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Advanced Public Transportation Systems: A Taxonomy, Commercial Availability and Deployment Phase II

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ADVANCED PUBLIC TRANSPORTATION SYSTEMS: A TAXONOMY, COMMERCIAL AVAILABILITY AND DEPLOYMENT PHASE II

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ABSTRACT

This study explores the development and availability of APTS (Advanced Public Transportation Systems) technologies. APTS technologies can revitalize transit by directly improving service, increasing transit efficiency and reducing operating costs, as well as by producing direct benefits for travelers such as reduced travel times, increased safety and security and reduced stress in dealing with transit unreliability. To understand APTS impacts, this study refines a taxonomy of transit technologies developed during Phase I of the study and uses it to explore the availability of new technologies and their impacts in transit agencies. The refined taxonomy is based on defining the features, functions and performance characteristics of transit technologies. Further, new technologies are implemented in a context described by the spatial, temporal and user dimensions, i.e., where, when and for whom is the technology implemented. These dimensions of the implementation context then determine the impacts of APTS technologies.

Based on the taxonomy, three surveys were conducted and their results are reported. To explore the availability of APTS technologies, technology suppliers were surveyed. They were asked questions about the features, functions and performance of transit technologies, and the potential impacts on travelers and transit operators. To determine the extent of APTS testing, deployment and impacts, transit operators were surveyed. The respondents either were in the planning phase or had implemented an AVWCAD (Automatic Vehicle Location/Computer Aided Dispatch) system or a transit information system. The questions related to technology features, functions and performance as well as their implementation and impacts. The implications of key findings from the surveys are summarized in the report.

Keywords: Intelligent Transportation Systems, Advanced Public Transportation Systems, Evaluation, Advanced Traveler Information Systems, Automatic Vehicle Location Systems, Computer Aided Dispatch

EXECUTIVE SUMMARY

This study explored the commercial availability and deployment of new transit technologies. Survey research showed that APTS (Advanced Public Transportation Systems) technology suppliers had several products that were likely to vary in their direct and indirect impacts on transit operators and travelers. In the suppliers survey, most respondents either agreed or strongly agreed that their largest revenue technology will reduce transit operation costs, transit management costs and increase the comfort and convenience of transit travel. However, there was uncertainty about whether the new technologies will necessarily increase transit ridership, safety and security. This contrasts with one of the stated high priority goal of transit agencies which is to provide safe transportation. Moreover, most APTS technologies offer substantial flexibility in integration with other systems and a substantial number of systems were reported to be integratable with other systems. Overall, in the view of APTS suppliers, most new technologies can support either traveler decisions or transit operator decisions and in some cases both types of decisions.

The surveys of transit agencies provide insights into experiences with ATIS (Advanced Traveler Information Systems) and AVL/CAD (Automatic Vehicle Location/Computer Aided Dispatch) systems. In the pre-trip ATIS survey, all respondents agreed that the pre-trip information system was a valuable investment for their agency and for the customer. Further, there was broad agreement that the pre-trip ATIS improved the agency's image and increased access to transit services. A majority of the agencies agreed that their pre-trip information system has the ability to increase transit ridership and reduce the number of passenger complaints. However, the benefit of the system as a means of attracting auto users to transit was

questionable. The benefits of a pre-trip ATIS to the traveler as seen by the transit agencies were that they generally reduced uncertainty about transit service, reduced anxiety of travel and enabled travelers to plan trips more effectively. However, tourists were viewed as experiencing the most difficult transition to the new technology.

The AVL/CAD survey indicated that those who responded positively include general managers, board of directors, planners, schedulers and analysts, dispatchers, phone operators/customer service agents, on-street supervisors, ride or trip checkers, maintenance staff, information system managers and drivers (in that order). They resulted in improved ability to monitor vehicle location, improved schedule adherence, and enhanced security for bus drivers and passengers.

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CHAPTER 1

INTRODUCTION

While traffic congestion grows, public transportation continues to lose market share in the United States. Specifically, the share of transit trips shows a declining trend: 3.6% in 1969, 2.6% in 1983 and 2% in 1990 (Pisarski 1992). Moreover, the use of public transportation for work travel has declined from 12.6% in 1960 to 5.3% in 1990 (Ball 1994). Recent advances in electronic technologies may allow greater integration of transit services and increase transit use. Advanced Public Transportation System (APTS) technologies may increase transit efficiency, improve transit level of service, reduce costs and avoid further reductions in transit use. To assess the potential of APTS technologies, there is a need to systematically explore their impacts (Khattak et al. 1993). The main objectives of this study are to:

- Refine the definition and classification structure for APTS technologies developed in Khattak et al. (1993) and examine the nature of APTS impacts.
- Use the classification structure for exploring availability and deployment of new transit technologies. Specifically, conduct a survey of technology suppliers, a survey of AVL/CAD (Automatic Vehicle Location/Computer Aided Dispatch) system implementers and a survey of ATIS (Advanced Traveler Information Systems) implementers in the transit industry.

To assess the potential for new transit technologies, Khattak et al. (1993) developed an initial technology classification structure and applied it to investigate the availability of new technologies in the market. The current structure is a refinement of the original structure. After refining the taxonomy for classification of new transit technologies, survey research was used to explore the commercial availability of new technologies.

Our Phase I work was well received in academia and it was recently published in the *Journal of Public Transportation* (Khattak et al. 1996). There is some overlap between this report and Phase **I** report by Khattak et al. (1993) with regards to the conceptual structure. However, the overlap is necessitated by the desire for completeness and the sections where the overlap exists are clearly identified.

The structure developed to classify and investigate the availability and deployment of new transit technologies is based on defining technologies in terms of their features, functions and performance. For example, one feature of transit information technology is the communication medium (whether information is disseminated through visual or audio means), a function is served by the content of disseminated information (subject matter and whether the information is historical or real-time) and a key performance measure is information quality (accuracy and relevance).

To support the implementation of APTS technologies, their spatial, temporal and user dimensions should be defined. For example, the spatial dimensions of transit information technologies are the transit vehicles that are monitored and the roadway and/or transit links served. The temporal dimensions are the free-flow travel times on relevant roadway and/or transit links, the times network monitoring is in effect and frequency of information updates. The user dimensions are whether certain travelers access transit information devices and actually choose to take transit.

APTS technologies can be traveler-based, operator-based or both. The traveler-based technologies influence traveler behavior *directly* but can indirectly impact operators (e.g., pre-trip or in-terminal information systems). Similarly, operator-based technologies influence transit operators *directly* and travelers indirectly (e.g., Automatic Vehicle Monitoring systems). Mixed technologies simultaneously impact both travelers and operators. Finally, the technologies are implemented and the impacts occur in a context characterized by the spatial, temporal and user dimensions. For example, the transportation network structure, its state at various times and population characteristics (density and socioeconomics) can be important determinants of APTS impacts.

The following chapters describe the process of transit technology implementation. Then, taxonomies for new transit technologies and their impacts are discussed. Next, the development, implementation and results of transit technology supplier and transit implementer surveys are presented. Finally, the conclusions are drawn and the need to develop a strategy for systematically testing new transit technologies is identified.

CHAPTER 2

LITERATURE AND CONCEPTUAL STRUCTURE

LITERATURE AND CURRENT APTS EFFORTS

This study explores the availability and deployment of newly developed transit technologies for field testing in transit agencies. There are several projects in the United States aiming to test different advanced technologies (see Khattak et al. 1993). For example, the Federal Transit Administration (FTA) and California Department of Transportation (Caltrans) are co-funding a four-phase California Smart Traveler Project where public and private sectors will jointly test an audiotext/videotext-based Advanced Traveler Information System in suburban California. We hope to help the development of such projects through research on the features, functions and performance of new transit technologies and through suggestions on deployment strategies. This requires that the technologies, their implementation context and impacts be defined clearly. Importantly, a structure, knowledge and models are needed to determine the impacts of APTS technologies individually and collectively.

Unique Features of This Study

This study will complement other APTS studies (e.g., Schweiger, Kihl and Labell 1994). Important aspects of this study are:

- Development of taxonomy that defines direct and indirect operator and traveler impacts of APTS technologies.
- Defining APTS technologies by their design dimensions relevant to functional evaluation

and application dimensions relevant to field testing and implementation.

- Surveying APTS suppliers and implementers and examining the synergistic potential of APTS technologies in various implementation contexts.

This requires exploring individual effects and interaction effects of new technologies--an issue not identified or addressed in the APTS literature. Further, this develops a unique set of surveys, providing insights into the APTS market and early deployment of AVWCAD and transit information systems. Finally, this study suggests a method for synthesizing knowledge gained from field tests and early implementations. That is, to facilitate APTS deployment decisions, what can be learnt from past successes and mistakes.

Summary of Prior Research Effort

In the Khattak et al. (1993) study, about 100 questionnaires, based on the classification scheme, were sent to technology suppliers--twenty-seven responded, including most major Advanced Public Transportation Systems suppliers in the United States. The survey results showed that technology suppliers had several products that vary in their benefits to transit operators and transit users. For example, technology suppliers rated automatic vehicle location and identification systems highly on improving monitoring as well as controlling transit headways for transit operators. Suppliers also reported that transit information technologies will have relatively strong impacts on transit users.

Advanced Transportation Systems: The State-of-the-Art

Schweiger, Kihl and Labell (1994) provide a summary of most advanced public transportation projects throughout the US, Canada, and Europe. The report covers Smart Traveler Technology, Smart Vehicle Technology and Smart Intermodal Systems. The authors define each technology cluster and identify potential benefits from the technology or system. Their sub-categorization is as follows:

The Smart Traveler Technology

Smart traveler technologies include Passenger Information Systems, Real-Time Rideshare Matching, Multi-provider Trip Reservation and Integrated Billing Systems, Integrated Fare Media, Electronic Ticketing and Automated Trip Payment. The authors provide a list of the studies/projects under research/implementation. Their information is primarily derived from interviews with APTS implementers. In some instances, the future prospects for the technology are discussed. Particularly, the authors have compared the use of Electronic Ticketing and Automated Trip Payment in different modes of public transportation such as motor bus, heavy rail and commuter rail.

The Smart Vehicle Technology

Smart vehicle technologies include communication systems, Automatic Vehicle Location (AVL) Systems, Transit Operations Software, and Automated Demand-Responsive Dispatching Systems. According to the authors, the applications of new communication technologies seem non-existent. However, they provide detailed information about AVL, i.e., a list of implementers, their size (number of vehicles), cost of the system, status (research or early implementation), AVL suppliers and type of technology (GPS, sign-post, dead-reckoning, etc.).

Smart Intermodal Systems

Smart intermodal systems include Traveler Information Systems, Multimodal Smart Cards/Payment Systems, High Occupancy Vehicle Facility Monitoring, Transportation Management Centers, and Vehicle Guidance Systems.

Relevant California Projects

We document selected California projects that are interesting from the APTS implementation perspective.

Santa Clara Paratransit Project

The Americans with Disabilities Act (ADA) requires that comparable public transportation services be provided to the disabled. To meet this requirement and to serve an anticipated increase in ridership in the next few years, the Santa Clara County Transit District (SCCTD) has decided to help OUTREACH implement AVL using the GPS satellite network, a digital geographical database (DGD), and a paratransit routing software (PRS) to automate route planning (Chira-Chavala and Kanafani 1993). (OUTREACH is a non-profit private organization contracted by SCCTD to provide paratransit services to the disabled.) The AVL-GPS is probably the first of its kind being implemented by a transit agency. It is hoped that the integrated system will improve tracking, extend the basemap, and add routing capabilities to the existing semi-manual paratransit planning system. Since the new integrated system can operate in both pre-planned and real-time modes, OUTREACH can perform real-time scheduling, and thus increase shared rides and demand-response rides. Furthermore, the real-time system will improve transfers between paratransit and fixed route transit, and thus reduce operating costs for long trips that are currently serviced by paratransit vehicles alone.

The project is divided into three phases:

1. The installment of the UMA Trapeze routing and scheduling software and necessary hardware.
2. The upload of the geo-coded basemap and its database.
3. Finally, the installment of AVL devices and the overall integration.

The project is currently in its second phase, which is the upload of the geo-coded map and database. AVL devices will be installed first on 14 accessible vans, then on 33 selected taxi vehicles frequently used for paratransit rides, and finally on 15 buses operated by SCCTD. Overall, SCCTD expects the new system to increase ridership, to serve the ADA group on a cost-effective basis, and to provide a valuable operational test model to other agencies.

Riverside Paratransit System

The Riverside project derives its motivation from the ADA. The Riverside Transit Agency has implemented real-time scheduling and extended hours of service. Real-time scheduling requires the agency to install Pac Tel Teletrac equipment in 17 paratransit vehicles (Riverside Special Transit Program 1993). The equipment monitors vehicles in real-time and thus allows rescheduling/re-routing of vehicles to respond to real-time passenger requests. In addition, the system will be a useful tool for data collection and documentation of activities to meet Federal Transit Administration requirements. The system is expected to handle increased ridership, provide better service to the public, and improve the scheduling and routing tasks of the agency. The equipment is already installed and operational.

Summary of the Sacramento Rideshare Matching System

The Sacramento Rideshare project has two phases. The first phase is the evaluation of user needs and system requirements done by University of California at Davis--UCD (Kowshik et al. 1994), and the second is the operational test of the software being done by Sac Area Council of Governments (SACOG).

The UCD evaluation explores rideshare user needs and uses them as the basis to recommend functional attributes for a future rideshare matching system. The evaluation project has two primary parts: literature review and focus group interviews. The literature review identified the components of conventional rideshare matching systems and their success. Components of conventional rideshare matching systems are service provider, system characteristics and functions, and user characteristics. The service provider acts as the "middle-man"; that is, it collects information, generates matches, and disseminates them to interested parties. The service providers are generally a rideshare agency or a transportation coordinator at an employer site. The functions of the rideshare matching system include information storage, processing, updating and validation, dissemination, and program evaluation. Most information is currently collected or disseminated by mail or telephone. The matching may be done manually or by computer. A dynamic rideshare matching system will likely have all the components of a conventional one, except that its functional component has to be fully or at least partially automated.

The participants of two focus groups consisting of carpoolers and solo drivers were asked about their preference for carpooling and their reaction to real-time ridesharing, as well as what they expect from a real-time rideshare matching system. The authors felt that the two focus groups sufficiently identified all relevant user needs. From the literature review and focus group interviews, the following user needs were identified: background screening, information security, matching/reliability, system access, flexibility, and compensation scheme. Based on the needs, the authors suggest the functional features of the future system. See the attached list of user needs and the corresponding functional requirements in Table 1. Ideally, the software being developed for the project should cover the listed functional requirements to some extent.

Concurrently, SACOG is actively advertising the real-time rideshare system with employers and other participants. SACOG has installed the hardware necessary to run the system. The remaining tasks are to build a rideshare database, develop an automated telephone and front end graphical user interface, integrate the software with a GIS basemap, and perform a demonstration for the system's operators and users.

OCTA Transit Probe Project

A cooperative agreement has been established between the California Department of Transportation (Caltrans) and the Orange County Transportation Authority (OCTA) to develop an integrated information system for transit and traffic management and for traveler information. This project is intended to improve the cooperative management of the transportation system and to allow travelers to get real-time information on both transit and traffic conditions in Orange County. Specifically, the project has the following objectives:

- Provide traffic managers with information to better manage their network flows.

- Provide transit operators with information to improve efficiency of vehicle operations.
- Provide the public with both transit and traffic information with which to evaluate trip-making alternatives.
- Provide a framework of institutional agreements.

There are several elements of this project, and a number of related existing and planned activities, designed to meet these objectives. The particular elements of this project include:

- Implementation of a global positioning system (GPS) for transit vehicle tracking, for about 40 transit vehicles.
- Development of a database of transit vehicle locations, speeds, and the congestion levels on freeways and arterial segments of the Orange County road network. This information is to be received by OCTA in real time, processed, and disseminated to OCTA bus dispatchers and traffic managers at the City of Anaheim, the City of Santa Ana, and Caltrans District 12.
- Development of three kiosks at appropriate locations in Orange County, allowing the public to access this real-time database.

This project is also well into the planning and system integration phase. Testing is to begin in summer 1997, with implementation in winter 1997. An on-going evaluation, conducted by researchers within the PATH program, is assessing the institutional, user acceptance, and system performance elements of this project.

TravInfo

TravInfo is a major federally funded Field Operational Test that will improve the quality of travel (traffic and transit) information in the Bay Area. It is being managed by the Metropolitan Transportation Commission; PATH is the independent Evaluator. Incoming travel information from various sources will be fused in a Transportation Management Center (TMC). Real-time information will be disseminated to the general public and information retailers. The means of dissemination will be diverse including pagers, cellular telephones, commercial radio broadcasts, in-vehicle displays, telephones and kiosks. The Travinfo project will also evaluate the feasibility of public-private partnerships in the travel information market.

TransCal Traveler Information System

TransCal is a comprehensive Interregional Traveler Information System (IRTIS) for the Interstate 80 and U.S. Highway 50 corridor connecting the Bay Area to the Lake Tahoe Region. TransCal has the following objectives:

- Reduce travel time and decrease congestion.
- Improve safety and security for rural and urban travelers.

TransCal collects data of interest to travelers in the TransCal region, converts the data to traveler information, and makes it available to travelers as quickly as possible. Information is disseminated through specially configured IRTIS receivers and displays, including in-vehicle devices, wayside traveler information kiosks, a touch tone telephone system and the Traveler Advisory Telephone System (TATS). TransCal is linked with TravInfo and has the capability of linking with other ATIS networks.

The project is well into the implementation phase and is under ongoing review by the Institute of Transportation Studies at the University of California at Davis.

Ventura/Lompoc Smart Card Project

The Ventura/Lompoc project is designed to complete development of an integrated high-tech Passenger Transaction Unit and a Vehicle Monitoring System. The project is intended to capture both the user and operator benefits which these systems confer.

The Ventura County smart card is a pre-paid bus pass that allows the user access to public transportation for the entirety of Ventura County. The Smart Card can be purchased by parents, employers and hotels to provide transportation to children, employees and guests. The cost is the same as normal busfare. However, the user has the convenience of using any system in the county without having to carry cash, coupons, passes, coins or tokens.

Concurrently, transit operators in Ventura and Lompoc have been supplied with systems which include, automatic vehicle location systems, automatic passenger counters, systems to produce synthesized speech, and fare transaction units. The project tests how well these systems can be integrated to improve schedule adherence, increase transit revenues and ridership, and aid in federally require data collection and reporting. The project is currently in the implementation and evaluation phase.

Overall, there are several APTS projects currently underway in California. Although these projects are being evaluated in one way or another, there is a need to broadly define the new technologies. Further, there is a need to carefully document the experiences of early implementers and provide a mechanism that will help transit agencies synthesize these experiences and use them to make technology implementation decisions.

PROCESS OF TECHNOLOGY IMPLEMENTATION

Figure 1 shows the process of technology supply, demand and implementation. The demand for transit technologies may come from the political process, which can encourage the use of APTS technologies. For example, the ISTEA (Intermodal Surface Transportation and Efficiency Act) legislation encourages multimodal systems because they can achieve certain goals such as reduce traffic congestion and pollution. Further, ISTEA encourages increased transit security by providing incentives. The Americans with Disabilities Act (ADA) promotes the use of certain technologies by mandating accessibility for the disabled. Besides federal policies, state and local policies create a demand for new transit solutions. Demand for improved technology in transit systems is also stimulated by the public, i.e., existing and potential transit users and citizens' groups (who advocate transit improvements).

Technology Definition

To refer to various aspects of APTS technologies, the term "technology space" is defined as having *design* dimensions (features, functions and performance) and *application* dimensions (space, time and user).

Design Dimensions

Transit technology developers and suppliers respond to the market (or sometimes create a market) by designing new technologies using advances in electronics and machines. To satisfy demand, suppliers develop technologies that have certain features, functions and performance characteristics. Table 2 gives a summary of advanced transit information technologies in terms of their features, functions and performance criteria (Khattak et al. 1993 provide similar summaries for other transit technologies). The technology features, functions and performance measures are based on a review of literature and our judgment (see Khattak et al. 1993 for a comprehensive review of relevant literature).

A set of design factors for pre-trip information technologies that partly determine impacts are the medium, content and quality of information. Table 2 suggests that pre-trip information systems can disseminate information by several means, including telephone, computer, and television. Therefore, the medium of information dissemination is important in technology definition. Transit information systems provide historical and real-time information on transit operations (routes, schedules and fares) to travelers; some systems do advanced ticketing and reservation. The content of information provided to travelers and other functions are important. Moreover, the accuracy and relevance of information provided is likely to vary; information quality is important in traveler decision making.

Application *Dimensions*

The spatial, temporal and user dimensions of the technologies partly determine impacts. In addition to the implementation context, the technology is also defined in terms of space, time and user dimensions. For example, Automatic Vehicle Monitoring (AVM) systems monitor transit vehicle location on specific network links, at certain times and the position information of vehicles is relevant to supervisors who make operations decisions (e.g., advise drivers on maintaining headways and schedules).

Context

Technology application takes place in an implementation context. The context is defined by transit agency characteristics such as service to certain populations (e.g., commuters, lower income, disabled), area characteristics and service on certain routes and at specific times (e.g., frequencies and schedules).

Impacts

The "impacts space" is defined in terms of *performance* criteria or dimensions (efficiency, service quality, cost, time savings) and *distribution* dimensions (space, time and users).

Performance Criteria

Technologies can have direct, indirect and simultaneous impacts on operators and travelers. For example, transit operations software, AVI (Automatic Vehicle Identification) and AVL (Automatic Vehicle Location) systems are expected to have strong direct impacts on transit operators while transit information systems are expected to directly influence travelers. The magnitude of direct operator impacts depends on the technology design dimensions, technology application dimensions and the implementation context.

The following direct transit operator impacts occur:

- Reduced costs such as maintenance, fuel, labor, management and marketing costs.
- Improved efficiency through better transit planning and operations.
    - Planning functions that can be improved include the selection of service area,

routes, stops and service frequencies.

- Operations improvements can come from a better ability to monitor driver and vehicle performance, improved scheduling and dispatching, reduced human errors, improved fare structure, and enhanced safety and security.

A key indirect benefit to a transit agency is increased ridership (and revenue). The extent of direct traveler impacts depends on the technology design and application dimensions and the implementation context.

The following direct traveler benefits due to APTS technologies can be expected:

- Travel time savings and reduced uncertainty in travel times.
- Improved accessibility.
- Improved content, medium and quality of transit information.
- Increased flexibility in travel choices.
- Improved (accident) safety and security.
- Ease of transit use, improved travel comfort and convenience.
- Improved satisfaction with transit service and customer feedback.

Indirect benefits of transit improvements accrue to transit travelers (and non-transit travelers through reduced congestion and pollution on highways).

Distribution dimensions

The impacts from individual APTS technologies can vary across the impacts space, i.e., the traveler impacts are distributed in space, time and by different travelers. Sometimes, APTS technologies may influence travelers differently by design. For example, a technology that enhances ease of transit use may be particularly appealing to the elderly and disabled, whereas a technology that increases travel choices may be attractive for shoppers (because of opportunities to shop at more destinations).

TECHNOLOGY DEFINITION AND EVALUATION'

Traveler Information Systems

Information content, medium and quality can influence various traveler choices. The taxonomy with regards to information content is explained below. Information can be either static or dynamic. Static information related to travel choices does not change with time, whereas dynamic information changes with time. Information can be further divided into qualitative or quantitative. Information content and travel choices form a two dimensional taxonomy matrix (Figure 2). **As** an illustration of this matrix, consider the following examples:

- *Static Qualitative, Multimodal Information (Cell* **"A")**. Static information about the availability of trip connections may support multimodal choice. For example, based on trip connection information, a traveler may use a bus instead of an automobile to reach the nearest train station.
- Static Quantitative, Multimodal Information (Cell "B"). Static information about transit schedules can reduce wait times and support mode choice.
- Dynamic Qualitative, Multimodal Information (Cell "C"). Real-time information about whether a bus is on-time can support the choice of using a bus or walking to a train

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[1] This section is synthesized from Khattak et al. (1993).

station, relieve rider anxiety and increase rider confidence in the system.

- Dynamic Quantitative, Multimodal Information (Cell "D"). Real-time information about expected arrival times of the next bus or train and expected delays can increase rider confidence and support travelers' modal choice.

In addition to static and dynamic information, transit systems may provide predictive information such as the expected time to recovery of a breakdown. Other functions provided by information systems are integrated billing service and multimodal (park-and-ride) trip reservation.

Information medium is important in determining traveler impacts. Whether a device is portable or fixed (and if fixed, whether it is in-vehicle or out-of-vehicle) and visual or audio are fundamental aspects of traveler information technologies. Furthermore, information quality is an important performance criterion. Clearly, individuals prefer higher quality information.

Where and when the information technology is implemented and who uses it are important in determining its impacts. The spatial dimensions of transit information technologies are the transit vehicles that are monitored through surveillance technologies and the relevant routes. The temporal dimensions are the free-flow travel times on transit links and the windows of time during which vehicles are monitored. The user dimensions include traveler decisions to access transit information and devices and, ultimately, whether the traveler chooses to ride public transit.

Rideshare Systems Technologies

Real-time rideshare matching systems allow trip makers to call in to request sharing a ride either as drivers or as passengers. Rideshare matching software allows travelers to review rideshare options, identify individuals whose needs closely match their own and reserve the trip in advance. Real-time rideshare systems will provide information on other travelers to potential ridesharers. The taxonomy matrix can be used to understand how travel decisions may be influenced by the content of rideshare information. The following information can be provided by a rideshare information service (for high occupancy vehicles):

- Static-Qualitative Information. Examples of static-qualitative information are potential candidates for rideshare, location of candidates' homes and their preferences.
- *Static-Quantitative Information.* Examples of static-quantitative information are preferred times of departure and distance to homes of the candidates.
- *Dynamic-Qualitative Information.* The rideshare system may inform customers of delays due to personal emergencies.
- *Dynamic-Quantitative Informution.* The service may give information on the number of persons available at certain times of the day, expected length of delays, and dynamic travel time information for HOV (High Occupancy Vehicle) and mixed-flow lanes.

Automatic Vehicle Control Technologies

Early versions of Automatic Vehicle Control System technologies provide driver warning and assistance, resulting in collision avoidance. The technologies can perform collision avoidance by obstacle detection, lane edge warning, and some level of lateral/longitudinal control. These systems are in their early stages of development. They use radar, infrared laser or sonar and provide either warning only or warning with braking. They can improve transportation safety by reducing accidents. The information provided to drivers is dynamic. It can be qualitative, such as you are very close to the right edge of the lane,” or quantitative, such as you are x feet away from the vehicle in the right lane.” The information will be disseminated through visual, audio or both means. The content, medium and quality of information will influence the driver response to the warnings.

Automatic Vehicle Monitoring, Automatic Ticketing, Automatic Passenger Counters, and On-Board Computer Systems

To support supervision and coordination, certain technologies provide surveillance and monitoring. Automatic Vehicle Monitoring systems can simultaneously improve transit operations (dispatching, scheduling and security), while providing real-time transit system operation information to travelers. Electronic Ticketing Systems (ETS) automate fare collection, increasing convenience and adding modest travel time savings to a trip. Automatic Passenger Counters (APC) send passenger counts to a central facility in real-time. Together APCs and ETS provide valuable data to transit operators on passenger loads and schedule adherence. These data can be used to support operations (dispatching and scheduling) and planning.

A taxonomy of technologies can be applied to the information that comes from various technology sources to a central transit management center. The operator decisions that can be supported include operations (dispatching, scheduling, supervision and monitoring, coordination and fare collection) and planning (area and routes to serve, service type--regular or express, stops, frequencies, fare structure, maintenance). The content of information, its medium and quality are likely to influence operator decisions. In addition, the analysis techniques used to process information (e.g., expert systems and breakdown duration prediction models) can influence operator decisions. The information can be historical (qualitative or quantitative) or real-time (qualitative or quantitative). For example, real-time information about the location of buses and whether they are on-time is available to operators through **AVI** and **AVL** systems. Such information can be used to avoid bunching, detect breakdowns and disseminate the information to travelers. On-board computers collect vehicle data (oil, water, engine temperature, vehicle speed, etc.) which can be used by the driver and transit operators to monitor vehicle performance and detect and deal effectively with breakdowns. Transit operations software supports transit planning decisions of vehicle and crew scheduling, maintenance and marketing. The software can also be connected to **AVI/AVL** systems for greater integration.

More generally, the type of information and how transit operators choose to process it can support different decisions. The information can relate to transit system performance, traffic system performance and traveler demand at various origins, destinations and times of day.

CHAPTER 3

METHODOLOGY AND RESULTS

METHODOLOGY

The objectives of this study are to define APTS technologies, track their development and implementation, and to evaluate their impacts on transit operators and travelers. Ideally, the study should address these objectives simultaneously. However, APTS technologies are under development and not fully implemented in transit agencies, therefore, their impacts are uncertain. During the first phase of this study, a decision was made to survey technology suppliers only (Khattak et al. 1993). This second phase has a broader scope and focuses on surveying technology suppliers as well as transit agencies that have adopted either ATIS or AVL/CAD system. The third phase will include traveler response to APTS technologies.

APTS Suppliers Survey

The methodology for the technology supplier survey is illustrated in Figure 3. After classifying Advanced Public Transportation Systems (APTS) according to their features, functions and performance, a survey was designed to explore their (commercial) availability. This design is largely similar to the Khattak et al. (1993) survey. The survey inquired (from technology suppliers) about supplier attributes, the application of their technologies in transit agencies and their perceived impacts on travelers and transit operators. The analysis of the APTS suppliers survey involves synthesizing information on available transit technologies.

A similar methodology was used to survey transit agencies that had implemented either

ATIS or AVL/CAD systems. These two systems were selected because (a) we wanted to balance traveler based technologies (ATIS) with operator based technologies (AVWCAD), (b) both technologies are relatively widely deployed in the field and (c) significant impacts are expected in both cases.

ATIS Survey

A list of transit agencies having experience with ATIS was compiled using professional contacts as well as published materials from trade magazines concerning the use of advanced technologies in public transit. The passenger information system survey was mailed to a total of 122 transit agencies identified as either considering implementation of such a system, in the process of installing such a system, or operating with an actual system. It was recognized that an agency's ability to respond to certain survey questions would vary depending upon the implementation phase of the technology. All of the transit agencies were encouraged to respond through a reminder letter mailed 3 weeks after the initial questionnaires were sent. Twenty transit agencies responded to the survey. The relatively low response rate may be due to the length and complexity of the questionnaire. Of the 20 respondents, 7 indicated that they were not currently considering the use of a passenger information system at their agency. Responses from the remaining 13 transit agencies having different degrees of experience with passenger information systems are tabulated. Note that statistical inferences cannot be drawn from the small group of agencies.

For clarification purposes, a 'no response' was coded whenever the respondent failed to provide any information in response to a particular question. A response of 'don't know' was coded under 3 circumstances: (1) when the respondent checked the 'don't know' category, (2) when the respondent provided information relevant to the question without successfully answering the question itself, (3) when the respondent inappropriately checked multiple responses. In some instances within this report (where a response of 'don't know' is difficult to imagine), incorrect responses have been specifically represented as their own category.

AVLKAD Survey

A total of 140 AVL/CAD questionnaires were sent to the various transit agencies operating in the **US** and Canada. To increase the response rate, a reminder letter was sent about three weeks after the initial surveys were mailed. Of the 29 respondents, 5 indicated that they had no AVWCAD system or did not indicate the type of their system. However, to determine perceptions regarding AVL/CAD systems, their responses to other questions, if applicable, are included in this report. The report also includes those who do not currently have AVWCAD, but are in the process of installing these technologies. Those who filled out the surveys include Directors, Transit Manager, Senior System manager, Assistant Superintendent, Directors, Communication System Specialist, Engineers, Project Managers, and Planners. In this report, we summarize the responses of transit agencies as cases rather than a sample of representative implementers. The experiences in individual cases are of interest.

RESULTS

Analysis of the APTS Suppliers Survey

This section presents a summary analysis of the APTS supplier survey. The survey consisted of three portions. The first portion explored the background of the companies. The second portion of the survey consisted of technology-related questions on the company's most recent commercially available products. The third portion consisted of questions about the impacts of largest revenue transit technology of the companies. Each part of the survey is discussed separately.

Part 1: Context

In all, forty responses were coded into the computer. Table 3 presents the country affiliation of the companies. Six of the respondents were foreign companies whereas, the remaining 34 were U.S. based. Seventeen of these companies have offices in California. The respondent profile is shown in Table 4. There is large variance in the number of years the companies were in business and in the number of employees. Six companies are relatively young as they were in business for five or less years. The majority of the companies (12) were in business from 6-10 years. Nine companies were in business for 11-20 years and eight were in business from 21-50 years. Five companies were in business for more than 50 years. Judging from the number of employees, it appears that both small and large companies are engaged in this arena.

The percentage of products manufactured in the **U.S.** ranged from zero to one hundred. Eight companies do not manufacture in the US. Only three manufacture between one and twenty percent of their products in the **US.** Ten companies manufacture between fifty one to ninety-nine percent of their products in the **US.** whereas, a sizable majority of the companies (15) manufacture all of their products in the **US.** All companies except two, manufacture some of their products in-house. The survey indicates that thirty-seven companies work with other companies, manufacturers, or consultants to provide a complete system. It appears from the profile that the respondents represent a wide spectrum of the companies in the market, both inside and outside the **US.** Table 5 presents the number of companies that sell different systems such as, Automatic Vehicle Identification (AVI), Automatic Vehicle Location (AVL), and Automatic Passenger Counter (APC) systems, etc. Each system is discussed below.

Part 2: Transit Technology

Automatic Vehicle Identification Systems

About one third (14/40) of the companies sell AVI systems. Table 6 shows the type of sensors/detectors utilized by the systems. Twelve systems are based on radio frequency (RF)/Microwave, five are based on inductive loop sensors, three are based on infrared/optical, and one system is based on surface acoustic wave (SAW). Among these systems, eleven offer two-way communication between the reader unit and the vehicle mounted transponder. Twelve systems encode variable data (e.g., passenger counts). All of these systems have fairly high accuracy. Five systems do not miss at all (miss defined as a vehicle not counted) and eight systems miss less than 1%. The accuracy of one system was not known.

Automatic Vehicle Location Systems

Eighteen companies are involved in selling AVL systems, making it the most popular system being marketed. Three aspects of AVL systems were investigated. These were the method used for tracking vehicles, accuracy, and frequency of location information update.

Satellite-based AVL systems (with GPS/NAVSTAR, GPS with dead reckoning or map matching, and differential GPS) and AVL systems that use dead reckoning methods are most common. Six systems use one of the above mentioned two methods. Proximity beacon/sign post method (with sharp transmissions) is used by three systems. Two systems use radio determination (one using certain radio frequencies and the other the Omega system). All systems were reported as fairly accurate. Twelve systems can track the location of a transit vehicle to less than 30 feet. Two systems can track the vehicle between 31 and 100 feet. One system tracks the vehicle between 101 to 200 feet and the accuracy of one system is greater than 200 feet. The frequency of location information updates was investigated. One system updates the information continuously. Four systems update the information between 1 and 10 seconds. Two systems update the information every 30 seconds and three systems update the information every 60 seconds. Two systems can update the information according to customer preference and in one system it depends upon data loading and system configuration.

Automatic Passenger Counter Systems

Only five companies responding to the survey sell APC systems. Pressure sensitive mats and infrared beams are common counting devices. In the opinion of most respondents, the infrared beam method is the most cost-effective. With one exception, all of the systems could send passenger counts to the dispatcher in real-time. On average all systems missed some passengers in counting. Four out of five systems provided the total number of passengers served along a certain route and the actual number of passengers on the bus. However, only three systems could provide the number of passengers boarding and alighting the vehicle at a specific stop.

Electronic Ticketing Systems

Electronic ticketing systems are marketed by nine companies. Seven companies are involved with systems that are both on-board and stationary devices. Except for one system, all collect origin-destination data. Revenue information is disaggregated by 'ticket type' by all systems and disaggregation by route is available in all but one system. Disaggregated passenger information by class and route is available in all but one system and, except for two systems, disaggregation by time of day is also available. The different forms of payment accepted by the systems are shown in Table 7. The most popular form of payment is the proximity card (contactless) followed by the swipe card/pass and the magnetic stripe cards. These are followed by the smart card (contact) and the credit card. Surprisingly, only two companies indicated that their systems accept cash. Cash form of payment may be somewhat under-reported because it was not offered as an option in the questionnaire. Six companies indicated that their system tickets could be reused by adding fare to them. Five system tickets were good for one ride only and eight companies indicated that the tickets were good for an unlimited number of rides. Interestingly, the tickets for all systems could be used for multi-modal transportation. Therefore, it appears that companies put a high value on this feature in their electronic ticketing systems.

Pre-Trip Information Systems

Companies were asked about their pre-trip information systems. One fourth (10/40) of the companies indicated that they sell pre-trip information systems. Popular technologies for pre-trip information systems are computers and modems, telephones and computers, and kiosks. Other technologies employed are touch-tone phone and teletext. Companies were asked about the map base used for the pre-trip information software. The most popular mapbase used is Tiger followed by Etak, Navtek and Thomas Bros. mapbases. It is interesting to note that two companies (Volvo of Sweden and Enware S. A. of Spain) use their own proprietary databases. Others in use are the USGS (modified and used by Rockwell of USA) and TransCAD database (originally based on the Tiger database and used by Multisystems Inc. of USA).

The different types of information provided by the pre-trip information systems are summarized in Table 8. Seven systems provide schedule/departure time information (four based on historical information and 3 based on real-time information). Five systems provide multimodal itineraries (four based on historical information and one based on real-time information). Trip chaining (itinerary optimization) information is provided by four systems (all based on historical information) and five systems provide information on rideshare opportunities (three based on historical and two based on real-time information). Two systems (one each based on historical and real-time data) provide information on best route based on shortest time. Information on routes with lowest fare and intermediate stops are provided by five systems. Two systems provide information on best route by maximum use of rail rapid transit and four systems provide information on least walking distance. Only three systems provide information on transit vehicle location. Therefore, it seems that more companies regard provision of information on schedule/departure times, fare, and connection points as important or the cost of providing transit vehicle location information is prohibitive. Only two systems provide advance ticketing and reservation and three record queries for later analysis by service planners. Eight pre-trip travel information systems could be linked to other sources of information (e.g., traffic information, special events information).

In-Terminal Traveler Information Systems

Information was obtained on in-terminal traveler information systems. Fourteen companies were involved in selling these systems. Table 9 shows the different technologies and the number of companies utilizing those technologies. Dot Matrix and Liquid Crystal Displays (LCD) are more popular than other technologies. These are then followed by synthesized voice messages, interactive video terminals with keypads and touch-sensitive screens. Only two systems use interactive audio terminals. Two systems employ the Tiger map base for the in-terminal information software, one each employs the Etak and the Navtek map bases. Three companies, GEC Alsthom Signarail (Canada), Enware S. A. (Spain), and Vultron Inc. (USA) use their own proprietary databases. Rockwell (USA) uses a modified USGS database and McCain Traffic Supply (USA) lets the customer choose the database.

The companies were asked about the different types of information that were provided by their in-terminal information systems. These are summarized in Table 10. Ten systems offer schedule/departure times (five each based on historical and real-time information). Four systems offer multi-modal itineraries and trip chaining (itinerary optimization). In both cases, three systems are based on historical information and one on real-time information. Three systems offer rideshare opportunities (two based on historical information and one based on real-time information). Two systems offer the option of best route based on shortest time (one each based on historical and real-time information). Information on least walking distance is offered by four systems, connection points and fare information by eight systems. Transit vehicle location information is provided by six systems (all in real-time) and transit vehicle delay information by eight systems (two in historical and six in real-time). Ten systems provide information on destinations of interest (e.g., city hall, or museum).

Information on ticketing and reservations, recording of queries, and linkage to other sources of information was also obtained for the in-terminal information systems. None of the systems provided ticketing and reservations facilities whereas, five systems provided recorded queries for later analysis by service planners. Eleven systems were capable of being linked to other sources of information.

In-Vehicle Traveler Information Systems

Questions were asked to explore the capabilities of in-vehicle traveler information systems. Fifteen companies sell such systems, making it the second most popular system after AVL systems. The most common technology used for dissemination of information is the dot matrix display (used by eleven systems). Flap displays are used by six systems, four systems use liquid crystal displays (LCD), and three use video displays. The system marketed by Volvo (Sweden) can utilize the Etak, Tiger, Navtek, and the Thomas Bros. map base for the in-vehicle information software. Volvo has its own map base as well. Other systems use the VCNet, USGS (modified by Rockwell), and IBIS European Standards 51708 map bases.

The different types of information supplied by the in-vehicle traveler information systems is shown in Table 11. Seven systems provide schedule information (two are based on historical information whereas, five are based on real-time information). Nine systems give information on expected arrival time at next stop (eight based on historical information and one based on real-time information). Four systems, all based on real-time information, provide waiting time information to the travelers. Information on connecting services are furnished by five systems (two historical and three based on real-time information), fare information is supplied by four, seating availability by two, and next stop announcements by eleven systems. Delay information is provided by eight systems, emergency information by ten systems, and destination of interest information is supplied by nine systems. None of the systems provide advance ticketing and reservations facilities whereas, ten systems can be linked to other sources of information. In general, companies emphasize next stop announcements, emergency information, destination of interest, expected arrival time at next stop, and delay information.

Demand-Responsive Computer-Aided Dispatching (CAD) Systems

Companies were asked about demand-responsive CAD systems. Seven companies are involved in selling these systems. Only one uses Etak mapbase, two use Tiger, and others use proprietary map databases. The different functions provided by demand-responsive CAD systems are summarized in Table 12. Five systems provide passenger trip scheduling (two based on historical information and three based on real-time information). Six companies provide vehicle and crew scheduling, routing, and dispatching functions (three each based on historical and real-time information). Passenger account status is supplied by three systems (two based on historical and one based on real-time information), passenger service monitoring and reporting (e.g., pick-ups, drop-offs) is supplied by five systems (three based on historical and one based on real-time information), and four systems provide the function of checking ADA eligibility of passengers (two each based on historical and real-time information).

Three demand-responsive CAD systems consider traveler preferences. One provides transit vehicle location information to travelers in real-time. Four provide advance reservations. Five systems respond to immediate requests while four respond to standing orders. Only three systems can be linked to other sources of information (e.g., traffic or special events information). From the above information, it seems that passenger trip scheduling, vehicle and crew scheduling, routing, and dispatching are considered important functions by the CAD suppliers.

Transit Operations Software

Information was collected on different transit operations software. Eight companies provide such software. Most companies such as Terrafix Ltd. (UK) and GEC Alsthom Signarail (Canada) use proprietary map databases for their software. Only one company (Rockwell, USA) uses the Etak and one (Multisystems Inc., USA) uses the Tiger map base. The functions that the transit operations software provide are summarized in Table 13. Four companies provide management of personnel. Five companies provide budget and finance functions, and vehicle maintenance scheduling, and communications support (e.g., vehicle identification, etc.). Six systems offer network and operations planning (five based on historical information and one in real time) and vehicle and crew scheduling (five based on historical and one based on real-time information). Other functions listed are inventory control, fuel consumption data, road call reporting (by Fleet Net, USA) and real-time engine monitoring (by IBM, USA). Six systems can be connected to AVL systems and five can be connected to AVI systems.

Ride-Share Matching Software

The availability and functions of ride-share matching software were also investigated in the survey. Only two companies (COMSIS Mobility Services and Rockwell, both located in **USA)** offer such software. COMSIS uses the Tiger map base whereas, Rockwell utilizes the Etak map base. Both systems are capable of providing real-time (immediate) matching. Both systems can match passengers by grid or by zip code. The system offered by COMSIS can match passengers by latitude and longitude.

Signal Priority Systems

Signal priority systems are offered by nine companies. Radio frequency from vehicle to signal and two-way radio frequency between vehicle and signal are common methods for communication between the systems and signal controllers. Other communication methods are loop detectors and microwave. All systems are fairly accurate. Two systems do not miss (defined as unsuccessful communication between the system and signal) at all. Six systems miss less than 1% and only one system misses between 1% and 5%. The range varies from 3 meters to 600 meters. In at least one case, the range depends upon the placement of loop antennae. Two systems change signal timing by reducing red time, one system increases green time, and three systems can do both. One system employs front end RFID (Radio Frequency Identification) only. Two companies did not answer this question.

Other Information Technologies

The companies supply a host of other information technologies. These are summarized in

Table **14.** These technologies cover a broad spectrum such as, real-time stock market information systems, signs and signals, fleet maintenance tracking systems, and satellite-based mobile communications systems.

Part 3: Largest Revenue Transit Technology

This part of the survey focused on the largest revenue transit technology of the companies. Respondents were asked to indicate the category to which their technology belonged. These are summarized in Table 15. Six systems each belonged to AVI and AVL categories, five to electronic ticketing and payment category, three to on-board computers and three to in-vehicle traveler information category. Two transit technologies belonged to the transit operation software category, one belonged to demand-responsive CAD system, one to automatic passenger counter, one to pre-trip information system, one to in-terminal traveler information system, and one to signal priority system categories. (Four respondents did not answer the question.)

The possibility of APTS technological integration reported by the suppliers is shown in Table 16. On average, about 7 systems can be integrated with AVI, 8 with AVL, 6 with electronic ticketing systems, 7 with on-board computers and 8 with in-vehicle information systems. On average, 6 systems each can be integrated transit operations software and demand-responsive CAD systems, 11 with automatic passenger counter systems, 6 with pre-trip information systems and 10 with in-terminal traveler information systems and 4 systems can be integrated with signal priority systems. Therefore, most APTS technologies seem to offer substantial flexibility in integration with other systems.

Companies were asked about the APTS technologies that are currently integrated with their latest system. Table 16 provides the average number of systems currently integrated. About four systems are integrated with AVI, 4 with AVL, 2 with electronic ticketing systems, 2 with on-board computers, **3** with in-vehicle information systems and 3 with transit operations software. One each is integrated with Automatic Passenger Counters and pre-trip information systems. No systems are integrated with demand responsive CAD systems, in-terminal information systems, signal priority system and rideshare matching software. While suppliers reported that APTS technologies have high potential to be integrated, the current levels of integration are significantly lower.

Important aspects of any system are initial cost, training, maintenance, and operational fees. The price range of the largest revenue APTS technologies offered by different companies was explored (Table 17). There is large variation in APTS technology prices. Many companies did not report the prices for different reasons; these include no fixed price (the company bids), industry competitiveness, or they depend, to a large extent, upon the customer requirements and specifications.

Companies were asked to indicate the status of their technology. The options offered were 1) proposed, 2) prototype, 3) experimental, 4) pilot, and 5) in service. Table **18** presents the status of the different technologies. Most of the technologies are in service. No technology is in proposed or experimental stages. Only one technology is in prototype stage (on-board computers). One pre-trip information system and three AVL technologies are in the piloting stage.

Finally, respondents were asked to indicate their agreement or disagreement with several statements regarding the benefits of their main transit product. The results are summarized in

Table 19. The first statement is regarding benefits for reduction in transit operating costs. Twenty of the respondents strongly agree that their technology will reduce transit operation costs. Twelve agree with the statement, three respondents don't know, whereas, in three cases, the statement does not apply. The second statement was about reduction in transit management costs. In this case, nineteen respondents strongly agree, fifteen agree, five don't know, and in one case it does not apply. The third statement asked about increases in transit ridership. In this case, only three respondents strongly agree that their technology will result in increased ridership. Twenty-two respondents agree with the statement, ten don't know and in five cases it does not apply. The fourth statement was about improvement in travel convenience and comfort for the user. In this case, nineteen respondents strongly agree and fifteen respondents agree with the statement. Two respondents don't know, and in four cases, it did not apply. The fifth statement was about improvement in accident safety for the user. Four respondents strongly agree, and sixteen agree that their technology will improve accident safety for the user. One respondent disagrees with the statement. Seven don't know, and the statement does not apply in twelve cases. The last statement was about improvement of security for the user. Ten respondents strongly agree with the statement whereas, sixteen respondents agree with the statement. Five respondents don't know, and, in nine cases, it does not apply.

Analysis of the Transit Operators Survey: APTS Information Technologies

A survey of transit operators was conducted in order to determine their experiences with passenger information systems. The following sections are organized according to the questionnaire's structure. The questionnaire consisted of four parts:

- Context. Information about the transit agency and its operating environment.
- Technology Attributes. Inquiries about the passenger information system technology being used by the transit agency.
- Technology Implementation. Questions related to the selection and implementation of the passenger information system technology.
- Impact. Experiences of the transit agency with the passenger information system technology.

A copy of the questionnaire is included in the Appendix to this report. The following summary includes the responses of those respondents who are considering implementing a passenger information system even though they have no operational experience with the system.

Part I: ***Context***

Nine of the 13 transit agencies responding to the questionnaire identified themselves as serving large urban areas. Suburban and rural service areas were each represented by a single transit agency response. Two respondents identified themselves as responsible for two types of service areas. No transit agency representing a small urban area completed the survey.

As anticipated, the number of unlinked passenger trips increases as both the number of full-time equivalent employees (1 full time = 2,000 hours/year) and the size of the agency's fleet increase. Tables 20 and 21 represent cross-tabulations of unlinked passenger trips and number of employees by fleet size, respectively.

One purpose of the survey was to determine what priority transit operators placed on different agency goals. Several operators were unable to complete this section correctly because they did not follow directions or were hesitant to rank the response set. By adding the rankings provided by the 9 respondents who identified their preferences, the goals can be divided into the following categories. The sum of the rankings was used to identify higher, medium and lower priorities.

High Priority

- Provide safe transportation
- Provide reliable transportation
- Provide economical transportation

Medium Priority

- Improve transit accessibility
- Improve transit convenience/comfort
- Relieve traffic congestion

Low Priority

- Improve mobility for special groups
- Coordinate the agency's service with other modes of transportation
- Minimize environmental impacts

Thus providing safe, reliable and economical transportation are the highest priorities. Two respondents wrote in their own priorities: (1) striving for a unified transportation system rather than one with multiple providers of fixed-route and dial-a-ride service and (2) transportation needs as defined by voters.

Part 2: Technology Attributes

The passenger information system survey attempts to learn about three different types of information systems: pre-trip information systems, in-terminal information systems and in-vehicle information systems. Table 22 reveals which systems are in place at the transit agencies completing the questionnaire. Note that it is possible for an agency to have more than one system.

Table 23 represents agency responses to questions regarding the prime contractor's level of experience for all 3 types of information systems. The 'experience' of the contractor is measured in terms of years of experience with the stated information system, and not necessarily years in business.

Table 24 summarizes agency responses when asked how many years their information system has been in operation. **A** majority of information systems appear to be relatively recent agency acquisitions (within the last 5 years).

Data on initial costs of the 3 different information systems is aggregated in Table 26. **A** majority of the systems described in this study required an initial investment of more than $200,000. Note that this question does not ask the respondent to consider the effects of inflation on the initial cost.

Tables 26, 27, 28 display the types of technology that make up the respondents' pre-trip, in-terminal and in-vehicle information systems. Respondents revealed that their preferred means of disseminating pre-trip information is by a telephone link to a computer operator. Dot matrix displays and TV monitors were the preferred means of transmitting in-terminal information. Message displays for in-terminal information systems occurred most frequently in stations and terminals (three out of five respondents not including one no response). One agency each noted that displays were located ‘at stops/transfer points’ and ‘at shopping malls, plazas, museums, etc. One respondent reported that displays are installed at park-n-ride lots. The small amount of data regarding the technology type of in-vehicle information systems is summarized in Table 28.

Respondents were asked questions pertaining to the maintenance needs of their passenger information systems. Table 29 measures maintenance need in terms of system breakdowns during normal operating hours. Table 30 tabulates data regarding employee resources that must be devoted to the information system in order to operate it satisfactorily. Pre-trip information system operation requires more resources with five respondents requiring more than 9 hours of employee time per day for system operation.

The majority of all agencies indicated that the supplier of their information system provided them with technical support. Table 31 outlines the provision of technical support relative to each type of information system.

Of those responding to the pre-trip portion of the survey, it is apparent that the majority of information supplied by the system is taken from historical data. Real-time information was most popular as a source for delay information. In aggregate, the most common types of information supplied by the pre-trip information system were schedule/departure times, delay information and travel times to destination stop. Table 32 provides a catalog of survey responses concerning the types of information their systems provide to the traveler.

The six agencies with in-terminal information systems indicated that schedule/departure times, delay information and destination displays were the preferred information types for the system. Delay information is generally provided in real-time. Table 33 highlights the types of information displayed by the in-terminal information systems responding to this survey.

Table 34 shows the types of information that three respondents indicated were supplied by their in-vehicle information systems. **A** few agencies offered real-time information on connecting services, next stop announcements and route destination.

Table 35 reveals that survey respondents were at least twice as likely to have an information system that did not link to other sources of information than one that did. Of those survey respondents who stated their agreement or disagreement, a majority disagreed that commuters and tourists use the pre-trip information system frequently. This makes sense with respect to commuters who are likely to travel the same route to work every morning, eliminating the need for many of the trip planning functions of a pre-trip information system. With respect to tourists, this response is somewhat surprising since they could potentially derive many benefits from a system that could help them to navigate through the unfamiliar transit system. Table 36 sums up respondents' opinions regarding the frequency of use by different user groups.

Table 37 shows that the frequency of use of in-terminal information systems by tourists and commuters is drawn into question by respondents with such systems.

Part 3: Technology Implementation

Pre-trip information system

In Part 3 of the questionnaire, respondents were asked to answer a series of questions regarding their technological implementation experiences with respect to a single type of passenger information system. Nine respondents indicated that they would reference their pre-trip information systems when answering the questions while four chose to reference their in-terminal information systems. None of the respondents decided to answer the questions from the perspective of an in-vehicle information system. Therefore, only information pertaining to pre-trip and in-terminal information systems can be presented for Part 3 and Part 4.

Eight of nine respondents cited the following circumstances that spurred the acquisition of a pre-trip information system: (1) a member in the organization pushed for adoption, (2) the existence of sufficient managerial and financial resources to support operating the system, (3) a need to expand the agency's services/capabilities. Seven of nine stated that there was a need to replace/upgrade the existing information system. Several interesting write-in responses included the idea that consideration of the pre-trip information system was driven by (1) research objectives, **(2)** the need to improve customer service and (3) the need to increase ridership. Table 38 tabulates the data related to the circumstances driving the consideration of a pre-trip information system.

Respondents had considered a variety of alternatives to the pre-trip information system. Two agencies indicated that a radio system upgrade was the best alternative for their particular pre-trip information systems. Three agencies indicated that their best alternative was to do nothing. One agency each considered the following best alternatives instead of the pre-trip information system: a *different* pre-trip information system, transit operation software, signal pre-emption system. (One respondent did not follow directions.)

Table 39 summarizes reasons for choosing a pre-trip information system over competing alternate strategies or technologies.

As indicated in Table 40, the statement that provoked the most disagreement among pre-trip information system respondents concerned the ease with which employees adjust to the new operating procedures necessitated by the change in system; one-third of respondents felt that employees did not adjust easily.

Among the nine respondents, the most popular systems to have integrated with a pre-trip information system are an Automatic Vehicle Location system, a Demand-responsive Computer-Aided Dispatching system and an on-board computer. One respondent included a traffic information system among those integrated with the pre-trip information system. The type of future technology to integrate with the pre-trip information system spanned many system types. Responses are tabulated in Table 41.

Three of nine operators consistently did not respond to the question regarding benefits accruing to the operator and to the traveler as a result of the pre-trip information system. Many respondents strongly agree that information systems reduce wait time, improve travelers' ability to make connections and improve the systems' ability to respond to crimes and other security concerns. However, the realization of benefits including (1) reduced labor hours, (2) improved coordination with other transportation modes, (3) reduced number of vehicles resulting from better planning and (4) enhanced security for passengers provoked the most disagreement or uncertainty among the six respondents. One respondent wrote that the pre-trip information system provides the transit operator with the opportunity to increase transit ridership. Refer to Table 42 for the response breakdown.

In-terminal information system

As previously mentioned, a total of four respondents chose to reference their in-terminal information systems when answering Parts 3 and 4 of this questionnaire. However, two of these four agencies have not yet implemented the technology--they are currently evaluating it. Tables

43, 44, 45, 46, 47 summarize their responses regarding their experiences with technology implementation. (Note that there are only a few respondents.) The circumstances for considering in-terminal information systems included a member in the organization pushing for adoption, need to address a short-term problem and the need to expand agency's services and capabilities. Two of the respondents indicated that an in-terminal information system was the best alternative for the in-terminal information system, implying that they considered an alternative technology with the same system classification. The remaining two agencies noted that the do nothing option was their best alternative. The key features considered by those choosing in-terminal information systems were that they met agency needs, integrated well with other technologies, were easy to use and there was a high level of agreement in the agency over its acquisition. In operating and maintaining the in-terminal information system, key considerations were that suppliers be in business and provide system components and technical support.

The systems that were currently integrated with the in-terminal information system included AVI, AVL, CAD, on-board computers, transit operations software, and signal pre-emption. The key benefits included reduced traveler wait times and enhanced security for passengers.

*Part **4:** Impact*

Pre-trip information system

All nine respondents to the questionnaire agreed that the pre-trip information system was a valuable investment for their particular agency. Eight respondents found their pre-trip information system to be a valuable investment for the customer, as well.

Many of the performance measures highlighted by particular agencies as being relevant in their assessment of the pre-trip information system documented improvements after system implementation. Aside from those measures listed in the questionnaire, respondents identified several other performance measures for their respective pre-trip information systems: number of people helped by phone per day, total and average length of a customer call, annual or weekday ridership, customer acceptance of the system as indicated by a survey, percent of calls answered per day.

Table 48 illustrates responses to how different groups of employees responded to the implementation of a pre-trip information system. According to the respondents, all employees felt positive about the pre-trip information system. One respondent included professionals responsible for marketing the system as responding positively to its implementation. Recall that Table 40 indicates that 3 of the respondents disagreed with the statement that their employees adjusted easily to the new operating procedures for pre-trip information systems. It does not seem likely that people adjusting to a new system would respond positively to it, although that could be the case. It seems possible that managers, planners and administrators will respond more positively than those who operate and maintain the system.

Table 49 documents agency benefits resulting from the pre-trip information system. All nine of the pre-trip information system respondents agreed that their agency's image improved as a result of the acquisition of the new technology. Eight of nine respondents believe that the pre-trip information system increases access to transit services. Seven of nine agencies agreed that the pre-trip information system has the ability to increase transit ridership and reduce the number of passenger complaints. However, the benefit of the system as a means of attracting auto users to transit is questionable. One respondent remarked that the agency benefits because the pre-trip information system helps to familiarize non-transit riders with different transit options.

Pre-trip information systems seem to be used least by choice riders; they are not perceived to be very effective at attracting auto users to transit (Table **49).** These systems also seem to be a little more attractive to the elderly, disabled, and infrequent riders, but less so to choice riders, such as typical commuters (Table 36).

Table 50 reveals the benefits of a pre-trip information system to the traveler as seen by the nine survey respondents. They are generally reported to reduce uncertainty about transit service, reduce anxiety of travel uncertainties and enable travelers to plan trips more effectively.

In terms of particular groups of the population and their receptiveness to the pre-trip information system, tourists are viewed as experiencing the most difficult transition to the new technology. This is consistent with earlier remarks about the frequency with which tourists use the system itself (Table 36). Table 51 records responses to this issue by the 9 respondents for the different user groups identified in the survey. Note that all other riders including senior riders and disabled riders are reported to have responded positively.

In-terminal information system

Two of the four survey respondents who referenced an in-terminal information system indicated that their systems were not yet in service. Of the four respondents who had in-terminal information systems, only one stated that the technology was a valuable investment for the agency as well as the customer. Two other respondents indicated that they did not know if the technology was beneficial for either. **A** fourth respondent did not answer either question.

One agency indicated that no performance evaluation existed for their in-terminal information system. Another referenced survey data as a means of evaluating system performance. The remaining two respondents did not respond which was consistent with the fact that their systems were not yet operational.

The remaining data concerning the impact of the in-terminal information system appears in tabular form without comment due to the small number of responses; refer to Tables 52, 53, 54, 55.

Analysis of the Transit Operators Survey: AVWCAD Systems

This section summarizes the results of a survey of the Automatic Vehicle Location (AVL) and Computer Aided Dispatching systems (CAD) currently used by the transit agencies. The survey consisted of four parts:

- Context. Information about the transit agency and its operating environments.
- Technology Attributes. Information about the AVL/CAD technology being used by the transit agency.
- Technology Implementation. Issues related to selection and implementation of their AVWCAD technology.
- Impact. Experiences of the transit agency with AVL/CAD technology.

The responses of the transit agencies are summarized according to these four parts. A copy of the survey is included in the appendix to this report.

Part 1: Context

A majority of the survey responses were from transit agencies operating in urban areas: 18 of the 29 respondents were from large urban areas, five from small urban areas, and one from a suburban area. Five respondents either did not indicate the type of operating area or operated in more than one environment. Table 56 shows a summary of respondents by fleet size.

As expected, agencies with larger fleet size also had more full-time equivalent employees (one full time employee works 2,000 hours/year) and provided more unlinked passenger trips during the last fiscal year. Cross tabulations of the unlinked passenger trips by fleet size and the number of employees by fleet size are presented in Tables 57 and 58, respectively.

When asked to rank their goals, most agencies indicated that providing safe transportation was their highest priority followed by reliable and economical transportation. By simply adding the ranks indicated by each respondent for each goal, they can be grouped into the following categories:

High Priority

- Provide safe transportation
- Provide reliable transportation
- Provide economical transportation

Medium Priority

- Improve transit accessibility
- Improve transit convenience/comfort
- Improve mobility for special groups (e.g. handicapped, lower income)

Low Priority

- Relieve traffic congestion
- Coordinate with other transportation modes
- Minimize environmental impacts

Interestingly, these priorities closely resemble the priorities of the transit information system respondents.

*Part 2: **Technology Attributes***

A majority of the respondents indicated satellite based system as their main system of tracking vehicles and two-way radio as their main communication technology (Tables 59, 60, 61, 62). Two respondents indicated that they use a satellite system and dead reckoning, and one respondent indicated that they use dead reckoning and proximity beacons for tracking vehicles. None of the agencies indicated using dead reckoning only for tracking transit vehicles. One respondent reported that they use cellular phone and trunked radio for vehicle dispatching. Since the survey focused only on single technology, they are not included in Tables 59-62.

Most new AVL/CAD systems use satellite systems for their tracking (Table 61). Although some agencies indicated the type of their system, they did not indicate the number of years in service. **As** a result, the total agencies in Table 61 is less than the number of agencies indicated above. (Similarly with other tables below.)

The ability to locate vehicles disaggregated by tracking system type are summarized below. There is significant variation in the location accuracy of the systems as perceived by their users.

As currently installed, 24 agencies indicated that they have silent alarms; 22 indicated that they have on-board computers; and, 14 indicated that they have mobile data terminals. A cross tabulation of these systems by tracking system type is presented in Table 63.

With respect to the possibility of upgrading their existing system (add a system), six agencies indicated that they can upgrade their system with on-board computers or with silent alarms; and, five agencies indicated that they can upgrade their system with mobile data terminals (Table 64).

A majority of the transit agencies indicated that they have integrated Automatic Vehicle Identification Systems and On-board Computers with their current AVWCAD system. Of the systems currently not installed, the largest group indicted that they would like to add an automatic passenger counter to their existing system.

The benefits of these combinations depend on the type of technologies integrated within each transit agency (Table 65). Most agencies stated that they are satisfied with the AVWCAD technologies. In some instances, respondents who reported questionable benefits resulting from AVWCAD technologies were found to have technologies unrelated to the question concerned. For example, a transit agency with an electronic payment system may disagree that their system improves their ability to respond to breakdowns, accidents. (Perhaps due to the fact that a "not applicable" column was not included in the questionnaire.)

Tables 66 and 67 presents a summary of operator and traveler benefits as perceived by transit implementers. Within each table, overall benefits of the AVWCAD system are ranked based on the average scores which were computed as follows: Strongly agree = 3, Agree = 2, Disagree = 1, Strongly disagree = 0. (Note that this scale is ordinal and the truly permissible statistic is the mode.) The “don’tknows” were not included in the calculation. The important benefits include:

- Improved ability to monitor vehicle location.
- Enhanced security for drivers, improved schedule adherence.
- Improved ability to respond to crimes and security concerns.
- Improved ability to monitor drivers performance.
- Improved ability to respond to breakdowns and accidents.
- Improved ability to direct en-route vehicles.

Table 67 shows that enhanced security and improved ability to make connections are key traveler benefits.

Part 3: Technology Implementation

The main aim of this section was to determine the factors which led transit agencies to install AVL/CAD systems. These factors were classified into the following categories: Each agency was asked to indicate the degree to which a particular factor influenced system selection;

- Opportunity-based conditions
- Need-based conditions
- Operating the system
- Maintaining the system

Responses are summarized in Tables 68, 69, 70, 7 1. Key opportunity-based conditions were that a member in the organization pushed for adoption and that financial assistance was easy to secure. The need to replace (or upgrade) the existing radio/dispatching system and the need to expand the agency's services and capabilities proved to be important need-based considerations. In operating the system, key considerations were whether the system effectively identifies vehicles and monitors schedule adherence. Other important considerations included effectively monitoring drivers' performance, monitoring vehicle location, supporting dispatching decisions, employees adjusting easily to the new operating procedures and the system giving consistently accurate information. Important maintenance considerations are whether suppliers are in business and whether they continue to provide system components and technical support.

Part 3 also contained questions about what alternate system, if any, they had considered. In particular, agencies were requested to indicate why they had selected their system over the alternate system. Since most agencies did not answer these questions, the responses are not reported.

Part 4: Impact

Part 4 contained questions about transit agencies' experiences (or perceived benefits, if not currently in operation) with the AVL/CAD systems. It also contained questions about actual performance before and after system implementation. Most agencies did not indicate how their performance improved after implementing an AVL/CAD system. The reported impacts of AVL/CAD technologies are summarized in Table 72 and 73. Those who responded positively include general managers, board of directors, planners, schedulers and analysts, dispatchers, phone operators/customer service agents, on-street supervisors, ride or trip checkers, maintenance staff, information system managers and drivers (in that order). The hierarchy of benefits was as follows: improved ability to monitor vehicle location, improved schedule adherence, and enhanced security for bus drivers and passengers.

CHAPTER 4

CONCLUSIONS AND RECOMMENDATIONS

The basic structure for APTS technologies in this study is summarized as follows:

- APTS technologies can be defined by their *design* and *application* dimensions. The design dimensions are technology features, functions and performance. The technology application dimensions are spatial, temporal and user measures. These dimensions indicate where, when, and for whom the technology is implemented.
- Technology deployment takes place in an implementation *context.* The spatial, temporal and user dimensions of the implementation context are important determinants of technology impacts. For example, network structure and density, duration of peak flows and mix of travelers can influence APTS impacts.
- The technology design and application dimensions and the context dimensions will have direct, indirect and simultaneous impacts on transit operators and travelers. Specifically, the technologies that have direct impacts on traveler decisions (e.g., mode and route choices) are termed traveler-based and those with direct impacts on operator decisions (e.g., operations and planning choices) are termed operator-based. The impacts are measured in terms of criteria that include costs and efficiency. The impacts themselves can be classified in terms of distribution dimensions. The impacts have spatial, temporal and user distributions and these are distinct from technology application dimensions. That is, the impacts can occur more widely than where the technology is implemented.

The structure developed in the study was used to explore the commercial availability and deployment of new transit technologies. Survey research showed that technology suppliers had several products that were likely to vary in their direct and indirect impacts on transit operators and travelers. The opinions provided by technology suppliers give some insights into technology dimensions and impacts. Specifically, the ATPS suppliers survey focused on their largest revenue technology and there was large variation in the prices of different technologies. The suppliers reported a diverse set of APTS technologies as providing the largest revenue. A substantial number of systems were reported to be integratable with other APTS technologies. Therefore, APTS technologies offer substantial flexibility in integration. Respondents were asked to indicate their agreement or disagreement with several statements regarding the benefits of their main transit product. Most respondents either agreed or strongly agreed that their technology will reduce transit operation and management costs and increase the comfort and convenience of transit travel. This matches well with the high priority goals of transit agencies, namely providing economical and reliable transportation. However, there was uncertainty about whether the new technologies will necessarily increase transit ridership, and safety and security. This contrasts with the stated high priority goal of transit agencies, namely providing safe transportation. Overall, in the view of APTS suppliers, most new technologies can support either traveler decisions or transit operator decisions and in some cases both types of decisions.

Many APTS suppliers reported AVL/CAD technologies as their highest revenue technology. This is reasonable because transit agencies may have a greater demand for such systems. Strangely, transit information systems were not the highest revenue technologies for many vendors. This might be due to a small demand and possibly a small number of transit suppliers cornering the market.

The surveys of transit agencies provide insights into experiences with ATIS and AVL/CAD systems. Before referring to the results, it is important to recognize that there are certain biases associated with survey research. The relevant ones include non-coverage and non-response biases. Furthermore, respondents who have adopted a specific APTS technology may exaggerate its benefits.

In the pre-trip ATIS survey, all respondents agreed that the pre-trip information system was a valuable investment for their agency and for the customer. Further, there was broad agreement that the pre-trip ATIS improved the agency's image and increased access to transit services. A majority of agencies agreed that their pre-trip information system has the ability to increase transit ridership and reduce the number of passenger complaints. However, the benefit of the system as a means of attracting auto users to transit was questionable. The benefits of a pre-trip ATIS to the traveler as seen by the transit agencies were that they generally reduced uncertainty about transit service, reduced anxiety of travel and enabled travelers to plan trips more effectively. Tourists were viewed as experiencing the most difficult transition to the new technology while all other riders, including senior riders and disabled riders, were reported to have responded positively. Pre-trip information systems seem to be used least by choice riders; they are perceived to be ineffective at attracting regular auto users to transit and supporting tourists' choices.

The AVL/CAD survey indicated that those who responded positively to their implementation include general managers, board of directors, planners, schedulers and analysts, dispatchers, phone operators/customer service agents, on-street supervisors, ride or trip checkers, maintenance staff, information system managers and drivers (in that order). The benefits were improved ability to monitor vehicle location, improved schedule adherence, and enhanced security for bus drivers and passengers. It is not clear whether many transit agencies believe that AVL/CAD systems reduce costs (i.e. by reducing labor- or vehicle-hours). Furthermore, there was evidence that AVWCAD implementation decisions are made as longer-term upgrades and/or investments. This raises questions about the overall cost-effectiveness of such systems. It is also telling that the AVL/CAD systems are liked most by the white-collar workers and relatively less by the people who are working day-to-day with the system and with the public (i.e. on the "front line").

Based on the reported experiences with ATIS and AVL/CAD systems, few transit agencies see APTS technologies as a means to coordinate with other transportation services and agencies. This means that, although technologies can act as a bridge between organizations, they are not always perceived that way.

This study has developed a structure for APTS technologies that can help in:

- Evaluating the operator and traveler impacts of alternative APTS technologies in terms of performance measures.
- Selecting the appropriate APTS technologies for field testing and deployment.

While APTS suppliers and implementers perceive significant benefits, there is a need to synthesize the experiences of transit agencies. Specifically, to improve APTS planning, a decision support mechanism is needed. The system should be able to suggest strategies for implementation of technologies considering the broader mix of APTS alternatives. Importantly, there is a need to identify APTS technologies that can be mixed to provide the correct balance between operator effectiveness and customer satisfaction. Individually APTS technologies may be of limited value but collectively they may significantly enhance the performance of the transit system and attract travelers. Therefore, the issue of APTS integration is critical.

For transit agencies considering APTS deployment, a customized strategy should be designed to select appropriate technologies. However, the selection of new transit technologies and their testing/evaluation in real-life situations will most likely be iterative and semi- or un-structured. The APTS technology selection process in transit agencies should consider *synergistically* implementing various operator- and traveler-based technologies. To accomplish this, a systematic strategy that determines the value of new transit technologies is needed. This strategy must not degenerate into a muddled and opportunistic transit technology testing process, that results in sloppy evaluations and inconsistent conclusions. Additional research regarding (1) design and application dimensions of various technologies and (2) their implementation context must be undertaken to guard against an undesirable technology testing process. This research should focus on how these two factors influence APTS benefits.

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APPENDIX

APTS Suppliers Survey

ATIS Survey

AVWCAD Survey

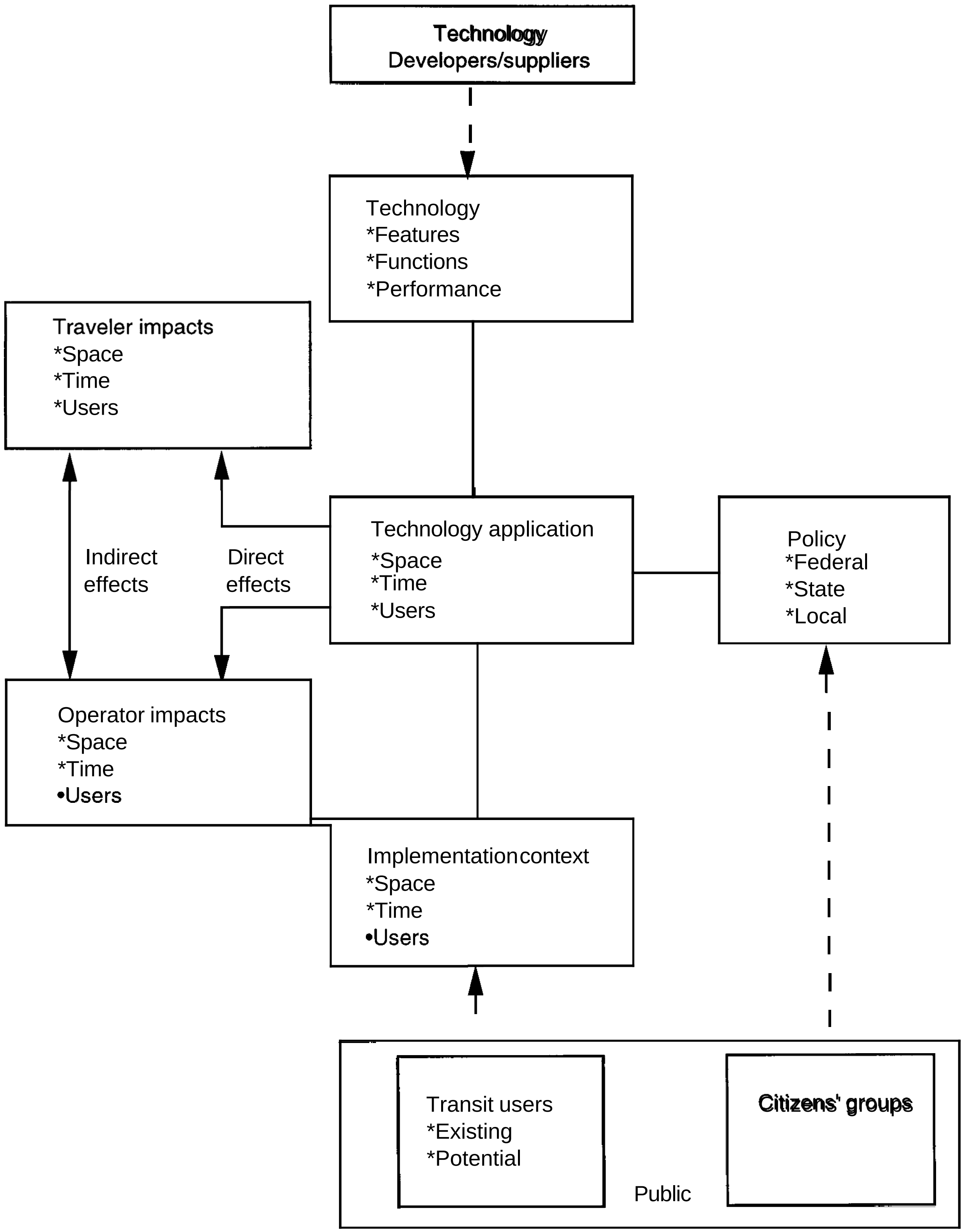

Figure 1 . The process of technology supply, demand and implementation.

TECHNOLOGY ______________________________

MANUFACTUREW SPONSOR: ______________________________

INFORMATION CONTENT / TRAVELER CHOICES	STATIC		DYN MIC	
	QUALITATIVE	QUANTITATIVE	QUALITATIVE	QUANTITATIVE
DESTINATION				
MULTIMODAL	A	B	C	D
DEPARTURE TME				
ROUTE				
PARK AND R E				
TRP CHAINING				

TECHNOLOGY FUNCTIONS:

MULTIMODAL RESERVATION ☐ YES ☐ NO

INTEGRATED BILLING SYSTEM ☐ YES ☐ NO

SEATING AVAILABILITY ☐ YES ☐ NO

INFORMATION MEDIUM:

☐ PORTABLE ☐ NON-PORTABLE

☐ IN-VEHICLE ☐ OUT-OF-VEHICLE

☐ AUDIO ☐ VISUAL

Figure 2. Taxonomy of traveler-based transit information systems

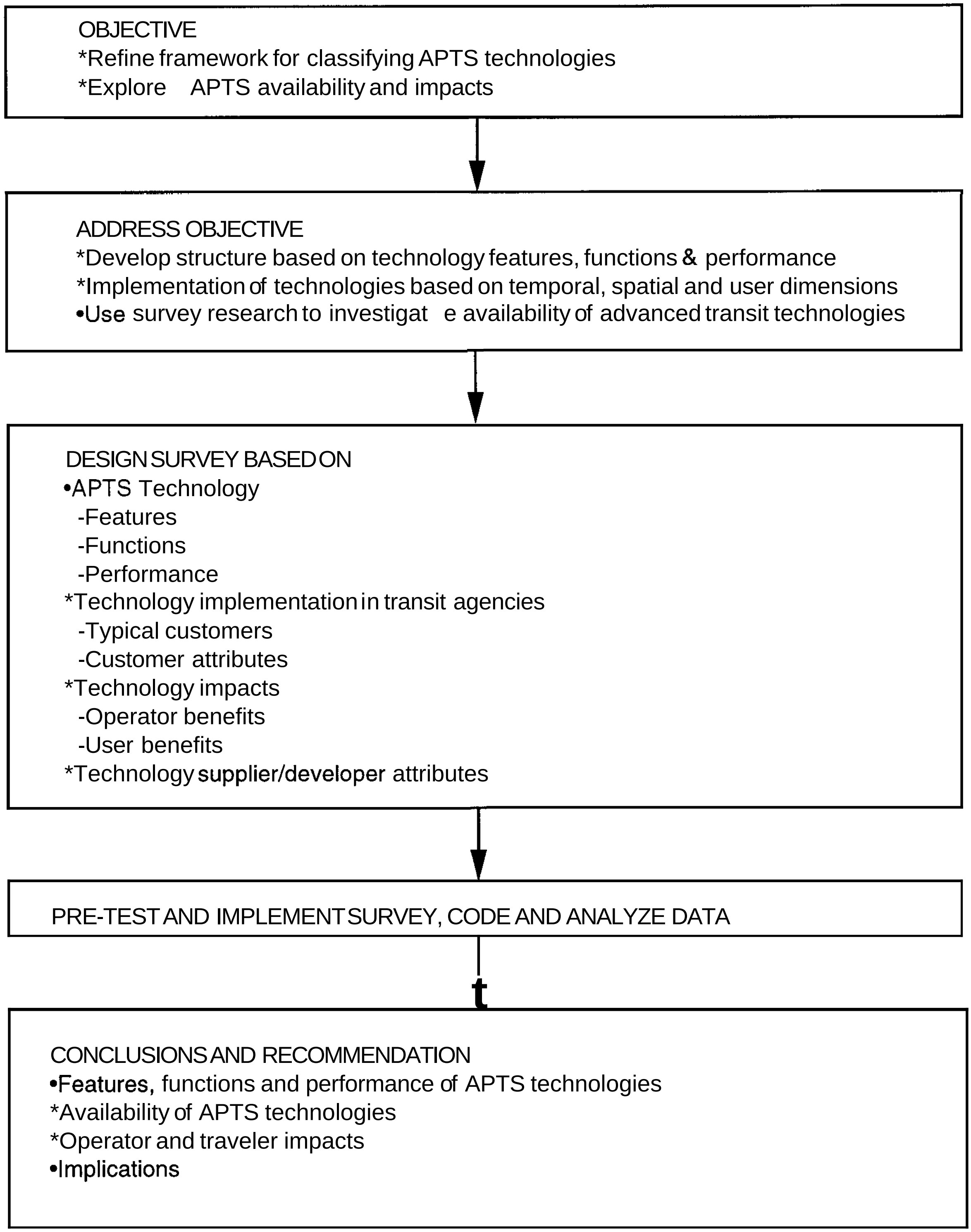

Figure 3. Study methodology.

Table 1. real-time rideshare matching user needs (Source: Kowshik et al. 1993)

USER NEEDS	FUNCTIONAL REQUIREMENTS
*Background screening	Check criminal record Check driving record Check insurance status Verify employment
*Information Security	Safeguard personal info. from unauthorized user access (once in system, person has passed) Restricted access by system operator
*Matching/Reliability	
a. Registration, high likelihood of matching	Ability to generate potential matches
b. Flexible pick-up and drop-off	Allow matches for non-identical origins and destinations
c. Communications between ridesharers	Info dissemination to both parties
d. Meeting as scheduled	Backup for no-show
*System access	Provide matching services at any time of day
*Flexibility	
a. Allow users to vary O-D, route and times, drive/ride preferences	Accommodate one-time trip information
b. Allow 'urgent' ride-sharing	Operator override of usual preferences or matching criteria
*Compensation scheme Uniform compensation schedule	Ability to generate cost of match

Table 2. Characteristics of selected advanced transit information technologies (see Khattak et al. 1993)

Technology	Technology Features (information medium)	Technology Functions (information content)	Technology Performance (Information quality)
Pre-Trip Information Systems	*Auto dial phone *Telephone to computer operator *Voice recognition Computer & modem *Teletext •Videotext •Audiotext *Cable TV *Interactive voice response *Interactive TV	*Provides historical or real time information: -Schedule/departure times -Multi-modal itinerary -Trip chaining (itinerary optimization) -Ride share opportunities -Best route based on traveler criteria: Shortest time Lowest fare Intermediate stops Maximum use of rapid transit Least walking distance -Connection points -Transit vehicle location *Provides advance ticketing & reservation	*Presentation quality *Accuracy of information *Relevance of information
In-terminal Information Systems	*Dot matrix dsply. •Flipover dsply. *LCD •TV monitors *Synthesized voice messages *Audio terminals *Video terminals: with keypads with touch screens	*Provides historical or real time information: -Schedule/departure times -Multi-modal itinerary -Trip chaining (itinerary optimization) -Ride share opportunities -Best route based on traveler criteria: Shortest time Lowest fare Intermediate stops Maximum use of rapid transit Least walking distance -Connection points -Transit vehicle location/delays information -Terminal related information (e.g., layout) -Destination *Provides advance ticketing & reservation	*Presentation quality *Accuracy of information *Relevance of information

Table ***3*****.** Country Affiliation of the Companies

Country	Number of Companies
USA	24
Canada	6
Sweden	2
Finland	2
Australia	**1**
France	1
Italy	1
Netherlands	1
Spain	1
UK	1

Table **4.** Respondent Profile

Number of years in Business	Number of Companies
Less than or eaual to *5*	**6**
6-10	12
11-20	9
21-50	8
*5*1 or more	*5*
Number of Full-Time Employees	Number of Companies
Less than or equal to 20	8
21-50	8
51-100	**6**
101-250	*5*
200 or more	12
Not Reported	1
Percentage of Goods Manufactured **in** the **U.S.**	Number of Companies
0	**8**
1-20	**3**
21-50	1
*5*1-99	10
100	
Not Reported	3

Table **5**. Number of Companies that Sell Different Systems

Technology	Number of Companies
Automatic Vehicle Identification (AVI)	14
Automatic Vehicle Location (AVL)	18
Automatic Passenger Counter (APC)	5
Electronic Ticketing Systems	9
Pre-trip Information Systems	10
In-terminal Traveler Information Systems	14
In-vehicle Traveler Information Systems	15
Demand-responsive Computer-aided Dispatching (CAD) Systems	7
Transit Operations Software	8
Ride-share matching Software	2
Signal Priority Systems	9

Table 6. Type of Sensors/Detectors Used by AVI Systems

Type of Sensor/Detector	Number of Companies
Radio Frequency (RF)/Microwave	12
Inductive Loop	5
Infrared/Optical	3
Surface Acoustic Wave (SAW)	1

Table 7. Number of Systems Accepting Different Forms of Payments

Form of Payment	Number of Systems
Proximity Card (contactless)	8
Swipe Card/Pass	7
Magnetic Stripe Card	7
Smart Card (Contact)	***6***
Credit Card	*5*
ATM Card	2
Other (cash, etc.)	3

Table 8. Different Types of Information Provided by Pre-Trip Information Systems

Type of Information	Number of Companies	Historical1 Real-Time
Schedule/Departure Times	*7*	413
Multimodal Itineraries	*5*	**4/** 1
Trip Chaining	4	410
Rideshare Opportunities	*5*	3/2
Best Route Based on Traveler-Selected Criteria - Shortest Time	2	111
- Lowest Fare	*5*	
- Intermediate Stops	*5*	
- Maximum Use of Rail Rapid Transit	2	
- Least Walking Distance	4	
Connection Points	*7*	
Fare Information	8	
Transit Vehicle Location	3	112

Table 9. Information Dissemination Technologies Utilized in In-Terminal Traveler Information Systems

Information Dissemination Technology	Number of Companies
Dot Matrix Displays	9
Flip-Over Displays	4
Liquid Crystal Displays (LCD)	8
TV Monitors	7
Synthesized Voice Messages	7
Interactive Audio Terminals	2
Interactive Video Terminals with Keypads	7
Interactive Video Terminals with Touch-Sensitive Screens	7

Table 10. Different Types of Information Provided by In-Terminal Traveler Information Systems

Type of Information	Number of Companies	Historical/ Real-Time
Schedule/Departure Times	10	5/5
Multimodal Itineraries	4	3/1
Trip Chaining	4	311
Rideshare Opportunities	3	2/1
Best Route Based on Traveler-Selected Criteria - Shortest Time	2	1/1
- Lowest Fare	3	
- Intermediate Stops	6	
- Maximum Use of Rail Rapid Transit	2	
- Least Walking Distance	4	
Connection Points	8	
Fare Information	8	
Transit Vehicle Location	6	0/6
Transit Vehicle Delay Information	8	216
Destination of Interest Information	10	

Table 11. Different Types of Information Provided by In-Vehicle Traveler Information Systems

Type of Information	Number of Companies	Historical1 Real-Time
Schedule	7	2/5
Expected Arrival Time at next Stop	9	811
Waiting Times at Connecting Points	4	014
Connecting Services	5	213
Fare Information	4	
Seating Availability	2	
Next Stop Announcements	11	-
Delay Information	8	-
Emergency Information	10	-
Destination of Interest	9	-

Table 12. Functions Provided by Demand-Responsive Computer-Aided Dispatching (CAD) Systems

Type of Function	Number of Companies	Historical/ Real-Time
Passenger Trip Scheduling	5	2/3
Vehicle and Crew Scheduling	6	3/3
Routing	6	3/3
Dispatching	6	3/3
Passenger Account Status	3	2/1
Passenger Service Monitoring and Reporting	5	3/2
Check ADA Eligibility of Passenger	4	2/2

Table 13. Functions Provided by Transit Operations Software

Type of Function	Number of Companies	Historical1 Real-Time
Personal Management	4	
Budget/Finance	5	
Vehicle Maintenance Scheduling		
Communications Support	5	
Network and Operations Planning	6	511
Vehicle and Crew Scheduling	6	511

Table 14. Other Information Technologies

Company	Technology
Union Switch & Signal (USA)	V_Frame++ (Vital Software Framework, TIPS (Train Inertial Positioning SystemS), DIGITRAC (DSP-based transponder data system), MICROCAB (cab signal system), MICROCAB++ (carborne control system)
Mentor Engineering (Canada)	Design/Manufacture Mobile Data Terminals and/or Transit Control Heads for Use in Transit Systems
Tapeswitch Corp. (USA)	Passenger Signalling Switches, Passenger Alarm Systems
Terrafix Ltd. (UK)	Automatic two-way Data and Information Systems
CUE Network Corp. (USA)	Provides FM Radio Network for Traffic Alerts to be Sent to In-Vehicle Receivers and PCs
Saab Systems Inc,(Sweden)	Electronic Toll Collecting System
Multisystems Inc. (USA)	Fleet Maintenance Tracking
Volvo (Sweden)	In-Vehicle Navigation and Real-Time Information
QUALCOMM Inc. (USA)	OmniTRACS (two-way satellite-based mobile communications system with vehicle tracking capabilities), Software for use with OmniTRACS
Vultron Inc. (USA)	Electronic Flip-Dot Destination Signs (3"-10" character height) for buses
Technotour Eltech (Italy)	Automatic Fare Collection Systems, Self-Service Ticket Vending Machines, Ticket Office Machines and Ticket Cancelling Machines
Enware S. A. (Spain)	Real-Time Stock Market Information Systems, Library Information and Control Systems
Unicon Consulting Uy (Finland)	Smart Card Based Ticketing Systems, Clearing Systems and Card Management Software
Navigation Technologies (USA)	Digital Map Databases

Table 15. Categorization of Largest Revenue Transit Technology

Technology Category	Number of Systems
Automatic Vehicle Identification Systems	6
Automatic Vehicle Location System	6
Electronic Ticketing and Payment Systems	5
On-Board Computers	3
In-Vehicle Traveler Information System	3
Transit Operation Software	2
Demand-Responsive CAD system	1
Automatic Passenger Counter	1
Pre-Trip Information System	1
In-Terminal Traveler Information System	1
Signal Priority System	1
Ride-Share Matching Software	0
Other (composite products)	6
No Response	4

Table 16. Technological Integration of Different Systems

Technology to Which Other Systems can be Integrated/are Integrated	Average Number of Systems Feasible	Average Number of Systems Currently Integrated
Automatic Vehicle Identification Systems	39/6=6.5	25/6=4.1
Automatic Vehicle Location System	49/6=8.1	22/6=3.6
Electronic Ticketing and Payment Systems	32/5=6.4	9/5=1.8
On-Board Computers	22/3=7.3	6/3=2.0
In-Vehicle Traveler Information System	24/3=8.0	10/3=3.3
Transit Operation Software	12/2=6.0	6/2=3.0
Demand-Responsive CAD system	6/1=6.0	0
Automatic Passenger Counter	11/1=11.0	1/1=1.0
Pre-Trip Information System	6/1=6.0	1/1=1.0
In-Terminal Traveler Information System	10/1=10	0
Signal Priority System	4/1=4.0	0
Ride-Share Matching Software	0	0
Other	40/6=6.6	26/6=4.3

Table 17. Average price of APTS technologies ($) in 1996.

Technology	Purchase & Installation	Initial Training Fee	Additional Annual Fee	Annual Maintenance	Annual Operation Cost
AVI	5000	Unknown	Varies	Unknown	Unknown
On-Board Computers	1400 per veh	3000-10,000	25 per veh	Minimal	Minimal
CAD	20,000	Varies	Varies	Varies	Varies
Automatic Pax counter	Unknown	Unknown	Unknown	Unknown	Unknown
Pre-trip	Unknown	Unknown	Unknown	Unknown	Unknown
In-terminal	Varies	Varies	Varies	Varies	Varies
In-vehicle	Varies	Varies	Varies	Varies	Varies
Ride match	Unknown	Unknown	Unknown	Unknown	Unknown
Transit ops software	150,000	15,000	10,000	Unknown	Unknown
Electronic ticketing	250,000-500,000	25,000-50,000	25,000-50,000	50,000-180,000	70,000-250,000
Signal priority	Unknown	Unknown	Unknown	Unknown	Unknown
AVL	2000 per **bus** 800,000 per system	6,000-40,000	10,000 per system	150,000 per system	*300,000* per system

Table 18. Technology **Status**

Technology	In Service	Prototype	Pilot
Automatic Vehicle Identification Systems	6		
On-Board Computers	2	1	
Demand-Responsive CAD Systems	1		
Automatic Passenger Counters	1		
Pre-Trip Information Systems			1
In-Terminal Traveler Information Systems	1		
In-Vehicle Traveler Information Systems	3		
Ride Matching Software	0		
Transit Operation Software	2		
Electronic Ticketing and Payment Systems	5		
Signal Priority Systems	1		
Automatic Vehicle Location Systems	3		3
Other	5		1

Table 19. Respondent Perceptions of their Technologies

1. Reduces Transit Operating Costs

Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know	Does Not Apply
20	12			5	3

2. Reduces Transit Management Costs

Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know	Does Not Apply
19	15	0	0	5	1

3. Increases Transit Ridership

Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know	Does Not Apply
3	22	0	0	10	5

4. Improves Travel Convenience or Comfort for User

Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know	Does Not Apply
19	15	0	0	2	4

5. Improves Accident Safety for User

Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know	Does Not Apply
4	16	1	0	7	12

6. Improves Security for User

Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know	Does Not Apply
10	16	0	0	5	9

Table 20: Number of unlinked trips (millions)

Fleet Size	Number of Agencies					
	<1	1-100	101-200	201-300	301-400	>400
< 50	-	-	-	-	-	-
50 - 100	1	-	-	-	-	-
101 - 200	-	1	-	-	-	-
201 - 500	-	1	-	-	-	-
501 - 800	-	-	2	-	-	-
> 800	-	4	-	1	1	1

No response = 1

Table 21: Number of full-time equivalent employees

Fleet Size	Number of Agencies				
	< 100	101 - 1,000	1,001 - 5,000	5,001 - 10,000	> 10,001
< 50	1	-	-	-	-
50 - 100	-	1	-	-	-
101 - 200	-	1	-	-	-
201 - 500	-	-	-	-	-
501 - 800	-	-	1	1	-
> 800	-	-	4	1	2

No response = 1

Table 22: Breakdown of passenger information systems

System Type	Number of Agencies			
	Yes	No	No Response	Don't Know
pre-trip information system	10	*3*		
in-terminal information system	6	5	1	1
in-vehicle information system	*3*	8	2	

Table 23: Prime contractor's level of experience (years)

System Type	Number of Agencies				
	< I	1 - 3	3+ - 5	> 5	No Response
pre-trip information system		1	2	6	1
in-terminal information system		2	1	2	1
in-vehicle information system			2	1	

Table 24: Number of years in operation

System Type	Number of Agencies					
	< 1	1 - 5	5+-10	> 10	No Response	Don't Know
pre-trip information system	1	4	3	1	1	
in-terminal information system	1	3		1		1
in-vehicle information system	1	1			1	

Table 25: Initial system cost ($1,000s)

System Type	Number of Agencies				
	< 50	50 - 100	100+ - 200	> 200	No Response
pre-trip information system		2	1	5	2
in-terminal information system			2	3	1
in-vehicle information system		1		2	

Table 26: Technology of pre-trip information system

Technology Type	Number of Agencies
Automatic touch tone phone	3
Telephone & voice recognition	1
Teletext	-
Cable TV	
Telephone to computer operator	6
Computer & modem	3
Videotext	2
Other technology	1
No response	1

Table 27: Technology of in-terminal information system

Technology Type	Number of Agencies
Dot matrix displays	**3**
Liquid crystal displays	
Synthesized voice messages	1
Interactive video terminals w/keypads	
Flip-over displays	
TV monitors	3
Interactive audio terminals	
Interactive video terminals w/touch-sensitive screens	
Other technology	
No response	

Table 28: Technology of in-vehicle information system

Technology Type	Number of Agencies
Synthesized voice messages	1
Dot matrix displays	2
Flap displays	
Video displays	1
Other technology	
No response	

Table 29: Frequency of system breakdowns (events per month)

System Type	**Number of Agencies**					
	< 1	1 - 2	3 - 5	> 5	No Response	Don't Know
pre-trip information system	7	-	2	-	1	-
in-terminal information system	3	-	1	-	1	1
in-vehicle information system	2	-	-	-	1	-

Table 30: Devoted employee resources (hours per day)

System Type	Number of Agencies				
	≤ 8	9 - 16	17 - 40	> 40	No Response
pre-trip information system	**4**	3	2	0	1
in-terminal information system	**4**	1			1
in-vehicle information system	1				2

Table 31: Technical support provided by supplier

System Type	Number of Agencies			
	Yes	No	No Response	Don't Know
pre-trip information system	6	1	2	1
in-terminal information system	4		1	1
in-vehicle information system	**3**			

Table 32: Pre-trip information provided to the traveler

Information Type	Number of Agencies				
	Historical	Real-Time	No Info	No Response	Don't Know
Schedule/departure times	8	2	-	1	-
Delay information	2	5	2	1	-
Travel times to destination stop	5	1	2	2	-
Multi-modal itineraries	2	-	4	4	-
Trip chaining	4	-	2	4	-
Rideshare opportunities	2	-	4	4	-
Best route based on...					
Shortest time	3	1	2	4	-
Lowest fare	2	-	3	5	-
Intermediate stops	2	-	3	5	-
Max. use of rail rapid transit	1	-	5	4	-
Least walking distance	2	-	4	4	-
Other	1	-	1	8	-
Connection points	3		3	**4**	
Transit vehicle location			6	**4**	
Other information				9	1

Table 33: In-terminal information provided to the traveler

Information Type	**Number of Agencies**				
	Historical	Real-Time	No Info	No Response	Don't Know
Schedule/departure times	4	2	-	-	-
Travel times to destination stop	1	-	5	-	-
Multi-modal itineraries	1	-	5	-	-
Trip chaining	-	-	5	1	-
Rideshare opportunities	-	-	5	1	-
Best route based on...					
Shortest time	-	-	5	1	-
Lowest fare	-	-	5	1	-
Intermediate stops	-	-	5	1	-
Max. use of rail rapid transit	-	-	5	1	-
Least walking distance	-	-	5	1	-
Other	-	-	2	1	-
Connection points	-	-	5	1	-
Transit vehicle location	-	-	5	1	-
Delay information	2	4	1	-	-
Destination	2	1	2	1	-
Other information			1	4	1

Table 34: In-vehicle information provided to the traveler

Information Type	**Number of Agencies**				
	Historical	Real-Time	No Info	No Response	Don't Know
Schedule	-	-	3	-	-
Expected arrival time at next stop	-	-	3	-	-
Travel times to destination stops	-	-	3	-	-
Connecting Services	1	1	1	-	-
Schedules of connecting services	-	-	3	-	-
Next stop announcements	-	2	1	-	-
Route destination	-	1	2	-	-
Delay information	-	-	3	-	-
Emergency procedures	-	-	3	-	-
Other	-	-	-	3	-

Table 35: Links to other sources of information

System Type	Number of Agencies		
	Yes	No	No Response
pre-trip information system	2	7	1
in-terminal information system	2	4	
in-vehicle information system	1	2	

Table **36:** *The following group uses the pre-trip information system frequently.*

System User Group	Number of Agencies					
	Strongly Agree	Agree	Disagree	Strongly Disagree	No Response	Don't Know
Senior riders	4	2	1	-	2	1
Occasional riders	4	2	1	-	2	1
Commuters		3	4	-	2	1
Students	1	4	1	1	2	1
Tourists	2		4	1	2	1
Disabled riders	3	2	1	-	3	1
Off-peak regular riders	2	2	2		2	2
Recreational riders	2	3	-	-	3	2
Shoppers		4	1	-	3	2
Other	-	-	-	-	9	1

Table 37: *The following group uses the in-terminal information system frequently.*

System User Group	Number of Agencies					
	Strongly Agree	Agree	Disagree	Strongly Disagree	No Response	Don't Know
Senior riders	-	4	-	-	1	1
Occasional riders	1	3	-	-	1	1
Commuters	-	2	1	-	2	1
Students	1	3	-	-	1	1
Tourists	-	2	2	-	1	1
Disabled riders	-	3	-	-	1	2
Off-peak regular riders	1	3	-	-	1	1
Recreational riders	-	4	-	-	1	1
Shoppers	-	3	1	-	1	1
Other	-	-	-	-	6	-

Table 38: Circumstances for considering the pre-trip information system

Circumstance	Number of Agencies				
	Strongly Agree	Agree	Disagree	Strongly Disagree	No Response
Financial assistance for acquiring system was easy to secure	-	5	1	1	2
Member in the organization pushed for adoption	2	6	-	-	1
Managerial and financial resources sufficient to support operating system	-	8	-	-	1
Other opportunity-based	3	-	-	-	6
Need to replace (or upgrade) existing information system	3	4	-	1	1
Need to address short-term problem	-	-	4	1	4
Need to address long-term problem	1	4	1	-	3
Need to expand agency's services/capabilities	5	3	-	-	1
Other need-based	-	1	-	-	8

Table 39: Comparison between pre-trip information system and best alternate

Basis for Comparison	Number of Agencies							
	Pre-Trip Information System				Best Alternate			
	Agree	Disagree	No Response	Don't Know	Agree	Dis agree	No Response	Don't Know
Strong consultant recommendations	4	2	3	-	-	3	5	1
Strong product support	5	1	3	-	2	2	5	-
Reliable suppliers	7	-	2	-	4	1	4	-
Easy to assemble	4	3	2	-	3	2	4	-
Easy to install	5	2	2	-	2	2	4	1
Easy to integrate system components	5	2	2	-	1	3	4	1
Easy to test	5	2	2	-	4	1	4	-
Easy to use by average customers	3	2	3	1	2	1	5	1
Easy to use by employees	4	3	2	-	3	1	4	1
High technical maturity	4	1	3	1	3	1	5	-
"High-tech" status of technology	3	2	3	1	2	1	5	1
Product has a long life	5	-	3	1	3	1	5	-
Product is robust	3	1	3	2	-	3	5	1
Infrequent component failures	6	1	2	-	2	2	4	1
Complete breakdowns are rare	6	-	2	1	2	2	4	1
Integrates well with other technologies	6	-	2	1	2	2	4	1
Requires less employee training	4	2	3	-	2	2	5	-
Low maintenance costs	5	1	2	1	1	3	4	1
Meets agency's important needs	7	-	2	-	4	1	4	-
High internal agency agreement over acquisition	4	2	3	-	2	2	5	-
Other	-	-	9	-	-	-	9	-

Table 40: Operating and maintaining the pre-trip information system

Operational or Maintenance Issue	Number of Agencies					
	Strongly Agree	Agree	Disagree	Strongly Disagree	No Response	Don't Know
Employees adjusted easily to new operating procedures	1	5	3	-	-	-
Callers are familiar with the automated answering system	2	4	-	-	1	2
Customers prefer human interaction	3	1	1	-	-	4
Customers know about the information service	1	8	-	-	-	-
System gives consistently accurate information	3	4	-	-	-	2
Other operating issue	-	-	-	-	9	-
Suppliers are still in business	7	2	-	-	-	-
Suppliers continue to provide technical support	5	3	1	-	-	-
Suppliers continue to provide system components	5	3	1	-	-	-
Other maintenance issue	-	-	-	-	9	-

Table 41: Systems integrated with pre-trip information system

System Type	Number of Agencies	
	Currently Integrated	Integrated in Future
Automatic Vehicle Identification system (AVI)	1	1
Automatic Vehicle Location system (AVL)	**3**	**1**
Demand-responsive Computer-Aided Dispatching (CAD) system	***3***	
Ride-share matching software		
On-board comuuter	**3**	
Automatic passenger counter	**1**	
Pre-trip information system	6	
In-terminal traveler information system	1	1
In-vehicle traveler information system		
Transit operation software	2	1
Electronic ticketing and payment system		1
Signal pre-emption system		**1**
Other	1	
None	1	N/A
No Response	2	1
Incorrect Response		2

Table 42: Operator and traveler benefits of pre-trip information system

Operator and Traveler Benefits	**Number of Agencies**					
	Strongly Agree	Agree	Disagree	Strongly Disagree	No Response	Don't Know
Improved ability to monitor vehicle location	2	4	-	-	3	-
Improved schedule adherence	-	6	-	-	3	-
Enhanced security for bus drivers	1	3	-	-	3	2
Improved ability of operator to monitor driver's performance	2	4	-	-	3	-
Reduced labor hours	1	1	2	-	3	2
Improved ability to respond to breakdowns, accidents, schedule adjustments, etc.	1	4	-	-	3	1
Improved ability to respond to crimes or other security incidents	3	2	-	-	3	1
Improved ability to direct en-route vehicles	1	5	-	-	3	-
Improved coordination with other transportation modes	-	2	2	-	3	2
Reduced number of vehicles as a result of better planning	-	1	3	-	3	2
Other operator benefits	-	-	-	-	8	1
Reduced wait times	4	3	-	-	1	1
Improved ability to make connecting services	3	3	-	-	1	2
Enhanced security for passengers	1	4	1	-	2	1

Table **43:** Circumstances for considering the in-terminal information system

Circumstance	**Number of Agencies**					
	Strongly Agree	Agree	Disagree	Strongly Disagree	No Response	Don't Know
Financial assistance for acquiring system was easy to secure	-	2	-	-	1	1
Member in the organization pushed for adoption	-	3	-	-	1	-
Managerial and financial resources sufficient to support operating system	-	2	-	-	1	1
Other opportunity-based	-	-	-	-	4	-
Need to replace (or upgrade) existing information system	-	-	2	-	1	1
Need to address short-term problem	-	1	2	-	1	-
Need to address long-term problem	-	3	-	-	1	-
Need to expand agency's services/capabilities	-	3	-	-	1	-
Other need-based					4	

Table 44: Comparison between in-terminal information system and best alternate

Basis for Comparison	Number of Agencies							
	In-Terminal Information System				Best Alternate			
	Agree	Dis-agree	No Response	Don't Know	Agree	Dis-agree	No Response	Don't Know
Strong consultant recommendations	1	2	1	-	-	-	3	1
Strong product support	1	1	1	1	-	-	3	1
Reliable suppliers	1	1	1	1	-	-	3	1
Easy to assemble	-	2	1	1	-	-	3	1
Easy to install	1	1	1	1	-	-	3	1
Easy to integrate system components	2	1	1	-	-	-	3	1
Easy to test	2	1	1	-	-	-	3	1
Easy to use by average customers	3	-	1	-	-	-	3	1
Easy to use by employees	2	-	1	1	-	-	3	1
High technical maturity	2	-	1	1	-	-	3	1
"High-tech" status of technology	1	1	1	1	-	-	3	1
Product has a long life	2	-	1	1	-	-	3	1
Product is robust	2	-	1	1	-	-	3	1
Infrequent component failures	2	-	1	1	-	-	3	1
Complete breakdowns are rare	2	-	1	1	-	-	3	1
Integrates well with other technologies	3	-	1	-	-	-	3	1
Requires less employee training	1	-	1	2	-	-	3	1
Low maintenance costs	2	-	1	1	-	-	3	1
Meets agency's important needs	3	-	1	-	-	-	3	1
High internal agency agreement over acquisition	3	-	1	-	-	-	3	1
Other	-	-	4	-	-	-	4	-

Table 45: Operating and maintaining the in-terminal information system

Operational or Maintenance Issue	Number of Agencies					
	Strongly Agree	Agree	Disagree	Strongly Disagree	No Response	Don't Know
Employees adjusted easily to new operating procedures	-	1	-	-	2	1
Callers are familiar with the automated answering system	-	-	-	-	3	1
Customers prefer human interaction	-	-	-	-	2	2
Customers know about the information service	-	-	-	-	3	1
System gives consistently accurate information	-	1	-	-	2	1
Other operating issue	-	-	-	-	4	-
Suppliers are still in business	1	1	-	-	2	-
Suppliers continue to provide technical support	1	1	-	-	2	-
Suppliers continue to provide system components	1	1	-	-	2	-
Other maintenance issue	-	-	-	-	4	-

Table 46: Systems integrated with in-terminal information system

System Type	Number of Agencies	
	Currently Integrated	Integrated in Future
Automatic Vehicle Identification system (AVI)	1	-
Automatic Vehicle Location system (AVL)	2	1
Demand-responsive Computer-Aided Dispatching (CAD) system	1	
Ride-share matching software		
On-board computer	2	
Automatic passenger counter		1
Pre-trip information system		
In-terminal traveler information system	1	
In-vehicle traveler information system		
Transit operation software	2	
Electronic ticketing and payment system		
Signal pre-emption system	1	
Other		
None		NIA
No Response		2

Table 47: Operator and traveler benefits of in-terminal information system

Operator and Traveler Benefits	Number of Agencies					
	Strongly Agree	Agree	Disagree	Strongly Disagree	No Response	Don't Know
Improved ability to monitor vehicle location	1	-	-	-	2	1
Improved schedule adherence	-	1	-	-	2	1
Enhanced security for bus drivers	-	1	-	-	1	2
Improved ability of operator to monitor driver's performance	-	-	1	-	1	2
Reduced labor hours	-	-	1	-	1	2
Improved ability to respond to breakdowns, accidents, schedule adjustments, etc.	1	-	-	-	1	2
Improved ability to respond to crimes or other security incidents	-	1	-	-	1	2
Improved ability to direct en-route vehicles	-	-	-	-	1	3
Improved coordination with other transportation modes	-	1	-	-	1	2
Reduced number of vehicles as a result of better planning	-	-	-	-	1	3
Other operator benefits	-	-	-	-	2	2
Reduced wait times	-	2	1	-	1	-
Improved ability to make connecting services		1	1	-	1	1
Enhanced security for passengers	-	2	-	-	1	1

Table 48: *The following group responded positively to the implementation of a pre-trip information system.*

Group	Number of Agencies					
	Strongly Agree	Agree	Disagree	Strongly Disagree	Response	Don't Know
Planners	5	2		-	1	1
Maintenance staff		3		-	2	4
Phone operators/customer service agents	3	4		-	-	2
Information system managers	5	2		-	1	1
General manager	6	2		-	1	-
Board of Directors	5	1		-	2	1
Other group		1		-	8	-

Table **49:** Agency benefits from pre-trip information system

Agency Benefits	**Number of Agencies**					
	Strongly Agree	Agree	Disagree	Strongly Disagree	No Response	Don't Know
Increases transit ridership	2	5	-	-	-	2
Reduces number of passenger complaints	2	5	-	-	1	1
Attracts auto users to transit	-	2	2	-	-	5
Improves the image of transit service	5	4	-	-	-	-
Increases accessibility to transit service	5	3	-	-	-	1
Satisfies ADA and ISTEA legislation requirements	2	2	1	-	2	2
Other agency benefit	1	-	-	-	8	-

Table 50: Traveler benefits from the pre-trip information system

Traveler Benefits	**Number of Agencies**					
	Strongly Agree	Agree	Disagree	Strongly Disagree	No Response	Don't Know
Increases accessibility to transit services	3	4	-	-	1	1
Reduces uncertainty about transit services	5	4	-	-	-	-
Reduces anxiety of travel uncertainties	5	3	-	-	1	-
Reduces waiting time for transit services	3	4	-	-	1	1
Enables travelers to plan a trip more effectively	5	4	-	-	-	-
Makes it easier to use transit	4	5	-	-	-	-
Other traveler benefit	-	-	-	-	9	-

Table 51: *The following group responded <u>positively</u> to the implementation of the pre-trip information system.*

Group	Number of Agencies					
	Strongly Agree	Agree	Disagree	Strongly Disagree	No Response	Don't Know
Senior riders	2	2	-	-	3	2
Occasional riders	1	4	-	-	3	1
Commuters	1	3	-	-	3	2
Students	1	2	1	-	3	2
Tourists	-	2	2	-	3	2
Disabled riders	2	2	-	-	3	2
Off-peak regular riders	1	3	-	-	3	2
Recreational riders	2	3	-	-	3	1
Shoppers	2	2	-	-	3	2
Other group	1	-	-	-	8	-

Table 52: *Thefollowing group respondedpositively to the implementationof an in-terminal information system.*

Group	Number of Agencies					
	Strongly Agree	Agree	Disagree	Strongly Disagree	No Response	Don't Know
Planners	1	1	-	1	-	1
Maintenance staff	-	-	-	1	-	3
Phone operators/customer service agents	1	-	-	1	-	2
Information system managers	1	-	-	1	-	3
General manager	1	2	-	-	-	1
Board of Directors	1	2	-	-	-	1
Other group	1	-	-	-	3	-

Table 53: Agency benefits from in-terminal information system

Agency Benefits	Number of Agencies					
	Strongly Agree	Agree	Disagree	Strongly Disagree	No Response	Don't Know
Increases transit ridership	-	-	-	-	-	4
Reduces number of passenger complaints	-	1	-	-	-	3
Attracts auto users to transit	-	-	-	-	-	4
Improves the image of transit service	-	1	-	-	-	3
Increases accessibility to transit service	-	1	-	-	-	3
Satisfies ADA and ISTEA legislation requirements	-	2	-	-	-	2
Other agency benefit	-	1	-	-	3	-

Table 54: Traveler benefits from the in-terminal information system

Traveler Benefits	Number of Agencies					
	Strongly Agree	Agree	Disagree	Strongly Disagree	No Response	Don't Know
Increases accessibility to transit services	-	2	-	-	-	2
Reduces uncertainty about transit services	-	2	-	-	-	2
Reduces anxiety of travel uncertainties	-	2	-	-	-	2
Reduces waiting time for transit services		1				3
Enables travelers to plan a trip more effectively		1				3
Makes it easier to use transit		2				2
Other traveler benefit					4	

Table 55: *Thefollowing group responded positivelv to the implementation of the in-terminal information* system.

Group	Number of Agencies					
	Strongly Agree	Agree	Disagree	Strongly Disagree	No Response	Don't Know
Senior riders	-	-	-	-	-	4
Occasional riders	-	-	-	-	-	4
Commuters	-	-	-	-	-	4
Students	-	-	-	-	-	4
Tourists	-	-	-	-	-	4
Disabled riders						4
Off-peak regular riders						4
Recreational riders						4
Shoppers						4
Other group		1			2	1

Table 56: Fleet size of responding transit agencies

Fleet Size	Number of Agencies
Up to 50 vehicles	3
51 - 100 vehicles	3
101 - 200 vehicles	8
201 - *500* vehicles	*5*
501 - 800 vehicles	*5*
More than 800 vehicles	4

Total = 28

Table 57: Number of Unlinked Trips (Millions)

Fleet Size	Number of Trips				
	< 1	1 - 10	10 -50	50 - 80	> 80
< 50	3	-	-	-	-
50 - 100	-	2	-	-	-
101 - 200	1	5	1	-	-
201 - 500	-	-	4	-	-
501 - 800	-	-	1	3	-
> 800					2

No response = 6

Table 58: Number of Employees

Fleet Size	Number of Agencies			
	< 50	50 - 100	100 - 1000	>1000
< 50	3	-	-	-
50 - 100	-	1	2	-
101 - 200	-	-	8	-
201 - 500	-	-	4	1
501 - 800	-	-	-	3
> 800	-	-	-	4

No response = 2

Table 59: Traclung System

Tracking system	Number of Agencies
Dead reckoning	0
Proximity beacon / sign post	5
Radio determination	1
Satellite based	**13**
Other (sign post and odometer)	1

No response = 5

Table 60: Communication Technology

Communication Technology	Number of Agencies
Two-way radio	15
Trunked radio	4
Cellular phone	1
Other	1

No response = 6

Table 61: Years in Service

Tracking System	Number of Agencies		
	< 1 year	1-5 years	> 5 years
Dead reckoning			
Proximity beacon / sign post		2	2
Radio			1
Satellite based	6	6	
Other			

No response = 11

Table 62: Ability to Locate Vehicles with Their Current Tracking System

Tracking System	Number of Agencies			
	< 30 feet	30 - 100 feet	101 - 200 feet	> 200 feet
Dead reckoning				
Proximity beacon/sign post		2	1	1
Radio			1	
Satellite based	1	6	5	
Other(sign post and odometer)				1

No response = 10

Table 63: Other Systems Included with Their Current Tracking System

Tracking System	Number of Agencies		
	Silent Alarms	On-board Computers	Mobile Data Terminals
Dead reckoning			
Proximity beacon/sign post	5	5	1
Radio	1		
Satellite based	11	11	9
Other (sign post and odometer)	1	1	1

Table 64: Upgrading Their System with Other Systems

Tracking System	Number of Agencies		
	Silent Alarms	On-board Computers	Mobile Data Terminals
Dead reckoning			
Proximity beacon/sign post			1
Radio	1		
Satellite based	4	5	**3**
Other			

No response = 11

Table 65: Other Integrated Systems

	Number of Agencies	
	Currently Installed	Likely to be Integrated in the Future
Automatic vehicle identification system	16	
On-board computer	15	
Automatic passenger counter	3	6
Pre-trip information systems	**8**	**1**
In-terminal traveler information systems	5	1
In-vehicle traveler information systems	6	_
Ride-share matching software	1	-
Transit operation software	9	1
Electronic ticketing and payment system	2	3
Signal pre-emption system	3	1

Table 66: Operator Benefits

	Number of Agencies					Average Score*
	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know	
Improved ability to monitor location	16	6	-	-	1	2.73
Enhanced security for drivers	14	9	-		1	2.61
Improved schedule adherence	12	11	-	-	1	2.52
Improved ability to respond to crimes and other security incidents	11	12	-		1	2.48
Improved ability to monitor driver's performance	7	14	1		2	2.27
Improved ability to respond to breakdown, accidents, etc.	7	15	1		1	2.26
Improved ability to direct en-route vehicles	6	15	1		2	2.23
Reduced labor hours	2	16	3	-	3	1.95
Improved coordination with other transportation modes	2	15	3	-	4	1.95
Reduced number of vehicles as a result of better planning			7	1	3	1.81

Table 67: Traveler Benefits

	Number of Agencies					Average Score
	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know	
Enhanced security for passengers	9	13	1		1	2.35
Improved ability to make connecting services	4	16	2		2	2.09
Reduced wait times	3	15	4		2	1.95
Reduced walk distance to stops / stations		3	13	3	4	1

Table 68: Opportunity-Based Conditions

	Number of Agencies					Average Score
	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know	
A member in the organization pushed for adoption	6	13	-	-	2	2.32
Financial assistance for acquiring system was easy to secure (e.g., federal grant)	7	9	4	-	3	2.15
Managerial and financial resources were insufficient to support operating system	2	13	5	-	2	1.85

Table 69: Need-Based Conditions

	Number of Agencies					Average Score
	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know	
Need to replace (or upgrade) the existing radio/dispatching system	17	4	3	-	1	2.58
Need to expand the agency's services / capabilities	4	15	2	1	2	2
Need to address a long-term problem	5	13	5	1	1	1.92
Need to address a short-term problem	1	4	15	2	1	1.18

Table 70: Operating the System

	Number of Agencies					Average Score
	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know	
Performs vehicle identification effectively	8	7	-	-	3	2.53
Monitors vehicle schedule performance effectively	9	8	-	-	3	2.53
Monitors drivers performance effectively	6	8	1	-	5	2.33
Monitors vehicle location effectively	8	6	-	2	3	2.25
Supports dispatching decisions effectively	8	7	-	2	3	2.24
Employees adjusted easily to new operating procedures	3	10	2	-	5	2.07
System gives consistently accurate information	5	9	2	1	3	2.06
Monitors vehicle's conditions effectively	2	6	4	-	5	1.83
Monitors in-vehicle security effectively	2	6	4	-	5	1.83
Directs on route operations (demand responsive or fixed-route) effectively	2	7	2	2	5	1.69
Monitors passenger loads effectively	1	1	6	2	8	1.1

Table 71: Maintaining the System

	Number of Agencies					Average Score
	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know	
Suppliers are still in business	6	9	1		4	2.31
Suppliers continue to provide technical support	5	9	1	2	3	2
Suppliers continue to provide system components	4	10	2	1	3	2

Table 72: Positive Responses

	Number of Agencies					Average Score
	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know	
General manager	13	8	-	-	2	2.62
Board of directors	9	5	1	-	6	2.53
Planners / schedulers / analysts	11	10	1	-	1	2.45
Dispatchers	7	11	-	-	4	2.39
Phone operators /customer service agents	4	14	-	-	4	2.22
On-street supervisors	7	6	4		6	2.18
Ride or trip checkers	3	4	2		9	2.11
Maintenance staff	4	11	3		3	2.06
Information system managers	5	9	2	1	2	2.06
Drivers of transit vehicles	4	11	4		4	2

Table 73: Expected Benefits

	Number of Agencies					Average Score
	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know	
Improve ability to monitor vehicle location	23	2		-	1	2.92
Improve schedule adherence	20	5	-		1	2.8
Enhance security for bus drivers and passengers	17	8	-	-	1	2.68
Improve ability to respond to breakdown, accidents, schedule adjustment, etc.	17	8	-		1	2.68
Improve ability to monitor driver's performance	13	10	-	-	2	2.57
Improve ability to respond to crimes or other security incidents	13	11	-		1	2.54
Improve ability to direct en-route vehicles	12	11	1		2	2.46
Improve coordination with other transportation modes	5	13	2	-	5	2.15
Reduce labor hours (e.g. on-street supervisor)	9	8	5	1	3	2.09
Reduce number of vehicles as a result of better planning	7	8	6	1	3	1.95

Name/Title: ______________________ Company: ____________________ Date: __________
Address: ____________________________________ Tel: ______________ Fax: __________

SUPPLIER QUESTIONNAIRE

This questionnaire consists of three (3) parts regarding your company's advanced technology transit products: 1) company background information, 2) survey of all manufactured transit technologies, 3) specific questions about your largest revenue transit technology. Please answer all questions to the best of your knowledge. Any additional information about your company's advanced technology transit products would be welcome.

Part 1 Background

1. How many years have you been in business? ____________________ (number)

2. How many full-time employees do you have? ____________________ (number)

3. What percentage of your products are manufactured in the **U.S.?**___________ (0%-100%)

4. Do you manufacture any of your products in-house?

❑ Yes ❑ No

If yes, please list all products manufactured in-house ______________________________________

____

____

____

5. Do you have an office in California?

❑ Yes ❑ No

6. Do you work with other manufacturers/companies/consultants to provide a comple.te system?

❑ Yes

Manufacturers: ____

____

Companies: ____

____

Consultants: ____

____

❑ No

Part 2 Transit Products

Please answer technology-related questions based on your most recent commercially available products.

1. Do you sell **Automatic Vehicle Identification (AVI) systems?**

❏ Yes (please continue) ❏ No (skip to Q2)

i. On which type of sensors/detectors is your latest AVI system based?

❏ Infrared/Optical ❏ Inductive loop

❏ Radio Frequency (RF)/Microwave ❏ Surface Acoustic Wave (SAW)

ii. Does your latest AVI system have two-way communication between the reader unit and the vehicle mounted transponder?

❏ Yes ❏ No

iii. Does your latest AVI system encode variable data (e.g. passenger counts)?

❏ Yes ❏ No

iv. On the average, what percentage of the vehicles does your system miss, where 'miss' is defined as a vehicle that is not counted?

❏ Does not miss at all ❏ Misses less than 1%

❏ Misses from 1% to 5% ❏ Misses from 6% to 10%

❏ Misses more than 10%

2. Do you sell **Automatic Vehicle Location (AVL) systems?**

❏ Yes (please continue) ❏ No (skip to Q3)

i. What method does your latest AVL system use in tracking the vehicle? (Please check one only. If your system uses a combination of methods not listed below, please write the combination under Other.)

❑ Dead reckoning

❑ Proximity beacon / sign post ——————→
- O Sharp transmissions (localized signals)
- O Broad transmissions (long-range signals)

❑ Radio determination ——————→
- O Certain radio frequencies
- O Loran-C
- O Omega
- O Other____________________

❑ Satellite-based AVL systems ——————→
- O GPS/NAVSTAR (alone)
- O GPS (with either dead reckoning or map matching)
- O Differential GPS
- O TRANSIT
- O Other____________________

❑ Other (please specify)____________________

ii. How accurately can your latest system track the location of a transit vehicle?

❑ Less than 30 feet ❑ 31 to 100 feet

❑ 101 to 200 feet ❑ Greater than 200 feet

iii. How often does your latest system update location information? Every, seconds

3. Do you sell **Automatic Passenger Counter (APC) systems?**

❑ Yes (please continue) ❑ No (skip to Q4)

i. What counting device does your latest system use? (please check one)

❑ Pressure-sensitive mat ❑ Infrared beams

❑ Multi-switch treadle mat ❑ Other______________________

ii. Which of the following devices do you think is most cost effective? (please check one)

❑ Pressure-sensitive mat ❑ Infrared beams

❑ Multi-switch treadle mat ❑ Other______________________

iii. What does your latest system use to store the information?

❑ Random Access Memory (RAM) ❑ Magnetic tape

❑ Compact disk (CD-ROM) ❑ Other____________________

iv. Can your latest system send passenger counts to the dispatcher in real-time?

❑ Yes ❑ No

v. On the average, what percentage of passengers does your system miss?

❑ Does not miss at all ❑ Misses less than 1%

❑ Misses from 1% to 5% ❑ Misses from 6% to 10%

❑ Misses more than 10%

vi. Can your latest APC system provide the following information?	Yes	No
Total number of passengers served along certain route	a	❑
Actual number of passengers on the bus	❑	❑
Number of passengers boarding and alighting vehicle at certain stop	a	❑

4. Do you sell **electronic ticketing systems?**

❑ Yes (please continue) ❑ No (skip to Q5)

i. Is the ticketing device on board the vehicle, at a stationary location or both?

❑ On-board device ❑ Stationary device ❑ Both

ii. What information does your latest system collect? (check all that apply)

❑ Origin-destination data

❑ Revenue information disaggregated by ——→ ○ Route
○ Ticket type

❑ Passenger information disaggregated by ——→ O Class
○ Route
○ Time of day

❑ Other (please specify)__________________

iii. Please indicate all of the forms of payment that your system accepts:

❑ Swipe Card/Pass ❑ Magnetic Stripe Card
❑ Smart Card (contact) ❑ Proximity Card (contactless)
❑ Credit Card ❑ ATM Card
❑ Other ________________

iv. Can your tickets be reused by adding fare to them?

❑ Yes ❑ No

v. Are your tickets good for:

	Yes	No
One ride only?	❑	❑
Limited number of rides?	❑	❑
Unlimited number of rides?	❑	❑

vi. Can the traveler use your tickets for multi-modal transportation? (e.g. bus and subway)

❑ Yes ❑ No

5. Do you sell **pre-trip information systems?**

❑ Yes (please continue) ❑ No (skip to Q6)

i. What kind of technology does your latest pre-trip information system use? (check all that apply)

❑ Automatic touch-tone phone ❑ Telephone to computer operator
❑ Telephone & voice recognition ❑ Computer & modem
❑ Teletext ❑ Videotext
❑ Cable TV ❑ Other______________

ii. What is the map base of your pre-trip information software?

❑ Etak ❑ Tiger ❑ Navtek ❑ Thomas Bros. ❑ Other_______________

iii. Does your latest system provide the following information to the traveler?

	Yes	No	If yes, is the information: Historical	or Real-time?
Schedule/departure times	❑	a	Θ	Θ
Multi-modal itineraries	❑	❑	Θ	Θ
Trip chaining (itinerary optimization)	❑	❑	Θ	Θ
Rideshare opportunities	a	❑	Θ	Θ
Best route based on traveler-selected criteria				
Shortest time	❑	❑	Θ	Θ
Lowest fare	❑	❑		
Intermediate stops	❑	❑		
Maximum use of rail rapid transit	❑	❑		
Least walking distance	❑	❑		
Other__________________				
Connection points	❑	❑		
Fare information	❑	❑		
Transit vehicle location	❑	❑	Θ	Θ

Other (please specify and indicate if the information is historical or real-time) ______________________

____

____

iv. Does your latest pre-trip information system provide advance ticketing and reservations?

❑ Yes ❑ No

v. Does your latest pre-trip information system record queries for later analysis by service planners?

❑ Yes ❑ No

vi. Can your latest pre-trip information system be linked to other sources of information (e.g. traffic information, special events information)?

❑ Yes ❑ No

6. Do you sell **in-terminal traveler information systems?**

❑ Yes (please continue) ❑ No (skip to Q7)

i. How does your latest in-terminal information system disseminate information? (check all that apply)

❑ Dot matrix displays
❑ Flip-over displays
❑ Liquid crystal displays (LCD)
❑ TV monitors
❑ Synthesized voice messages
❑ Interactive audio terminals
❑ Interactive video terminals with keypads
❑ Interactive video terminals with touch-sensitive screens
❑ Other____________________

ii. What is the map base of your in-terminal information software?

❑ Etak ❑ Tiger ❑ Navtek ❑ Thomas Bros. ❑ Other_______________

iii. Does your latest system provide the following information to the traveler?

	Yes	No	If yes, is the information: Historical	or Real-time?
Schedule/departure times	❑	❑	Θ	Θ
Multi-modal itinerary	❑	❑	Θ	Θ
Trip chaining (itinerary optimization)	❑	❑	Θ	Θ
Rideshare opportunities	17	❑	Θ	Θ
Best route based on traveler-selected criteria				
Shortest time	❑	❑	Θ	Θ
Lowest fare	❑	❑		
Intermediate stops	❑	❑		
Maximum use of rail rapid transit	❑	❑		
Least walking distance	❑	❑		
Other_________________				
Connection points	❑	❑		
Fare information	❑	❑		
Transit vehicle location	❑	❑	Θ	Θ
Transit vehicle delay information	❑	❑	Θ	Θ
Destination of interest (e.g. city hall, museum)	❑	❑		

Other (please specify and indicate if the information is historical or real-time) ____________________

____

____

iv. Does your latest in-terminal information system provide advance ticketing and reservations?

❑ Yes
❑ No

v. Does your latest in-terminal information system record queries for later analysis by service planners?

❑ Yes ❑ No

vi. Can your latest in-terminal information system be linked to other sources of information (e.g. traffic information, special events information)?

❑ Yes ❑ No

7. Do you sell **in-vehicle traveler information systems?**

❑ Yes (please continue) ❑ No (skip to Q8)

i. What kind of technology does your in-vehicle information system use to disseminate information?

❑ Synthesized voice messages ❑ Flap displays

❑ Dot matrix displays ❑ Video displays

❑ Other____________________

ii. What is the map base of your in-vehicle information software?

❑ Etak ❑ Tiger ❑ Navtek ❑ Thomas Bros. ❑ Other________________

iii. Does your latest system provide the following information to the traveler?

	Yes	No	If yes, is the information: Historical	or Real-time?
Schedule	❑	❑	O	O
Expected arrival time at next stop	❑	❑	O	O
Waiting times at connecting points	❑	❑	O	O
Connecting services	❑	❑	O	O
Fare information	❑	❑		
Seating availability	❑	❑		
Next stop announcements	❑	❑		
Delay information	❑	❑		
Emergency information	❑	❑		
Destination of interest (e.g. city hall, museum)	❑	❑		

Other (please specify and indicate if the information is historical or real-time) ______________________

____

____

iv. Does your latest in-vehicle information system provide advance ticketing and reservations?

❑ Yes ❑ No

v. Can your latest in-vehicle information system be linked to other sources of information (e.g. traffic information, special events information)?

❑ Yes ❑ No

8. Do you sell **demand-responsive computer-aided dispatching (CAD) systems**?

❑ Yes (please continue) ❑ No (skip to Q9)

i. What is the map base of your automated dispatching system?

❑ Etak ❑ Tiger ❑ Navtek ❑ Thomas Bros. ❑ Other________________

ii. What functions does your latest system provide?	Historical	Real-time
❑ Passenger trip scheduling	O	O
❑ Vehicle and crew scheduling	O	O
❑ Routing	O	O
❑ Dispatching	O	O
❑ Passenger account status	O	O
❑ Passenger service monitoring and reporting (e.g. pick-ups, drop-offs)	O	O
❑ Check ADA eligibility of passenger	O	O

iii. Does your latest demand-responsive CAD system:	Yes	No
❑ Consider traveler preferences? (e.g. type of vehicle)	❑	❑
❑ Provide transit vehicle location information to traveler in real-time?	❑	❑
❑ Provide advance reservations?	❑	❑
❑ Respond to immediate requests?	❑	❑
❑ Respond to standing orders?	❑	❑

iv. Can your latest demand responsive CAD system be linked to other sources of information (e.g. traffic information, special events information)?

❑ Yes ❑ No

9. Do you sell **transit operations software?**

❑ Yes (please continue) ❑ No (skip to Q10)

i. What is the map base of your transit operations software?

❑ Etak ❑ Tiger ❑ Navtek ❑ Thomas Bros. ❑ Other________________

ii. What functions does your transit operations software provide?

❑ Personnel management

❑ Budget/Finance

❑ Vehicle maintenance scheduling

		Historical	Real-time
❑ Communications support (e.g. vehicle identification, etc.)			
❑ Network & operations planning	Is the info provided	ʘ	ʘ
❑ Vehicle & crew scheduling	Is the info provided	ʘ	ʘ
❑ Other__________________	Is the info provided	ʘ	ʘ

iii. Can your latest transit operations software be connected to:

	Yes	No
Automatic Vehicle Location (AVL) system	❑	❑
Automatic Vehicle Identification (AVI) system	❑	❑
Other________________________________		

10. Do you sell **ride-share matching software?**

❑ Yes (please continue) ❑ No (skip to Q11)

i. What is the map base of your ride-share matching software?

❑ Etak ❑ Tiger ❑ Navtek ❑ Thomas Bros. ❑ Other________________

ii. Does your latest software provide real-time (immediate) matching?

❑ Yes ❑ No

iii. How does your latest system match passengers? (check all that apply)

❑ By grid ❑ By zip code

❑ Other____________________

11. Do you sell **signal priority systems?**

❑ Yes (please continue) ❑ No (skip to Q12)

i. What method does your latest signal priority system use to "communicate" with signal controllers?

❑ Radio frequency from vehicle to signal ❑ Loop detectors

❑ Two-way radio frequency between vehicle and signal ❑ Other ________________________

ii. On average, what percentage of the vehicle does your system miss, where 'miss' is defined as not successfully communicating with a signal?

❑ Does not miss at all ❑ Misses less than 1%

❑ Misses from 1% to 5% ❑ Misses from 6% to 10%

❑ Misses more than 10%

iii. What is the range of the system's communication (in feet or meters)? ____________________

iv. How can the system change signal timing? (please check all that apply)

❑ Reducing red time ❑ Extending green time ❑ Other __________________

12. Please list all **other information technologies** that you supply as well as a brief description of each technology: ____

____

____

____

____

Part 3 Largest Revenue Transit Technology

Please answer the following questions about your **main (largest revenue) transit technology.**

A = Automatic Vehicle Identification System (AVI)
B = On-Board Computer
C = Demand-responsive Computer-Aided Dispatching (CAD) system
D = Automatic passenger counter
E = Pre-trip information system
F = In-terminal traveler information system
G = In-vehicle traveler information system (including Automatic Enunciation System)
H = Ride-share matching software
I = Transit operation software
J = Electronic ticketing and payment system (e.g. Smart card,...)
K = Signal priority system
L = Automatic Vehicle Location System (AVL)
M = Other (please specify)________________________

1. To which category does your system belong? (check only one)

CIA CIB ❑ C ❑ D ❑ E CIF CIG CIH ❑ I CIJ ❑ K ❑ L CIM

2. Which of these technologies can be integrated technically with your latest system? (check all that apply)

CIA CIB ❑ C CID ❑ E ❑ F ❑ G CIH ❑ I ❑ J ❑ K ❑ L ❑ M

3. Which of these technologies are *currently* integrated with your latest system? (check all that apply)

CIA ❑ B ❑ C CID ❑ E ❑ F ❑ G CIH ❑ I CIJ ❑ K ❑ L CIM

4. What is the price range of your technology?

Purchase & installation	$ __________________
Initial training fee	$ __________________
Additional annual fees (e.g. licensing fee, technical support)	$ __________________
Annual maintenance cost	$ __________________
Annual operation cost	$ __________________

Name/Title: ____________________ Agency: ____________________________ Date: ____________
Address: ____ Tel: _____________ Fax: _____________

PASSENGER INFORMATION SYSTEM SURVEY

This questionnaire consists of four (4) parts regarding your agency's passenger information system: 1) the context for the system, 2) the attributes of the technology, 3) the technology implementation process and 4) its impacts. For the purposes of this survey, a passenger information system is defined as any system that collects, processes and disseminates information with the assistance of computers and other information technologies. **Please consult other people in your organization for any answers you may not know.**

PART 1 CONTEXT

1. What is your agency's total fleet size?
   - ☐ Up to 50 vehicles
   - ☐ 51 to 100 vehicles
   - ☐ 101 to 200 vehicles
   - ☐ 201 to *500* vehicles
   - ☐ 501 to 800 vehicles
   - ☐ More than 800 vehicles

2. How many unlinked passenger trips did you provide during your latest fiscal year?
   ____________(number)

3. How many full-time equivalent employees (1 full time = 2,000 hours/year) work in your agency?
   ____________(number)

4. List the number of routes and the total vehicles in each service that you provide.

	Number of routes	Number of vehicles
Express/Limited	________________	________________
Local	________________	________________
Commuter	________________	________________
	Service Area Size	
Demand-responsive	_______(sq. miles)	________________

5. How would you characterize your agency's service area?
   - ☐ Large Urban (e.g. Metropolitan Area or inner city)
   - ☐ Suburban
   - ☐ Small Urban
   - ☐ Rural

6. Rank the following goals against one another according to your agency's priority. Assign '1' to the most important and '10' to the least important.

Rank:		Goal:
______	a.	Provide safe transportation
______	b.	Provide reliable transportation
______	c.	Provide economical transportation
______	d.	Improve transit accessibility
______	e.	Relieve traffic congestion
______	f.	Coordinate the agency's service with other modes of transportation
______	g.	Minimize environmental impacts
______	h.	Improve transit convenience/comfort
______	i.	Improve mobility for special groups (e.g. handicapped, lower income)
______	j.	Other ________________________

PART 2 TECHNOLOGY ATTRIBUTES

For the purposes of the remainder of this survey, the following definitions will be used.

Pre-trip information system. A computerized passenger information system that collects, processes and disseminates information to/from travelers (at home, work, etc.) prior to their trip departure.

In-terminal information system. A computerized passenger information system that collects, processes and disseminates information to travelers 'en-route' (e.g. linked trip, diverted trip, etc.) at a terminal or connecting point.

In-vehicle information system. **A** computerized passenger information system that collects, processes and disseminates scheduling, routing and connecting service information to transit users through on-board displays and communication devices.

1 Does your agency have a pre-trip information system?

☐ Yes (please answer sections i through xiv) ☐ No (please skip to question 2, Page 5)

i. Please provide the following information regarding your pre-trip information system.

Prime contractor: ________________________________

System responsibility: ________________________________

ii. What is the prime contractor's level of experience? (In this case, "Years of experience" pertains to a company's experience with passenger information systems, and not necessarily years in the business.)

☐ Less than 1 year ☐ 1 to **3** years ☐ 3+ to 5 years ☐ 5+ years

iii. How many years has your agency's pre-trip information system been in operation?

_______________________(years)

iv. What was the initial cost of your pre-trip information system?

☐ Less than $50,000
☐ $100,000+ to $200,000
☐ $50,000 to $100,000
☐ More than $200,000

v. What kind of technology does your pre-trip information system use? **(Check all that apply)**

☐ Automatic touch tone phone
☐ Telephone to computer operator
☐ Telephone & voice recognition
☐ Computer & modem
☐ Teletext
☐ Videotext
☐ Cable TV
☐ Other_______________

vi. What is the map base of your pre-trip information software? (Skip if not applicable)

☐ Etak ☐ Tiger ☐ NavTech ☐ Thomas Bros. ☐ Other_______________

vii. What is the operation schedule of your pre-trip information system?

Weekdays: ____________________ (e.g. **8** am to 5 pm)
Saturdays: __________________________
Sundays: ____________________

viii. How often is the information updated? Every _______ minute(s).

ix. How often does the system break down (become non-functional) during normal operating hours?

☐ Less than once a month
☐ 3 to 5 times a month
☐ 1 to 2 times a month
☐ More than 5 times a month

x. How many employee-hours per day are required to operate, update, and maintain the system?

☐ Up to **8** employee hours/day
☐ 17 to 40 employee hours/day
☐ **9** to 16 employee hours/day
☐ More than 40 employee hours/day

xi. Does the supplier offer technical support? ☐ Yes ☐ No

xii. Does your system provide the following information to the traveler? **(Check all that apply)**

	No information	Yes. historical	Yes. real-time
Schedule/departure times	☐	☐	☐
Delay information	☐	☐	☐
Travel times to destination stop	☐	☐	☐
Multi-modal itineraries	☐	☐	☐
Trip chaining (itinerary optimization)	☐	☐	☐
Rideshare opportunities	☐	☐	☐
Best route based on traveler-selected criteria			
Shortest time	☐	☐	☐
Lowest fare	☐	☐	☐
Intermediate stops	☐	☐	☐
Maximum use of rail rapid transit	☐	☐	☐
Least walking distance	☐	☐	☐
Other__________________		☐	☐
Connection points	☐	☐	☐
Transit vehicle location	☐	☐	☐

Other information (please specify and indicate if the information is historical or real-time) ______

____

____

____

xiii. Is your pre-trip information system linked to other sources of information (e.g. traffic information, special events information, in-terminal or in-vehicle systems)?

☐ Yes ☐ No

xiv. Please indicate your agreement or disagreement with the following statements:

Thefollowing group uses thepre-trip information systemfrequently.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know
Senior riders	☐	☐	☐	☐	☐
Occasional riders	☐	☐	☐	☐	☐
Commuters	☐	☐	☐	☐	☐
Students	☐	☐	☐	☐	☐
Tourists	☐	☐	☐	☐	☐
Disabled riders	☐	☐	☐	☐	☐
Off-peak regular riders	☐	☐	☐	☐	☐
Recreational riders	☐	☐	☐	☐	☐
Shoppers	☐	☐	☐	☐	☐
Other:________________________________	☐	☐	☐	☐	☐

2. Do you have an in-terminal information system?

☐ Yes (please answer sections i through xiv) ☐ No (please skip to question 3, page **8)**

1. Please provide the following information regarding your in-terminal information system.

Prime contractor: ____________________ ***System responsibility:*** ______________________________

ii. What is the prime contractor's level of experience? (In this case, "Years of experience" pertains to a company's experience with passenger information systems, and not necessarily years in the business.)

☐ Less than 1 year ☐ 1 to 3 years ☐ 3+ to 5 years ☐ 5+ years

iii. How many years has your agency's in-terminal information system been in operation?

_________________________(years)

iv. What was the initial cost of your in-terminal information system?

☐ Less than $50,000 ☐ $100,000+ to $200,000

☐ $50,000 to $100,000 ☐ More than $200,000

v. How does your in-terminal information system disseminate information? **(Check all that apply)**

☐ Dot matrix displays ☐ Flip-over displays
☐ Liquid crystal displays (LCD) ☐ TV monitors
☐ Synthesized voice messages ☐ Interactive audio terminals
☐ Interactive video terminals with keypads ☐ Interactive video terminals with touch-sensitive screens
☐ Other____________________

vi. Where are the message displays located? **(Check all that apply)**

☐ In stations/terminals ☐ At shopping malls, plazas, museums, etc.
☐ At stops, transfer points ☐ Other____________________

vii. What is the map base of your in-terminal information software? (Skip if not applicable)

☐ Etak ☐ Tiger ☐ NavTech ☐ Thomas Bros. ☐ Other______________

viii. How often is the information updated? Every _______ minute(s).

ix. How often does the system break down (become non-functional) during normal operating hours?

☐ Less than once a month ☐ 3 to 5 times a month
☐ 1 to 2 times a month ☐ More than 5 times a month

x. How many employee-hours per day are required to operate, update, and maintain the system?

☐ Up to **8** employee hours/day ☐ 17 to 40 employee hours/day
☐ **9** to 16 employee hours/day ☐ More than 40 employee hours/day

xi, Does the supplier offer technical support? ☐ Yes ☐ No

xii. Does your system provide the following information to the traveler? **(Check all that apply)**

	No information	Yes, historical	Yes, real-time
Schedule/departure times	☐	☐	☐
Travel times to destination stop	☐	☐	☐
Multi-modal itineraries	☐	☐	☐
Trip chaining (itinerary optimization)	☐	☐	☐
Rideshare opportunities	☐	☐	☐
Best route based on traveler-selected criteria			
Shortest time	☐	☐	☐
Lowest fare	☐	☐	☐
Intermediate stops	☐	☐	☐
Maximum use of rail rapid transit	☐	☐	☐
Least walking distance	☐	☐	☐
Other__________________		☐	☐
Connection points	☐	☐	☐
Transit vehicle location	☐	☐	☐
Delay information	☐	☐	☐
Destination	☐	☐	☐

Other (please specify and indicate if the information is historical or real-time) ________________

____

____

xiii. Is your in-terminal information system linked to other sources of information (e.g. traffic information, special events information, pre-trip or in-vehicle systems)?

☐ Yes ☐ No

xiv. Please indicate your agreement or disagreement with the following statements:
Thefollowing group uses the in-terminal informationsystemfrequently.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know
Senior riders	☐	☐	☐	☐	☐
Occasional riders	☐	☐	☐	☐	☐
Commuters	☐	☐	☐	☐	☐
Students	☐	☐	☐	☐	☐
Tourists	☐	☐	☐	☐	☐
Disabled riders	☐	☐	☐	☐	☐
Off-peak regular riders	☐	☐	☐	☐	☐
Recreational riders	☐	☐	☐	☐	☐
Shoppers	☐	☐	☐	☐	☐
Other:________________________	☐	☐	☐	☐	☐

3. Do you have an in-vehicle information system?

☐ Yes (please answer sections i through xiii) ☐ No (please skip to Part 3, Page 10)

1. Please provide the following information regarding your in-vehicle information system.

Prime contractor: ______________________ ***System responsibility:*** ______________________

ii. What is the prime contractor's level of experience? (In this case, "Years of experience" pertains to a company's experience with passenger information systems, and not necessarily years in the business.)

☐ Less than 1 year ☐ 1 to 3 years ☐ 3+ to 5 years ☐ 5+ years

iii. How many years has your agency's in-vehicle information system been in operation?

______________________(years)

iv. What was the initial cost of your in-vehicle information system?

☐ Less than $50,000 ☐ $100,000+ to $200,000
☐ $50,000 to $100,000 ☐ More than $200,000

v. What kind of technology does your in-vehicle information system use to disseminate information? **(Check all that apply)**

- ☐ Synthesized voice messages
- ☐ Flap displays
- ☐ Dot matrix displays
- ☐ Video displays
- ☐ Other____________________

vi. In how many vehicles (e.g. trains, buses) do you have the message devices (disseminating either visual or audible information, or both)? _____________ (number)

vii. What is the map base of your in-vehicle information software? (Skip if not applicable)

☐ Etak ☐ Tiger ☐ NavTech ☐ Thomas Bros. ☐ Other_______________

viii. How often is the information updated? Every _______ minute(s).

ix. How often does the system break down (become non-functional) during normal operating hours?

- ☐ Less than once a month
- ☐ **3** to 5 times a month
- ☐ 1 to 2 times a month
- ☐ More than 5 times a month

x. How many employee-hours per day are required to operate, update, and maintain the system?

- ☐ Up to **8** employee hours/day
- ☐ 17 to 40 employee hours/day
- ☐ 9 to 16 employee hours/day
- ☐ More than 40 employee hours/day

xi. Does the supplier offer technical support? ☐ Yes ☐ No

xii. Does your system provide the following information to the traveler? **(Check all that apply)**

	No information	Yes, historical	Yes, real-time
Schedule	☐	☐	☐
Expected arrival time at next stop	☐	☐	☐
Travel times to destination stop	☐	☐	☐
Connecting services	☐	☐	☐
Schedules of connecting services	☐	☐	☐
Next stop announcements	☐	☐	☐
Route destination	☐	☐	☐
Delay information	☐	☐	☐
Emergency procedures	☐	☐	☐

Other (please specify and indicate if the information is historical or real-time) ________________

____

____

xiii. Is your in-vehicle information system linked to other sources of information (e.g. traffic information, special events information, in-terminal or pre-trip systems)?

☐ Yes ☐ No

PART 3 TECHNOLOGY IMPLEMENTATION

We would like to know about your implementation experience with one of your passenger information systems. If you have more than one system running, please select only one to answer these questions.

1. Please indicate the **one** particular passenger information system that will be referenced when responding to all questions in Part **3 (check only one system that has been or will be implemented at your agency).**

   ☐ Pre-trip information system
   ☐ In-terminal information system
   ☐ In-vehicle information system

2. Describe the circumstances under which you came to consider the passenger information system.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know
Opportunity-based conditions:					
Financial assistance for acquiring system (e.g. federal grant) was easy to secure	☐	☐	☐	☐	☐
A member in the organization pushed for adoption	☐	☐	☐	☐	☐
Managerial and financial resources were sufficient to support operating the system	☐	☐	☐	☐	☐
Other: ______________________________	☐	☐	☐	☐	☐
Need-based conditions:					
Need to replace (or upgrade) the existing information system	☐	☐	☐	☐	☐
Need to address a short-term problem (e.g. natural disaster)	☐	☐	☐	☐	☐
Need to address a long-term problem (e.g. lower ridership)	☐	☐	☐	☐	☐
Need to expand the agency's services/capabilities	☐	☐	☐	☐	☐
Other: ______________________________	☐	☐	☐	☐	☐

3. Indicate the **best alternate** that you considered instead of the passenger information system **(Check only one).**

☐ Automatic Vehicle Identification System
☐ On-board computer
☐ Mobile data terminals
☐ Radio system upgrade
☐ Automatic passenger counter
☐ Pre-trip information system
☐ In-terminal traveler information system
☐ In-vehicle traveler information system
☐ Ride-share matching software
☐ Transit operation software
☐ Signal pre-emption system
☐ Do nothing
☐ Electronic ticketing and payment system (e.g. Smart card,...)
☐ Other (please describe)____

____

____

4. Quantify the costs of the chosen and best alternate technologies.

	Chosen (Information System)	Best Alternate (Q. 3)
Initial Cost (capital & installation)	$____________	$____________
Operating Cost per year	$____________	$____________
Maintenance Cost per year	$____________	$____________

5. We would like to know why you chose the passenger information system rather than the “Best Alternate” you indicated in question 3. **Please state your agreement or disagreement with the following statements for <u>each</u> of the systems.**

	Passenger Information System			Best Alternate		
	Agree	Disagree	Don’t Know	Agree	Disagree	Don’t Know
Strong consultant recommendations	☐	☐	☐	☐	☐	☐
Strong product support	☐	☐	☐	☐	☐	☐
Reliable suppliers	☐	☐	☐	☐	☐	☐
Easy to assemble	☐	☐	☐	☐	☐	☐
Easy to install	☐	☐	☐	☐	☐	☐
Easy to integrate system components	☐	☐	☐	☐	☐	☐
Easy to test	☐	☐	☐	☐	☐	☐
Easy to use by average customers	☐	☐	☐	☐	☐	☐
Easy to use by employees	☐	☐	☐	☐	☐	☐
High technical maturity	☐	☐	☐	☐	☐	☐
“High-tech” status of technology	☐	☐	☐	☐	☐	☐
Product has a long life	☐	☐	☐	☐	☐	☐
Product is robust	☐	☐	☐	☐	☐	☐
Infrequent component failures	☐	☐	☐	☐	☐	☐
Complete breakdowns are rare	☐	☐	☐	☐	☐	☐
Integrates well with other technologies	☐	☐	☐	☐	☐	☐
Requires less employee training	☐	☐	☐	☐	☐	☐
Low maintenance costs	☐	☐	☐	☐	☐	☐
Meets agency’s important needs	☐	☐	☐	☐	☐	☐
High internal agency agreement over acquisition	☐	☐	☐	☐	☐	☐
Other: ______________________	☐	☐	☐	☐	☐	☐

6. Describe your agreement or disagreement with these statements regarding your experience while implementing the chosen technology.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know
Operating the system:					
Employees adjusted easily to new operating procedures	☐	☐	☐	☐	☐
Callers are familiar with the automated answering system	☐	☐	☐	☐	☐
Customers prefer human interaction	☐	☐	☐	☐	☐
Customers know about the information service	☐	☐	☐	☐	☐
System gives consistently accurate information	☐	☐	☐	☐	☐
Other ______________________________	☐	☐	☐	☐	☐
Maintaining the system:					
Suppliers are still in business	☐	☐	☐	☐	☐
Suppliers continue to provide technical support	☐	☐	☐	☐	☐
Suppliers continue to provide system components	☐	☐	☐	☐	☐
Other _____________________	☐	☐	☐	☐	☐

The following information relates to questions 7, **8,** and 9.

A = Automatic Vehicle Identification System (AVI)
B = Automatic Vehicle Location System (AVL)
C = Demand-responsive Computer-Aided Dispatching (CAD) system
D = Ride-share matching software
E = On-Board Computer
F = Automatic passenger counter
G = Pre-trip information system
H = In-terminal traveler information system
I = In-vehicle traveler information system
J = Transit operation software
K = Electronic ticketing and payment system (e.g. Smart card,...)
L = Signal pre-emption system
M = Other (please specify)___________________

7. Which of the above systems are currently integrated with your passenger information system? **(Check all that apply)**

☐ A U B O C O D O E ☐ F U G ☐ H ☐ I O J O K O L U M ☐ None

8. Describe the total benefits of these combinations in terms of those accruing to the operator and those accruing to the traveler.

Operator benefits:	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know
Improved ability to monitor vehicle location	☐	☐	☐	☐	☐
Improved schedule adherence	☐	☐	☐	☐	☐
Enhanced security for bus drivers	☐	☐	☐	☐	☐
Improved ability of operator to monitor driver's performance	☐	☐	☐	☐	☐
Reduced labor hours (e.g. on-street supervisor)	☐	☐	☐	☐	☐
Improved ability to respond to breakdown, accidents, schedule adjustment, etc.	☐	☐	☐	☐	☐
Improved ability to respond to crimes or other security incidents	☐	☐	☐	☐	☐
Improved ability to direct en-route vehicles	☐	☐	☐	☐	☐
Improved coordination with other transportation modes	☐	☐	☐	☐	☐
Reduced number of vehicles as a result of better planning	☐	☐	☐	☐	☐
Other ________________________	☐	☐	☐	☐	☐
Traveler benefits:					
Reduced wait times	☐	☐	☐	☐	☐
Improved ability to make connecting services	☐	☐	☐	☐	☐
Enhanced security for passengers	☐	☐	☐	☐	☐

9. Which **one** of the above systems, not currently integrated, may in the future be integrated with your passenger information system? **(Check only one)**

U A ☐ B ☐ C ☐ D U E ☐ F U G ☐ H ☐ I U J ☐ K ☐ L ☐ M

PART 4 IMPACT

For Part **4,** continue answering with respect to the passenger information system identified in question 1 of Part **3.**

1. Has the passenger information system been a valuable investment **for your agency?**

   ☐ Yes ☐ Uncertain ☐ No ☐ Don't know

2. Has the passenger information system been a valuable investment **for your customers?**

   ☐ Yes ☐ Uncertain ☐ No ☐ Don't know

3. Which of the following measures does your agency use to evaluate the passenger information system's performance? **(Check and quantify all that apply.)**

	Before System Implementation	After System Implementation
☐ Operating cost per revenue vehicle hour	$ __________	$ __________
☐ Operating cost per passenger boarding	$ __________	$ __________
☐ Farebox revenue as a percentage of operating cost	__________ %	__________ %
☐ Passenger boarding per revenue vehicle mile	__________	__________
☐ Passenger boarding per revenue vehicle hour	__________	__________
☐ Number of service complaints	__________	__________
☐ Labor hours saved	__________	__________
☐ Other ____________________	__________	__________
☐ Other ____________________	__________	__________
☐ None of the above/No evaluation		

4. Please indicate your agreement or disagreement with the following statements.
Thefollowing group responded positively to the implementation of apassenger information system:

	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know
Planners	☐	☐	☐	☐	☐
Maintenance staff	☐	☐	☐	☐	☐
Phone operators/customer service agents	☐	☐	☐	☐	☐
Information system managers (MIS)	☐	☐	☐	☐	☐
General manager	☐	☐	☐	☐	☐
Board of Directors	☐	☐	☐	☐	☐
Other: ____________________	☐	☐	☐	☐	☐

5. Describe the agency benefits (i.e. benefits that are experienced) from your passenger information system.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know
Increases transit ridership	☐	☐	☐	☐	☐
Reduces the number of passenger complaints	☐	☐	☐	☐	☐
Attracts auto users to transit	☐	☐	☐	☐	☐
Improves the image of transit service	☐	☐	☐	☐	☐
Increases accessibility to transit service	☐	☐	☐	☐	☐
Satisfies ADA and ISTEA legislation requirements	☐	☐	☐	☐	☐
Other: ____________________	☐	☐	☐	☐	☐
____________________	☐	☐	☐	☐	☐

6. Describe how the information benefits the traveler.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know
Increases accessibility to transit services	☐	☐	☐	☐	☐
Reduces uncertainty about transit services	☐	☐	☐	☐	☐
Reduces the anxiety of travel uncertainties	☐	☐	☐	☐	☐
Reduces the waiting time for transit services	☐	☐	☐	☐	☐
Enables travelers to plan a trip more effectively	☐	☐	☐	☐	☐
Makes it easier to use transit	☐	☐	☐	☐	☐
Other: ____________________	☐	☐	☐	☐	☐

7. Indicate your agreement or disagreement with the following statements.
The following group responded <u>positively</u> to the implementation of the passenger information system:

	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know
Senior riders	☐	☐	☐	☐	☐
Occasional riders	☐	☐	☐	☐	☐
Commuters	☐	☐	☐	☐	☐
Students	☐	☐	☐	☐	☐
Tourists	☐	☐	☐	☐	☐
Disabled riders	☐	n	u	☐	☐
Off-peak regular riders	☐	☐	☐	☐	☐
Recreational riders	☐	☐	☐	☐	☐
Shoppers	☐	☐	☐	☐	☐
Other:________________________________	☐	☐	☐	☐	☐

Thank you for participating in this survey!

Name/Title: ____________________ Agency: ____________________________ Date: ____________
Address: ____ Tel: _____________ Fax: _____________

AVL/CAD SYSTEM SURVEY

This questionnaire consists of four (4) parts regarding your agency's AVL/CAD system: 1) the context for the system, 2) the technology's attributes, 3) the technology implementation process, and 4) the impact of the adopted system. An AVL/CAD system is defined as any computerized system that assists an operator to quickly determine a vehicle's location. **Please consult other people in your organization for any answers you may not know.**

PART 1 CONTEXT

1. What is your agency's total fleet size?
   - ☐ Up to 50 vehicles
   - ☐ 51 to 100 vehicles
   - ☐ 101 to 200 vehicles
   - ☐ 201 to 500 vehicles
   - ☐ 501 to 800 vehicles
   - ☐ More than 800 vehicles

2. How many unlinked passenger trips did you provide during your latest fiscal year?
   ____________(number)

3. How many full-time equivalent employees (1 full time = 2,000 hours/year) work in your agency?
   ____________(number)

4. List the number of routes and the total vehicles in each service that you provide.

	Number of routes	Number of vehicles
Express/Limited	______________	______________
Local	______________	______________
Commuter	______________	______________
	Service Area Size	
Demand-responsive	______ (sq. miles)	______________

5. How would you characterize your agency's service area?
   - ☐ Large Urban (e.g. Metropolitan Area or inner city)
   - ☐ Suburban
   - ☐ Small Urban
   - ☐ Rural

6. Rank the following goals according to your agency's priority. Assign '1' to the most important and '10' to the least important.

Rank: Goal:

______ a. Provide safe transportation
______ b. Provide reliable transportation
______ c. Provide economical transportation
______ d. Improve transit accessibility
______ e. Relieve traffic congestion
______ f. Coordinate the agency's service with other modes of transportation
______ g. Minimize environmental impacts
______ h. Improve transit convenience/comfort
______ i. Improve mobility for special groups (e.g. handicapped, lower income)
______ j. Other ________________________

PART 2 TECHNOLOGY ATTRIBUTES

1. Please provide the following information regarding your AVL/CAD system.

Prime contractor: ______________________________ ***System responsibility:*** ____

2. What is the prime contractor's level of experience? (In this case, "Years of experience" pertains to a company's experience with AVL/CAD systems, and not necessarily years in the business.)

☐ Less than 1 year ☐ 1 to 3 years ☐ 3+ to 5 years ☐ 5+ years

3. How many years has the AVL/CAD system been in operation at your agency? _________(years)

4. What was the initial cost of your AVL/CAD system?

☐ Less than $1 million ☐ $5+ million to $10 million
☐ $1 million to $5 million ☐ More than $10 million

5. In how many years do you expect to recover the costs of your AVL/CAD system? ______(years)

6. What location method does your AVL/CAD system use to track a vehicle?

☐ Dead reckoning
☐ Proximity beacon/sign post
☐ Radio determination (e.g. Loran-C, Omega, certain radio frequency)
☐ Satellite-based AVL/CAD system (e.g. GPS)
☐ Other ___________________________

7. What technology do you use to communicate the AVL/CAD data from the vehicle to dispatch?

☐ Two-way radio ☐ Cellular phone
☐ Trunked radio ☐ Other ___________________________

8. Does your AVL/CAD system include: **(Check all that apply)**

☐ Silent alarms ☐ Mobile data terminals
☐ On-board computers (control heads) ☐ Other___________________________

9. As currently installed, is it possible to upgrade the system with: **(Check all that apply)**

☐ Silent alarms ☐ Mobile data terminals
☐ On-board computers (control heads) ☐ Other___________________________

10. How accurately does your system track the location of a vehicle?

☐ Under 30 feet ☐ 101 to 200 feet
☐ 30 to 100 feet ☐ More than 200 feet

11. How often does your AVL/CAD system update location information? Every _____ seconds.

12. What is the map base you use with your AVL/CAD system?

☐ Etak ☐ Navtech ☐ Tiger ☐ Thomas Bros. ☐ Other ________________

13. How often does the system break down (become non-functional) during normal operating hours?

☐ Less than once a month ☐ 3 to **5** times a month
☐ 1 to 2 times a month ☐ More than 5 times a month

14. How many employee-hours per day are required to operate, update, and maintain the system?

☐ Up to **8** employee hours/day ☐ 17 to 40 employee hours/day
☐ 9 to 16 employee hours/day ☐ More than 40 employee hours/day

15. Does the supplier offer technical support? ☐ Yes ☐ No

The following information relates to questions 16, 17 and 18.

A = Automatic Vehicle Identification System (AVI)
B = On-Board Computer
C = Automatic passenger counter
D = Pre-trip information system
E = In-terminal traveler information system
F = In-vehicle traveler information system
G = Ride-share matching software
H = Transit operation software
I = Electronic ticketing and payment system (e.g. Smart card,...)
J = Signal pre-emption system
K = Other (please specify)______________________

16. Which of the above systems are currently integrated with your AVL/CAD system? **(Check all that apply)**

☐ A ☐ B ☐ C ☐ D ☐ E ☐ F ☐ G ☐ H ☐ I ☐ J ☐ K

17. Describe the total benefits of these combinations in terms of those accruing to the operator and those accruing to the traveler.

Operator benefits:	**Strongly** Agree	Agree	Disagree	Strongly Disagree	Don't Know
Improved ability to monitor vehicle location	☐	☐	☐	☐	☐
Improved schedule adherence	☐	☐	☐	☐	☐
Enhanced security for bus drivers	☐	☐	☐	☐	☐
Improved ability of operator to monitor driver's performance	☐	☐	☐	☐	☐
Reduced labor hours (e.g. on-street supervisor)	☐	☐	☐	☐	☐
Improved ability to respond to breakdown, accidents, schedule adjustment, etc.	☐	☐	☐	☐	☐
Improved ability to respond to crimes or other security incidents	☐	☐	☐	☐	☐
Improved ability to direct en-route vehicles	☐	☐	☐	☐	☐

	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know
Improved coordination with other transportation modes	☐	☐	☐	☐	☐
Reduced number of vehicles as a result of better planning	☐	☐	☐	☐	☐
Other ________________________	☐	☐	☐	☐	17
Traveler benefits:					
Reduced wait times	☐	☐	☐	☐	☐
Reduced walk distances to stops / stations	☐	☐	☐	☐	O
Improved ability to make connecting services	☐	☐	☐	☐	☐
Enhanced security for passengers	☐	☐	☐	☐	☐

18. Which **one** of the above systems, not currently integrated, may in the future be integrated with your AVL/CAD system? **(Check only one)**

☐ A ☐ B ☐ C ☐ D ☐ E U F ☐ G O H ☐ I ☐ J ☐ K

PART 3 TECHNOLOGY IMPLEMENTATION

1. How many vehicles *are* currently equipped with AVL/CAD technology? ____________(number)

2. Describe the circumstances under which you came to consider the AVL/CAD system.

Opportunity-based conditions:	Strongly Agree	Agree	Disagree	**Strongly** Disagree	Don't Know
Financial assistance for acquiring system (e.g. federal grant) was easy to secure	☐	☐	☐	☐	☐
A member in the organization pushed for adoption	☐	☐	☐	☐	*O*
Managerial and financial resources were sufficient to support operating the system	☐	☐	☐	☐	☐
Other: ____________________________________	☐	☐	☐	☐	☐

Need-based conditions:	**Strongly Agree**	**Agree**	**Disagree**	**Strongly Disagree**	Don't **Know**
Need to replace (or upgrade) the existing radio/ dispatching system	☐	☐	☐	☐	☐
Need to address a short-term problem (e.g. natural disaster)	☐	☐	☐	☐	☐
Need to address a long-term problem (e.g. service unreliability)	☐	☐	☐	☐	☐
Need to expand the agency's services/capabilities	☐	☐	☐	☐	☐
Other: ______________________________	☐	☐	☐	☐	☐

3. Indicate the best **alternate** that you considered instead of the AVL/CAD system **(Check only one).**

☐ Automatic Vehicle Identification System
☐ On-board computer
☐ Mobile data terminals
☐ Radio system upgrade
☐ Automatic passenger counter
☐ Pre-trip information system
☐ In-terminal traveler information system
☐ In-vehicle traveler information system
☐ Ride-share matching software
☐ Transit operation software
☐ Signal pre-emption system
☐ Do nothing
☐ Electronic ticketing and payment system (e.g. Smart card)
☐ Other (please describe)____

____

____

4. Quantify the costs of the chosen and best alternate technologies (identified in the previous question).

	AVL/CAD	Best Alternate (Q. 3)
Initial Cost (capital & installation)	$ ____________	$ ____________
Operating Cost per year	$ ____________	____________
Maintenance Cost per year	$ ____________	$ ____________

5. We would like to know why you chose the AVL/CAD system rather than the "Best Alternate" you indicated in question 3. **Please state your agreement or disagreement with the following statements for <u>each</u> of the systems.**

	AVL/CAD			Best Alternate		
	Agree	Disagree	Don't **Know**	Agree	Disagree	Don't **Know**
Strong consultant recommendations	☐	☐	☐	☐	☐	☐
Strong product support	☐	☐	☐	☐	☐	☐
Reliable suppliers	☐	☐	☐	☐	☐	☐
Easy to assemble	☐	☐	☐	☐	☐	☐
Easy to install	☐	☐	☐	☐	☐	☐
Easy to integrate system components	☐	☐	☐	☐	☐	☐
Easy to test	☐	☐	☐	☐	☐	☐
Easy to use by average customers	☐	☐	☐	☐	☐	☐
Easy to use by employees	☐	☐	☐	☐	☐	☐
High technical maturity	☐	☐	☐	☐	☐	☐
"High-tech" status of technology	☐	☐	☐	☐	☐	☐
Product has a long life	☐	☐	☐	☐	☐	☐
Product is robust	☐	☐	☐	☐	☐	☐
Infrequent component failures	☐	☐	☐	☐	☐	☐
Complete breakdowns are rare	☐	☐	☐	☐	☐	☐
Integrates well with other technologies	☐	☐	☐	☐	☐	☐
Requires less employee training	☐	☐	☐	☐	☐	☐
Low maintenance costs	☐	☐	☐	☐	☐	☐
Meets agency's important needs	☐	☐	☐	☐	☐	☐
High internal agency agreement over acquisition	☐	☐	☐	☐	☐	☐
Other: ______________________	☐	☐	☐	☐	☐	☐

6. Describe your agreement or disagreement with these statements regarding your experience while implementing and operating the AVL/CAD system.

Operating the system:	**Strongly Agree**	**Agree**	**Disagree**	**Strongly Disagree**	**Don't Know**
Monitors vehicle location effectively	☐	☐	☐	☐	☐
Monitors vehicle's conditions effectively	☐	☐	☐	☐	☐
Monitors passenger loads effectively	☐	☐	☐	☐	☐
Performs vehicle identification effectively	☐	☐	☐	☐	☐
Monitors driver performance effectively	☐	☐	☐	☐	☐
Monitors vehicle schedule performance effectively	☐	☐	☐	☐	☐
Monitors in-vehicle security effectively	☐	☐	☐	☐	☐
System gives consistently accurate information	☐	☐	☐	☐	☐
Supports dispatching decisions effectively	☐	☐	☐	☐	☐
Directs on route operations (demand-responsive or fixed-route svcs) effectively	☐	☐	☐	☐	☐
Employees adjusted easily to new operating procedures	☐	☐	☐	☐	☐
Other ________________________________	☐	☐	☐	☐	☐
Maintaining the system:					
Suppliers are still in business	☐	☐	☐	☐	☐
Suppliers continue to provide technical support	☐	☐	☐	☐	☐
Suppliers continue to provide system components	☐	☐	☐	☐	☐
Other ________________________________	☐	☐	☐	☐	☐

PART 4 IMPACT

1. Has the AVL/CAD system been a valuable investment?

☐ Yes ☐ Uncertain ☐ No ☐ Don't know

2. Which of the following measures does your agency use to evaluate the AVL/CAD's performance? **(Check and quantify all that apply.)**

	Before AVL/CAD Implementation	After AVL/CAD Implementation
☐ Operating cost per revenue vehicle hour	$ ______	$ ______
☐ Operating cost per passenger boarding	$ ______	$ ______
☐ Farebox revenue as a percentage of operating cost	______ %	______ %
☐ Passenger boarding per revenue vehicle mile	______	______
☐ Passenger boarding per revenue vehicle hour	______	______
☐ Miles between preventable accident	______	______
☐ Percent of vehicles adhering to schedule	______ %	______ %
☐ Percent scheduled departures on time (Indicate how many minutes late you consider 'on-time': _____ minutes)	______ %	______ %
☐ Response time to accidents	______	______
☐ Response time to breakdown	______	______
☐ Response time to crime	______	______
☐ Response time to schedule adjustment	______	______
☐ Number of service complaints	______	______
☐ Labor hours saved	______	______
☐ Number of (base/peak) vehicles reduced from service due to better scheduling and dispatching	______	______
☐ Other ______________________	______	______
☐ None of the above/No evaluation		

3. Please indicate your agreement or disagreement with the following statements.
The following group responded <u>positively</u> to the implementation of an AVL/CAD system:

	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know
Planners/schedulers/analysts	☐	☐	☐	☐	☐
Maintenance staff	☐	☐	☐	☐	☐
Phone operators/customer service agents	☐	☐	☐	☐	☐
Information system managers (MIS)	☐	☐	☐	☐	☐
Drivers of transit vehicles	☐	☐	☐	☐	☐
On-street supervisors	☐	☐	☐	☐	☐
Ride or trip checkers	☐	☐	☐	☐	☐
Dispatchers	☐	☐	☐	☐	☐
General manager	☐	☐	☐	☐	☐
Board of Directors	☐	☐	☐	☐	☐
Other: ________________________	☐	☐	☐	☐	☐

4. Describe the benefits **you** expect from your AVL/CAD system.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know
Improve ability to monitor vehicle location	☐	☐	☐	☐	☐
Improve schedule adherence	☐	☐	☐	☐	☐
Enhance security for bus drivers and passengers	☐	☐	☐	☐	☐
Improve ability to monitor driver's performance	☐	☐	☐	☐	☐
Reduce labor hours (e.g. on-street supervisor)	☐	☐	☐	☐	☐
Improve ability to respond to breakdown, accidents, schedule adjustment, etc.	☐	☐	☐	☐	☐
Improve ability to respond to crimes or other security incidents	☐	☐	☐	☐	☐
Improve ability to direct en-route vehicles	☐	☐	☐	☐	☐
Improve coordination with other transportation modes	☐	☐	☐	☐	☐
Reduce number of vehicles as a result of better planning	☐	☐	☐	☐	☐
Other _________________________	☐	☐	☐	☐	☐

Thank you for participating in this survey!