA owns six modules that can be installed on a bus to monitor as many as 10 functions on the bus. This is done through electronic leads and thermocouples to various components on the vehicle. At night, when these vehicles are parked in the yard, an RF transceiver in the garage automatically polls these machines and downloads the accumulated daily data to a PC. Additional software in the PC processes this data and produces summary reports for management. [According to Mr. Lonyai, the use of such modules is necessary because of the proprietary nature of existing computers and chips on the various vehicle components (engine, transmission, cooling system, etc.). Without an open standard for this data, there is no hope to retrieve this information through simpler means.] This data is also used to track problem vehicles, maintain warranty information, etc.

Paratransit scheduling and customer processing

We spoke briefly with Tim Wilcox who assists in scheduling and managing the ACCESS paratransit service in Orange County. ACCESS handles approximately 3500-4200 paratransit calls per day, with 180 vehicles operating during peak periods. Much of the service is run on a subscription basis, but about 1200 calls per day are for casual rides, which must be called in from 1 to 14 days in advance. The tool used to maintain a client database, a locations database, and to do service scheduling and routing is QuoVadis, a software product from UMA Engineering (the same company that makes Trapeze for fixed-route service).

OCTA has been using QuoVadis since January of 1995. The new software replaces a system that would take rider requests up until the day before, then do a single batch job to determine routes, schedules, etc. While it allowed some efficiency in trip and vehicle assignment, this resulted in OCTA making call-backs every day to confirm rider travel times. The QuoVadis software automatically inserts a call into an existing or new vehicle trip for a particular day, allowing confirmation of travel times at the time of the rider request. The whole process to call and receive a time slot for a trip now takes on the order of 2-3 minutes with this software.

ACCESS is a contract service in that the drivers alone are under contract; at present, there are 3 contractors. However, the passenger ADA certification, ride reservation, scheduling, and vehicle dispatching are all done internally at OCTA. To coordinate these activities, the various management and supervisory personnel are all on a LAN. There is some discussion of putting this information on a WAN, allowing a local download of vehicle and driver schedules locally at the garage at the time a driver pulls out, but these discussions are preliminary.

Fixed-route scheduling and customer information

Finally, we met with Mark Maloney, who is a project manager for the fixed-route scheduling using Trapeze. OCTA has been using Trapeze since September of 1994, and has managed to put all of the route and schedule information into Trapeze. This includes geo-coding of over 6000 bus stops and associated route patterns. The software handles OCTA's 60-70 routes and various branches with seeming ease. This version of Trapeze also automatically generates stop lists and reports for the Section 15 ride checks.

Since February, OCTA has also be refining and using a package called Customer Information, also from UMA. This system, installed on the LAN in service planning and also at the customer information office in Garden Grove, interprets the route and schedule data from Trapeze to do customer trip itinerary planning. Daily updates of schedules are sent over a WAN between the planning office and the customer information office. There, a peak of 12 operators handles calls on the 1-800-636-RIDE line. In addition to the project to connect Trapeze to Arc/Info, there is also an effort to connect this Customer Information package to Arc/Info, and to connect Trapeze with the QuoVadis software for paratransit.

Summary of Visit to Foothill Transit

We visited with Mr. William Forsythe at Foothill Transit on July 6. We had initially set up an interview with Mr. Roger Chapin, the acting general manager, but he was unavailable. Mr. Forsythe is his direct supervisor, and is president of Forsythe and Associates, the company that manages Foothill Transit. We spent some time talking about the experience at Foothill Transit and some of their philosophy and use of information technologies.

<u>Agency history and performance</u>

Foothill Transit was created in 1988 under a Joint Powers agreement for several suburban communities in Los Angeles County, defined within the San Gabriel and Pomona Valleys. These communities were not well served by the (then) Southern California Rapid Transit District (SCRTD), and jointly decided to create a so-called "transit zone" within SCRTD's jurisdiction. Efforts to create the zone began in 1985, culminating in the successful launch of the Foothill Transit Zone in 1988.

Foothill Transit is overseen by a "Zone Membership" made up of representatives from each of the communities in the zone (20 cities) plus three members from the county at large, for a total of 23 members in the full membership. This membership meets once per year, and sets high-level policy for Foothill Transit (i.e. fare changes, significant changes in service, and budget approval). The 20 communities are further subdivided into 4 regions. The representatives within each region select one representative to serve on a 5-member executive board, with the fifth member being chosen from the county at large. The executive board meets monthly and provides more public policy direction to the agency.

Foothill Transit itself has no employees. The unique feature of Foothill Transit is that the management and administration, as well as all bus operations, are provided through private contract. Mr. Forsythe's company currently performs all management, planning, and financial oversight required for the operations. Bus operations are contracted out in "service packages" consisting of 1-6 routes; at present, two contractors are providing the full complement of bus services. The four service packages are put out to bid fairly frequently; the contract periods typically run for 3 years, with two one-year options that may be exercised. Service packages are put out to bid at different times to ensure that one operating agency does not operate all routes. At least in Mr. Forsythe's opinion, leveraging the private sector in this way allows considerable economies in providing transit service. It is also notable that such a large system has been fully privatized: in total, Foothill's bus service consists of about 24 routes with 190 buses in operation during the peak period, making Foothill the second largest transit provider in Los Angeles County.

Funding for Foothill service comes from a variety of sources, including state Transportation Development Act (TDA) funds, local Proposition A and Proposition C sales tax revenue (1/2 cent each). This funding arrangement initially allowed Foothill to begin service without use of federal funds, and, hence, without facing the stiff labor requirements of Section 13(c) of the Federal Transit Act. More recently, Foothill has applied for and received Section 9 funds for capital; this funding was received only after a legal challenge from the transit unions at the Los Angeles County MTA (formerly the SCRTD).

According to Mr. Forsythe, Foothill's focus has been on customer service and in improving the quality of transit service for communities in the transit zone. There are a number of things that seem to separate Foothill from other transit agencies in terms of their services:

- Services are not required to be put out to the lowest bidder; other factors such as the company's track record and service reliability weigh heavily in the decision for a service award.

- The operator's contract allows a reasonable profit margin.

- There are specific disincentives in the operator's contract for a high-quality service. Penalties of $250 per violation are cited for:

  A. A driver who is not courteous.
  B. A bus is not clean or graffiti-free or free of body damage.
  C. A bus is significantly off schedule (> 10 minutes) without appropriate justification (i.e. traffic or delays due to customer service requests).
  D. A bus goes out of service during its daily runs due to lack of appropriate maintenance.
  E. A bus is not in sufficient condition to meet a planned pull-out for revenue service.

- The buses, while being standard transit buses, are well-upholstered and do not have any interior or exterior advertising. In Mr. Forsythe's view, this is a key deterrent to graffiti and other vandalism on the buses.

- The managing firm has the right to remove drivers and buses from service if performance is not adequate.

Foothill has also managed to increase service frequencies and hours of operation since 1988, and has reconfigured routes to serve its customer base more directly. This includes new feeder service to local Metrolink stations and some additional express service to downtown Los Angeles. In the coming year, additional service is planned to serve a set of 8 transit centers that are being developed at various locations throughout the zone.

Mr. Forsythe believes in service promotion, but credits the growth in riders at Foothill to more "word-of-mouth" advertising than any other means. At the same time, each of the communities in the transit zone has taken responsibility for marketing the transit service to its citizens, through public advertising, mailings of route and schedule information, public meetings, etc.

Foothill has also set up several "Transit Stores" in the zone to distribute route and schedule information and to sell magnetic-stripe debit-based fare cards. It is the hope of Foothill Transit to open a "Transit Store" in each city in the transit zone.

The performance of Foothill Transit since 1988 has been relatively impressive, particularly in reducing costs, providing additional service, and increasing transit ridership. Particularly when compared with the old service operated by the SCRTD or the current services operated by the MTA, Foothill Transit is doing very well. Ridership has grown to about 37,000 riders per weekday, compared with about 30,000 per weekday when the service was operated by the SCRTD in 1986. At the same time, Foothill is offering approximately 50% more service hours (with about 50% more peak buses) than SCRTD in 1986. This is being achieved even though the total operating cost has actually decreased very slightly since 1986, and the total public subsidy for operating costs has decreased by 21% (i.e. from higher revenues per passenger). Thus, while the ridership improvements are not exactly spectacular, the fact that these have been achieved simultaneously while lowering costs is very noteworthy.

Uses of information technology

Unfortunately, Foothill Transit did not complete our survey. As a result, we did not have sufficient "raw material" going into the interview to ask more educated questions about their uses and attitudes toward information technologies. A few points can be made about their capabilities:

- Foothill has a fairly standard two-way radio system for communicating with drivers, operating in the 900-MHz band.

- Passengers can use a magnetic stripe debit card, called "Metrocard," on all buses in the system. This card is compatible with systems on Culver CityBus and Montebello Bus Lines, and perhaps in the future will be available on other bus fleets in Southern California.

- Customer information is connected to the Los Angeles County MTA's Customer Information Computer System (CICS), allowing access to county-wide transit information.

- All PCs are networked on a LAN, containing such items as the agency's routes, schedules, and a maintenance information system for parts and vehicle records. Field supervisors also collect ride check and time check data on laptop PCs in the field and are downloaded onto the network daily.

Mr. Forsythe indicated that the agency has different ideas about the value of AVL. His belief is that it may assist in keeping buses on schedule and therefore providing better customer service; however, given the current contracting provisions, service reliability is not a big problem at Foothill. The AVL also can be invaluable as a safety feature for locating buses during "silent alarm" conditions. However, his concern involved the point at which drivers become more concerned about keeping a schedule and being tracked than about providing good customer service. In his opinion, customer service and convenience should be of highest priority in determining the value of information technologies like AVL.

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