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Ventura/Lompoc Smart Card Demonstration Evaluation: Final Report Volume 1 Technical Performance, User Response, and Institutional Analysis

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Volume 1 Technical Performance, User Response, and Institutional Analysis

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Volume 1
Technical Performance, User Response, and Institutional Analysis

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Research Report

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DISCLAIMER

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

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

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ABSTRACT

This report presents evaluation results of the Smart Card Phase III Field Demonstration. Its purpose is to demonstrate the feasibility of using Smart Cards and other technology to provide an integrated fare medium across several transit operators. The Demonstration took place from May 1995 through June 1997, and it was located in Ventura County, California. Participants included seven transit agencies, with the Ventura County Transportation Commission acting as the lead local agency. The technology deployed is an integrated fare transaction and vehicle management/monitoring system, termed FareTrans VMS. Major system elements include smart passenger fare cards, fare transaction hardware and software, automatic passenger counters, a geo-positioning system, and associated communications hardware and software.

The evaluation addressed technical performance, user response, and institutional issues. Many problems were encountered in installing and deploying the hardware and software, and equipment failures continued throughout the demonstration. Communications problems prevented complete deployment of the system and implementation of all planned support functions, though most technical elements were ultimately put into revenue service in the field. Technical problems were often the outcome of institutional issues. The system was deployed before adequate testing could take place. Problems at specific sites were due to inadequate training, lack of maintenance and trouble-shooting procedures, etc. Although Smart Card users were very satisfied with the new fare medium, few transit users bought and used the cards. Transit patrons in Ventura County have very low incomes, and many are not English speakers. Smart Cards are more attractive to higher income, discretionary riders. Overall, the demonstration suffered from the absence of clear roles and responsibilities, as well as a lack of understanding of the complexity and demands of the technology. Despite deployment problems, however, participating agencies were generally enthusiastic about the FareTrans VMS, and ultimately it became a permanent part of transit operations in the county.

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EXECUTIVE SUMMARY

ES.1 BACKGROUND

This report presents evaluation results of the Smart Card Phase III Field Demonstration, sponsored by the Federal Transit Administration and the California Department of Transportation. The purpose of Phase III is to demonstrate the feasibility of using Smart Card and other technology to provide an integrated fare medium across several transit operations. The demonstration took place in Ventura County, California, and had two parts: 1) development of a multi-agency fare card system to be demonstrated among seven transit operators, and 2) development of an automated system for demand-responsive services. This evaluation covers only the integrated fare demonstration.

The Phase III Demonstration took place from May 1995 through June 1997. After the field demonstration, the Smart Card system was retained and became permanent. This report covers project activities through August 1997.

This Phase is the last for the Smart Card demonstration, which is intended to bring an automated fare collection and operations monitoring system from conceptualization to full commercialization. Phase I assessed agency needs and defined functions to be delivered by the system; Phase II tested the technical feasibility of the Smart Cards. The final step in developing a fully integrated system is to provide a common fare medium and the associated data communications system to allow fare collection and distribution among the participating transit operators.

ES.2 THE VENTURA FIELD DEMONSTRATION

The Ventura County demonstration included seven small transit operators:

- South Coast Area Transit (SCAT), 29 peak buses, providing local fixed route service in Oxnard, Ventura, and surrounding communities
- Ventura Inter-city Service Transit Authority (VISTA), 8 buses, inter-city service provided by Ventura County on four routes across the County and operated by several private contractors; also providing demand-responsive service in two small rural communities
- Simi Valley Transit, 9 buses, providing local fixed route service in Simi Valley
- Thousand Oaks Transit, 4 buses, providing local fixed route service in Thousand Oaks, and operated by private contractor

- Camarillo Area Transit, 2 buses, providing local fixed route service in Camarillo and operated by private contractor
- Moorpark City Bus, 1 bus providing fixed route service in Moorpark and operated by private contractor
- Ojai Trolley Service, 1 trolley bus providing fixed route service in Ojai; later withdrew from the demonstration

The Phase III demonstration was intended to introduce a common fare card to Ventura County. However, the start of the project was delayed several months, and in the interim, Ventura County Transportation Commission (VCTC) decided to introduce the common fare when it began operation of the inter-city VISTA service in late 1994. The Ventura County Passport was a monthly pass which could be used on all seven transit services, and which could be purchased at VCTC or at any other location where transit passes are sold. When the FareTrans VMS was deployed, the new Smart Cards were sold as the Passport, and the old plastic Passports were withdrawn. Monthly fares remained unchanged. However, the new Passport was also offered as a debit card, purchasable in $10 increments, with each $10 purchasing $11 worth of cash fare equivalent.

ES.2.1 The FareTrans VMS

The FareTrans VMS was to accommodate integrated fare transactions among the seven transit operators, generate data and reports necessary for multi-agency operation, and produce ridership statistics suitable for Section 15 reporting requirements. To achieve these objectives, such a system must have a means for reading and writing to fare cards, both on buses and at card sales outlets; exchanging card status information among all transit operators on approximately a daily basis; counting passengers and transmitting these data to a database. The main system elements include the following:

- *Passenger Transaction Controller (PTC)* The PTC is the core of the system. The on-board controller receives, modifies, stores, and transmits data from and to a variety of sources.
- *Driver Interface Unit (DIU)* The DIU reports transaction status to the driver, adds value to fare cards, and allows the driver to provide information to the system needed to accommodate passengers and to effectively process transaction data files.
- *Passenger Transaction Unit (PTU)* The PTU reads and writes to the fare cards, identifying the user and decrementing the card balance.

- *Geo-positioning System (GPS)* The GPS provides the vehicle's geographic location data. The PTC polls the GPS, providing location data for card transactions, boardings and alightings.
- *Automatic Passenger Counters (APCs)* These are laser sensors installed near the front and rear doors. Boardings and alightings are counted by passengers breaking the sensor beam. Passenger counts are written to the PTC.
- *Spread Spectrum Radio Networks* PTCs located on buses communicate with garage computers over a short-range radio system installed at each garage.
- *Garage Computers* Garage computers receive data from the PTCs via local area radio. Accumulated fare transactions, bus location, and boarding and alighting data are stored by the PTC and automatically uploaded to the garage computers via a radio link. A card status database is automatically transmitted from the garage computers to the PTCs via the same link.
- *Mobility Manager* The Mobility Manager serves as the central data bank, or as the central node of communications between entities selling fare cards and the transit agencies. This was originally intended to be a fully automated function housed at VCTC; however the technology developer, Echelon Industries, Inc., retained the mobility manager role throughout the demonstration due to a variety of technical difficulties and requirements, and due to VCTC's ultimate reluctance to accept this role.
- *Other Communication Links* In addition to communication links between garages and vehicles, communication links are required between card sales outlets and the central data bank, and between garages and the central data bank. All of these links were to be accomplished via modem or radio and to function automatically. The most important links were established during the demonstration. Some of these links remained incomplete, and those that were completed often were not fully automated for a variety of reasons.

Changes made during the deployment were due to lack of spare telephone lines at some locations, lack of suitable computers, low computer literacy among participating staff, security policies that prevented access to government computer networks, and environmental problems affecting garage computers.

ES.2.2 Chronology of the Demonstration

The staging of the deployment had a significant impact on project outcomes. As with many other FOTs, the Phase III demonstration got off to a slow start. Although the expected start was late 1994, funding was not approved until May 1995, and the first project team meeting did not take place until August. Meanwhile, the technology developer had already begun developing and testing equipment. The anticipated deployment date was January 1996. Delays in equipment acquisition and system development began to be apparent in late 1995; nevertheless, marketing of the new Passport proceeded. Consequently, the new Smart Passport was in circulation before the on-board equipment to process the cards had been installed, and while communications links between agencies and the central data bank were conducted only via mail or fax.

Equipment installation continued for several months, as the VMS was incrementally developed. Installation of APCs began in late April 1996; these generated new problems for the PTCs, requiring major changes to software. Incremental development meant constant changes to hardware and software. Drivers, supervisors, and sales outlet staff therefore required re-training, and buses needed to be made available for equipment changes, and could only be accessed incrementally. Work on the APCs continued through December of 1996, and problems with communication links continued throughout the demonstration period.

In December of 1996 VCTC announced the extension of the FOT through June 1997. In February 1997, VCTC announced that the FareTrans VMS would be retained after completion of the FOT, and the technology developer was contracted to maintain the system through 1999.

ES.3 TECHNICAL PERFORMANCE

Phase III was an ambitious effort. The field demonstration had a duration of 18 months (plenty of time to test reliability under the harsh conditions of transit operations), and a wide variety of vehicles and operating conditions were part of the demonstration. Adding passenger counters and the central database with its required communication links implied a greater load for the PTCs, and necessitated both the development of appropriate software and communications hardware. The technical performance evaluation examines the overall reliability of the system and its potential for widespread implementation. The evaluation has three parts: field logistics, operational performance and functional performance.

ES.3.1 Field Logistics

The decision to sell the Smart Passport before the system was operational led to a series of problems. First, the pressure to get equipment into the field resulted in a lack of time for bench testing or non-revenue service field testing. Lack of testing explains some of the early equipment failures. Second, product delivery delays resulted in incremental software updates and multiple versions of software being used, which in turn created incompatibility problems. And third, the incremental installation required repeated access to buses, and some transit agencies or their contractors did not provide timely access. Other logistics problems resulted from variable equipment requirements across agency fleets, changes in agency requirements during the course of the demonstration, and the addition of the VISTA DAR service well after the demonstration had begun.

ES.3.2 Operational Performance

Rushed deployment was further complicated by the technology developer's decision to conduct product tests during the deployment. Participating operators thought they were getting a technologically mature system, yet the system developer was aggressively testing new hardware components and configurations. Operators were confused by frequent on-board equipment failures and frequent hardware and software changes. Major problem areas included card initialization and re-charge data problems, data management procedures that lead to lost files, and erratic maintenance reporting, trouble shooting and repair policies.

Initial training needs were underestimated by all participants. Because so few cards were in circulation, card sales and transactions were relatively infrequent activities for some operators; consequently drivers and agency staff did not remain familiar with the system. Training was further complicated by the many changes made to the system.

ES.3.3 Functional Performance

Our evaluation of the functional performance of the Fare Trans VMS led to the following observations:

- APC estimates of passenger counts were unreliable.
- Tests of debit card transactions on SCAT buses revealed that only 42 percent of these transactions could be traced in the central database. Losses of card transaction data occurred even at the end of the test period.
- Equipment failed at an unacceptably high rate for normal operating purposes.

In addition, communications could not be completely automated. We conclude that the technical performance of FareTrans VMS is explained by four factors: 1) the rush to deploy, which led to many field operational problems; 2) inadequate training, particularly of garage personnel; 3) the poor performance of APC equipment and algorithms; and 4) the complexity of bus practices.

ES.4 USER RESPONSE

The geography of Ventura County may be described as part small town, part agricultural community and part Los Angeles suburb. Population and jobs are dispersed across the county, and population centers are separated by large distances. The county is generally affluent, with pockets of low-income population in the cities of Oxnard and Ventura, and in the agricultural areas. Transit services within the county are limited both in terms of coverage and level of service. Connections between the seven participating operators are constrained both by geography and lack of coordination. It is therefore not surprising that the transit mode share is less than one percent, and most transit users are low-income transit dependents. This test of service integration took place in an area where there is little actual service integration, and where transit plays a minor role in regional mobility.

User response was examined by comparing Passport sales before and after introduction of the Smart Passport and by conducting two transit user surveys. The first survey was conducted on VISTA routes in May 1996. The second was a telephone survey of people who had purchased the Smart Passport. It was conducted in July 1997.

We find no evidence that the introduction of the Smart Passport resulted in higher Passport sales or in greater use of transit in Ventura County. This is not a surprising result. First, the Passport and new VISTA service was introduced long before the Smart Passport. Additional services, e.g., the availability of a debit card and more options for buying and renewing cards, did not materially affect the quality or availability of transit. Second, Ventura County's geography is not conducive to transit, hence the market is limited primarily to the transportation disadvantaged. Third, the County's geography limits demand for inter-service trips, and transit services in the county are not well integrated. Fourth, competing fares on the part of some operators made the Passport less attractive.

The market share represented by Passport users is about five percent of all transit riders. However, the small number of card users were most satisfied with the card. Many had problems using the card, but since most problems were solved by allowing the passenger to ride free, card users were unaffected.

Our surveys revealed that public transit serves a highly disadvantaged population in Ventura County. Incomes are far below the county median, and about half of those surveyed did not have a driver's license. Many are Spanish speakers, and many are mentally disabled. Possession of an ATM card, a basic necessity of modern banking, is uncommon, and possession of a credit card was rare among Spanish-speaking respondents. The likelihood of having a Smart Passport is associated with higher incomes and speaking English. For the very poor, assembling the sum necessary to purchase a multi-trip pass is often impossible. Finally, Passport users did not take advantage of the flexibility the card provided. Virtually no one renewed their card via telephone or Internet; most bought and renewed their cards at the same sales outlet. We conclude that the nature of the Ventura transit market is not well suited to the advanced technology Smart Passport. Such systems are more appropriated where transit serves higher income, discretionary riders, and where actual service integration exists.

ES.5 INSTITUTIONAL RESPONSE

The institutional analysis examines roles and responsibilities of project participants, relationships between participants, participant views and perceptions, and impacts of institutional factors on the FOT. The FOT took place within a rather complex set of institutional relationships. The technology developer was funded by the Small Business Administration, and his contract was with the Volpe National Transportation Systems Center. Caltrans served as the local sponsor. VCTC was the lead local participant. VCTC is both a funding agency (allocates all county transit subsidies) and a participant (operates the VISTA inter-city service). Institutional relationships were further complicated by the presence of the many private contractors involved. A Project Manager was hired by VCTC.

There are a number of institutional issues that affected project outcomes. First, there was no clear statement of project goals and objectives. The only formal statement of goals and objectives was in a work program document written by the technology developer. During the early months of the project, there was no oversight of the technology developer by project managers, nor was there any formal discussion of roles and responsibilities of participants. Participants were not told what the demonstration would require in terms of staff time, access to vehicles, provision of information, etc., nor were there any written agreements on these issues.

Second, the operators seemed to have been given minimal information about the project. They knew the Smart Card would replace the Passport, but they did not know the implications for driver training, vehicle access, computer equipment needs, or staff computer skills. The operators were under the impression that the demonstration involved technology that already had been tested and was fully operational. The long deployment process and continuous operational problems came as a disruptive surprise. The level of the demonstration's technical complexity was not adequately understood. This led to problems in deploying the system and in maintaining the database. Nor did the operators grasp the extent of cooperation required by the project. Decisions to customize the system to the specific requirements of different operators greatly complicated the technology (adding to deployment delays), but operators did not have sufficient understanding of the system to realize the added burden such customization implied.

Third, the project suffered from a lack of consistent leadership. The technology developer had a free hand most of the time. His contractor was the Volpe Center, which had almost no involvement in the FOT. The local Caltrans monitor attended one meeting during the entire demonstration period. The project manager coordinated monthly meetings of project participants, but rarely were there formal written minutes or assigned action items. The meetings were dominated by the technology developer's report of progress and problems, and much of the discussion was beyond the technical comprehension of the participants. There was no systemic approach to solving problems, to providing the technology developer with needed information, or to making key policy decisions. The project manager did not appear to have authority to take actions or enforce decisions. Consequently, problems typically accumulated until VCTC took (unilateral) action.

Fourth, as a result of the above, the transit operators never really bought into the demonstration. They had no financial stake in the project, and, with the exception of VISTA, the Passport represented a tiny share of operator revenue. Therefore, malfunctions were not terribly important to the operators. Maintaining and repairing the FareTrans VMS equipment was in effect an added burden. Even though the technology developer performed diagnosis and maintenance, this took buses out of service and it took the time of drivers and garage personnel. This created problems for training, which was further complicated by the technology developer's underestimation of the technical sophistication required to operate and trouble shoot the system.

The primary benefit of FareTrans VMS for transit operators was the anticipated ability of the system to provide data for operations planning and for Section 15 reporting. As it turned out, the small number of card users precluded the use of card data for planning. Passenger counts were not sufficiently reliable due to the problems with the APCs, and there is no evidence of any operator having had access to the GPS data for monitoring schedule adherence. Nevertheless, participating operators remained optimistic that eventually these problems would be solved and they would get the requested data. By the end of the demonstration, they felt that the worst was over, and that it made sense to keep the system and try to obtain some of its promised benefits.

ES.6 CONCLUSIONS

This FOT provides valuable lessons for future deployments of new technology. First, new technology tests are complex and should be approached incrementally. Combining many new elements in one test creates more potential for delays and increases the burden of participants. Second, delays are inevitable and should be built into FOT schedules. Third, FOTs require strong and consistent management to keep the project on track, broker disagreements among participants, facilitate problem solving, and enforce contractual obligations. Fourth, contractual arrangements should be formal, written, and clear to all parties. Fifth, buy-in is required of all participants, from top management to staff, and including contract service providers. Sixth, choice of the test site should be appropriate to the goals and objectives of the FOT. In this case, using seven small operators made sense, because it greatly simplified the technical and institutional challenges. On the other hand, small transit services typically do not have the technical or operations expertise of larger operations. In addition, Ventura County's transit market is not an obvious candidate for an integrated fare system. And finally, basic technical knowledge and expertise of participants cannot be assumed. FOTs should begin with the assumption that participants do not have technical knowledge, and that participating agencies do not have the latest computer equipment.

ES.6.1 The Potential for Integrated Fare Management Systems

What does this FOT tell us about the wider application of the technology? Is the Smart Card an appropriate fare media? Passengers who used the Passport were overwhelmingly positive, yet few transit patrons were card users. The transit market is changing; public transit is increasingly a mode for the poor, minorities, immigrants, and those unable to drive. Therefore the Smart Card will appeal to a declining share of transit patrons. Smart Cards will not replace cash fares, so they must be considered as an additional fare medium. Given the expense of installing and maintaining a Smart Card system, a careful of assessment of costs and benefits would be required to determine its cost-effectiveness, even for commuter-oriented transit services.

Is there a market for integrated fares? Service integration requires more than a common fare. It requires integration of the service itself – convenient transfers, coordinated schedules, and a demand for trips that require using more than one service. These conditions typically occur in dense urban settings, where different modes intersect, or where different operators offer service in the same area. This implies that the technology must be robust enough to perform in such an environment – far more robust than was observed in this FOT.

Is there any reason for bundling integrated fares, GPS and passenger counters? We have noted that the market for integrated fares may be quite limited. As Smart Cards become common for other types of financial transactions, it may be worthwhile for transit to adapt to more widespread systems. When linked with APCs, GPS provides a powerful tool for tracking ridership patterns both in time and space. GPS alone provides the capability for vehicle tracking and monitoring schedule adherence. APCs would make it possible to use automated data for Section 15 reporting. The problem is that the APCs did not work. The process of counting passengers based on electronic feedback from sensors is a very complex task, and it is not clear that there is yet a reliable technology available for this purpose. In any case, the benefits of both GPS and APCs would seem to increase with agency size. Equipping a limited number of vehicles and using them for sampling various routes may be very cost-effective.

ES.6.2 Events in Ventura County After the FOT

VCTC elected to retain the Fare Trans VMS and has contracted with the technology developer for maintenance. VCTC is also considering expansions of the Passport to the regional commuter rail services. VCTC reports that many of the problems identified in the FOT have since been resolved. The technology developer is now subject to regular reporting requirements, and maintenance practices have been established at all garages. New provisions have been added to the contracts of contract operators requiring systematic problem reporting. VCTC further reports that data problems have largely been resolved, and system reliability has improved; however, not all of the operators agree with this assessment.

CHAPTER ONE
INTRODUCTION

1.1 INTRODUCTION

This report presents evaluation results of the Smart Card Phase III Field Demonstration, sponsored by the Federal Transit Administration and the California Department of Transportation. The purpose of Phase III is to demonstrate the feasibility of using Smart Card and other technology to provide an integrated fare medium across several transit operations. The demonstration took place in Ventura County, California, and had two parts:

- development of a multi-agency fare card system to be demonstrated among seven Ventura area transit operators, and
- development of an automated system for demand-responsive services operating in the Lompoc area.

This evaluation covers only the integrated fare demonstration.

The Phase III Demonstration took place over a period of 25 months. The project began in May 1995. The field demonstration was scheduled to expire in December 1996; however, the project was extended through June 1997. After the field demonstration, the Smart Card system was retained and became permanent. This report covers project activities from inception through the first week of August 1997.

This Phase is the last planned phase of the Smart Card demonstration, which is intended to bring an automated fare collection and operations monitoring system from conceptualization to full commercialization. Phase I assessed agency needs and defined functions to be delivered by the system, known as the Fare Transaction and Vehicle Management/Monitoring System (FareTrans VMS). Several different types of fare card systems were tested, including communications, software, and hardware. Phase II tested the technical feasibility of the Smart Cards and radio frequency (RF) cards in a demonstration that included three Los Angeles area transit operators. This test focused on the performance of cards, card readers, and an associated GPS vehicle location system (Giuliano and Moore, 1996; Moore and Giuliano, 1998). The final step in developing a fully integrated system is to provide a common fare medium and the associated data communications system to allow fare collection and distribution among the participating transit operators.

1.2 WHY SMART CARDS?

There is growing interest within the transit industry in using new technology to improve productivity and increase ridership. Smart Cards have the potential to solve many fare collection problems, and consequently are attracting particular interest. A Smart Card is a transaction card, which has read/write capability — the ability to receive, store, and send data. The card itself has a memory chip and some form of communications capability, either contact (e.g., a swipe card) or contactless (e.g., radio frequency, or RF). The Phase III Smart Card demonstration utilized a radio frequency card, which exchanges information with onboard card readers. When used as a transit fare card, Smart Cards are issued to patrons and programmed for the appropriate fare category (e.g., regular, student, etc.). Smart Cards can potentially handle fares differentiated by passenger type, time of day, type of trip, or distance traveled. When used as an *integrated fare medium*, the Smart Card also differentiates between transit operators, allowing the transit rider to move between transit systems while using the same fare card.

There are many problems with traditional methods of pricing and fare collection in public transit:

- Fare collection takes time. When buses are crowded, the collection process, which requires depositing coins in a farebox, issuing or collecting transfers, checking passes, etc., increases dwell time and affects level of service.
- Cash is a problem. Most public transit operators use locked fareboxes and require correct change; this is an inconvenience for passengers, yet drivers remain concerned about safety when a large amount of cash is collected.
- Passes, transfers, tokens, etc. create work for the driver that may interfere with his attention to driving, and to passengers boarding and alighting.
- Emptying fareboxes and counting cash and tokens represent a significant share of operating costs.
- Fare evasion reduces transit revenues. Cash, tokens, and passes are subject to evasion, especially on heavily traveled routes where drivers have difficulty monitoring each fare deposit.
- Existing fare methods discourage differentiated pricing and encourage flat fares, leading to poor revenue recovery and inequities across classes of passengers. Absent an automated system, time of day and distance-based fares must be monitored and enforced by the driver. Historically, complicated fare structures have been opposed by transit labor, and flat fares have become the standard within the

industry. Flat fares result in lower per unit charges for longer trips and/or peak period trips, and therefore higher subsidy costs for such trips. In addition, lower-income transit riders are more likely to travel off-peak, and to make shorter trips. Thus lower-income transit riders pay relatively higher fares than other transit riders.

- Not being able to easily transfer from one operation to another discourages ridership. In areas served by more than one transit operator, passengers wishing to transfer from one operator to another typically must pay a separate fare on each system, as in the case of taking a local bus to a commuter rail station. The additional fare may be a barrier to using transit.

Smart Cards have the potential to address many of these problems. The onboard reader automatically verifies the status of the Smart Card and charges the appropriate fare. This process is faster than conventional forms of fare collection (Chira-Chavala and Coifman, 1996), and more accurate. Drivers must respond only when the card is not valid, or it malfunctions in some way. Fare data is compiled on the bus and then transmitted to a clearinghouse, eliminating manual fare collection. Fare evasion is more difficult, as cards are verified each time they are used, and they can be programmed to eliminate many types of invalid uses (e.g., using the same card on the same bus within a short period of time). Cards are easily programmed to accommodate time of day fares, special discounts, or distance-based fares. Cards are also easily programmed to accommodate different fare structures, transfers between different operators, etc. This capability vastly increases pricing flexibility and makes possible a seamless fare.

Finally, Smart Cards also can be integrated with other fare payment systems. In the Washington Metropolitan Area Transit Authority (WMATA) field demonstration, Smart Cards could be used to pay parking fees at WMATA Park-and-Ride facilities, as well as for transit fares (WMATA, 1996). Smart Cards could be integrated with ATM cards, retail cash debit cards, or even credit card accounts.

1.3 THE CHALLENGE OF SERVICE INTEGRATION

True service integration requires more than a common fare medium. Services must be coordinated, so that transfers are convenient, and there must be some demand for trips that require using more than one service. Conditions for service integration typically occur in dense urban settings, where different modes intersect (local bus and commuter rail, fixed route and paratransit), or where different operators serve the same or similar areas (regional bus and local bus). The history of transit has been one of regulated spatial monopolies:

public operators are given exclusive rights to provide service within a given jurisdiction, with fares and service parameters set by management (or the governing board). The transit operator's incentives are to protect its service area and ridership, and therefore to resist potentially competitive services. Thus, by virtue of the way public transit is organized, there are few opportunities or incentives for service integration.

Coordination with other service providers makes sense for the transit operator only if revenue (ridership) is enhanced or service is improved, hence most existing examples of integration are between commuter rail and the bus systems that feed them. In such cases, fare coordination is established by formal agreement, with arrangements for sharing fare revenue clearly defined. For example, the commuter rail operator may establish a discounted fare for those transferring from a local bus service, or a local bus service may accept a transfer in lieu of fare. Such agreements are typically the result of lengthy planning and negotiation, as they require agreement on how the costs of the arrangement are to be allocated. Net revenues could also increase as the coordinated service attracts more riders. Such arrangements may also require service changes, for example, so that transfer wait time is minimized, and these changes may affect other parts of the system.

The concept of the "seamless transit system" implies a much greater degree of service integration: passengers should be able to move between systems whenever such moves are efficient, and they should be subject to a single set of fare rules. Such a system would require all of the following:

- coordination of services — places and times where convenient transfers can take place,
- a common fare medium and a single fare schedule,
- agreement among operators regarding fare allocation, and
- a method for collecting and allocating fare revenue.

The seamless transit concept does not require sophisticated technology, but use of new technology makes the concept both easier to implement and more flexible. The Ventura demonstration, for example, was preceded by a Passport, a monthly pass that could be used on any of the seven fixed route services in Ventura County. See Chapter Two for details. In theory, a common cash fare with free transfers would work. Consider, for example, integration of three transit services. A set of three color-coded transfers could be introduced, each color representing transfers between two services. If a flat fare were charged, fare revenue of transferring passengers would be allocated on the basis of transfers collected. However, this simple system would limit the ways in which fares might be shared, and would get complicated very quickly as different types of fares are introduced (regular, student, senior; peak/off-peak, etc.), or as more services are integrated.

The Smart Card and its associated data collection and communications system can accommodate any number of different fares and fare revenue allocations. Passengers using Smart Cards can be tracked by journey segments, and when the system includes some form of vehicle location capability, passengers can be tracked in both space and time. It is therefore possible, for example, to establish fare allocation rules based on actual passenger-miles. Since the Smart Card can store value, cards can be bought at a variety of locations and used on all participating services.

The Smart Card data communications system must be able to exchange data among participating services and keep track of the status of all Smart Card on a real-time basis. That is, as trips are taken, cards must be debited, and the remaining value must be transmitted to a central data bank. These requirements imply a Smart Card system with the following elements:

- onboard equipment that communicates with Smart Cards (transmits and receives data), and with other data sources (transfers and receives card data from central data bank);
- data transmission links between vehicles and the central data bank;
- data transmission links between card sales outlets and the central data bank; and
- a central data bank containing all card transaction data, updated in near real-time.

1.4 THE VENTURA FIELD DEMONSTRATION

The Ventura County demonstration included seven transit operators, briefly described in Table 1-1. All but SCAT are very small operations; SCAT provides local fixed route service in the cities of Oxnard, Ventura, Port Hueneme, and Ojai and in the adjacent unincorporated County areas. VISTA provides inter-city service on four routes across Ventura County. The remaining services are limited to a single city. Note that four of the seven services are operated by private contractors. A description of the project area and participating operators is given in Chapter Two.

The Phase III demonstration was intended to introduce a common fare card to Ventura. However, the start of the project was delayed several months, and in the interim, Ventura County Transportation Commission (VCTC) decided to introduce the common fare with the Ventura County Passport, a monthly transit pass, when it began operation of the inter-city VISTA service. The Passport was first issued in late 1994, and so had been in use

Table 1-1 Participating Transit Operators

Name	Service Provider	No. Peak Buses	Annual Ridership (FY 95-96)
South Coast Area Transit (SCAT)	SCAT	29	2,889,000
Ojai Trolley Service	City of Ojai	1	66,632
Camarillo Area Transit	Laidlaw Transit	2	32,000
Moorpark City Bus	Antelope Valley Bus Lines	1	15,400
Simi Valley Transit	City of Simi Valley	9	366,900
Thousand Oaks Transit	Laidlaw Transit	4	114,000
Ventura Intercity Service Transit Authority (VISTA)	Antelope Valley Bus Lines, Santa Barbara Transportation, Fill-more Area Trans-portation Company (FATCO)	8	245,300

for more than a year before the Passport Smart Cards were made available for sale in January 1996. The Passport was a monthly pass which could be used on all seven transit services, and which could be purchased at VCTC and at any other location where transit passes are sold (e.g., at the city halls and SCAT offices). The Passport was identified by passenger type (regular, student, elderly/disabled), and validity was established by stickers color coded by month.

When the FareTrans VMS system was deployed, the Smart Cards were sold as the Passport, and the old plastic Passports were withdrawn. Monthly fares remained unchanged. However, the new Passport was also offered as a debit card, purchasable in $10 increments, with each $10 purchasing $11 worth of cash fare equivalent. Because the integrated fare concept had already been introduced, it was not possible to examine the effect of the integrated fare on transit demand.

1.4.1 Demonstration Objectives

The stated goal of the Ventura County demonstration is: "Develop and implement an **integrated** Fare Transaction and Vehicle Management/Monitoring System for fixed route operations for the transit agencies in Ventura County" (Echelon, 1995a, p. 1). The integrated Fare Transaction and Vehicle Management/Monitoring System (FareTrans VMS) was to be designed to accommodate integrated fare transactions among the seven transit operators, to generate data and reports necessary for multi-agency operation, and to produce ridership statistics suitable for Section 15 reporting requirements.

Echelon's Phase III proposal (Rebeiro, 1994) expresses more specific objectives, including

- "Create and implement a fare transaction system which will address the integrated inter- and intra-agency fare transaction needs of a multi-agency operation" (p. 5),
- "Produce ridership statistics to address Section 15 reporting needs" (p. 5),
- Develop and test "the potential to use the fare card in an institutional/commercial operation" (p.2), and
- Develop software systems to "allow for fare card user registration, card recharging, vehicle and fare card operations monitoring and management and systems reporting" (p. 5).

1.4.2 Technical Elements

The onboard Passenger Transaction Unit (PTU) of the FareTrans VMS was to have many different technical capabilities:

- accommodate interagency fare transactions and corporate fare card use,
- provide vehicle location data,
- produce synthesized speech,
- print transfers and receipts,
- local area radio communications links, and
- automated passenger counting (Rebeiro, 1994, p. 6).

As with the previous phase, changes took place over the course of the demonstration, and most, but not all, of the planned system components were fully implemented and tested. Corporate fare cards were never sold; however, a few public agencies purchased group cards for shared use by clients. Synthesized speech production was tested but not implemented, and the onboard printers were not installed. No paper transfers were required in the Ventura County system, so paper transfers were not part of the demonstration.

Given that the central goal of the demonstration was to develop an integrated fare system, updating and sharing of the passenger data is the key system element. The FareTrans VMS had to have the capability of maintaining and continuously updating a database of passenger card purchases, renewals, and use. This requires a central database, and two-way communications links between each operator and the database, as well as between card sales locations and the database. It was envisioned that the central database function would be completely automated and housed within the Ventura County Transportation Commission. However, communications links were never fully automated, and the central database function remained with the project technical developer, Echelon Industries, for the duration of the test.

The automated passenger counters were intended to provide the capability of producing ridership data for Section 15 reporting requirements. Passenger counters were installed in some buses of four of the seven transit operators, and some sample graphics illustrating boardings and alightings by transit stop were produced for one operator. However, ridership reports were not produced and distributed on a regular basis, and transit operators were not provided with software to generate their own reports. Driver login errors made it difficult to generate reports, because errors made it difficult to associate transaction data with the correct bus route and run.

1.5 DESCRIPTION AND PURPOSE OF THE EVALUATION

The purpose of the Phase III evaluation is to provide an overall assessment of the FOT that will help to inform the transit industry and federal sponsors of the utility and promise of systems such as the FareTrans VMS for widespread implementation within the industry. The evaluation covers the four general areas briefly described below.

1.5.1 Functional Performance of Hardware and Software Components

Performance of the main onboard (commercial) hardware elements of FareTrans VMS — RF Smart Cards, PTUs, GPS, and onboard computers — was demonstrated in Phase II. However, the Phase III environment is more challenging because the duration of the field demonstration is significantly longer (18 months vs. 5 months), and because a wider variety of vehicles were involved (mini buses, inter-city coaches, and several different types and configurations of transit coaches). The longer duration of the field demonstration should reveal whether Smart Cards or other commercial components of the system wear out more quickly than anticipated in the quasi-industrial environment of a transit bus.

In addition, the FareTrans VMS was significantly expanded to include automated passenger counters, the central database and its required communications links. These added functions imply a greater load for the onboard computer, as well as development of appropriate software and communications hardware. The concept of an automated central database function implies extensive software development for periodic polling, database updating, etc. The commitment to provide Section 15 reporting data requires software for generating these reports for each transit operator. Echelon Industries agreed to provide these reports during the demonstration.

Functional performance includes examinations of capabilities and performance expectations, analysis of in-use performance, and comparisons of actual performance with industry standards where applicable. Equipment malfunctions, communications problems, and software problems must be described and explained. The functional performance evaluation provides information on the overall reliability of the test system and its potential for widespread implementation.

1.5.2 Impacts on Transit Operations, Management, and Efficiency

The potential impact of the integrated fare system on the transit agency is significant. As noted earlier, automated fare payment has many potential benefits. At the same time, implementation involves costs, even when the hardware and software are provided at no charge, as was the case in this demonstration. Drivers must be trained to operate the equipment, and bus maintenance must incorporate monitoring the new equipment. Policies must be agreed upon for setting fares, sharing fare revenue among operators, and for dealing with card and other malfunctions. Vehicles and garages must be made available for equipment installation and periodic monitoring. Whether net benefits (in the form of productivity improvements or cost reductions) are realized depends on both the operating improvements provided and the costs of deploying the system and maintaining its operation.

1.5.3 Transit Passenger Responses

The Phase II evaluation showed that transit passengers' response to the Smart Card was overwhelmingly positive. Nearly all users reported being satisfied with their Smart Card, and users reported few problems with using the card. The likelihood of purchasing a card was greater for those who speak English and who have higher household income (Giuliano and Moore, 1996). The Ventura demonstration provides a much larger potential market of users, and the duration and technical complexity of the demonstration may increase the likelihood of users encountering problems with their cards. Experiences with the cards — including how and where they are purchased and renewed, how well they work, and how they are used — must be examined and compared to attitudes and perceptions about the cards. Of particular interest is the extent to which the cards are actually used in an integrated setting, i.e., for making trips involving more than one transit provider. Card use and perceptions are also evaluated across passenger socioeconomic and demographic segments to assess the feasibility of introducing Smart Cards on a broad scale.

1.5.4 Organizational and Institutional Issues

The demonstration and implementation of new technology require interaction between project sponsors, system developers, and participating transit agencies. In this case, participating transit agencies were asked to establish a common fare policy, policies for dealing with card malfunctions, policies for sharing data, and a fare allocation policy. The operators chose to retain their separate fair structures. VCTC viewed this capability as a strength of the system.

Cooperation is made more challenging by the number of contract operators involved. These contractors have no stake in the project, and likely have little influence on it. Moreover, the complexity of the technology itself may create barriers between the technology developer and agency participants, who may be far less technologically sophisticated (Giuliano and Moore, 1996). The FOT also requires an ability to respond to unforeseen changes and problems that are part of any test of new technology. As problems accumulate and deployment delays are encountered, agency participants may become less enthusiastic towards the entire project.

Success in proving the feasibility of using new technology elements is a necessary but not sufficient condition for widespread implementation; rather general implementation depends on agency assessments of the use and effectiveness of product and its overall impact on the organization. Monitoring the process of interagency negotiations and interactions can provide valuable insight on how FOTs are effectively accomplished.

1.6 CONTENT OF VOLUMES 1 AND 2

The Phase III evaluation was conducted as a joint project of University of Southern California and University of California, Berkeley. The UC Berkeley team conducted the evaluation of impacts on transit operations, management, and efficiency. The USC team conducted all other aspects of the evaluation. The USC team research results are presented in Volume 1 of the Final Report, and the UC Berkeley team results are presented in Volume 2.

The evaluation was conducted consistent with guidelines developed by the Volpe Center for FTA (Casey and Collura, 1994), which constitute an appropriate set of scientific procedures. Figure 1.1 summarizes the relationships these guidelines presume for field operation tests of advanced public transportation systems (APTS). The specific relationships operating in Smart Card Phase III are summarized in Figure 1.2.

Phase III is consistent with the generic framework described in Figure 1.1, but relatively more complex because of the large number of participants. Echelon is in receipt of a Small Business Administration award. These funds were administered through the FTA and the California Department of Transportation (Caltrans) Headquarters, and were passed with other funds to Caltrans District 7, Los Angeles and Ventura Counties, to pay for the project. Additional funds were provided by the Ventura County Transportation Commission. The funds for Echelon's contract were passed to the FTA's Volpe Center, which exercised sign-off authority over Echelon's status reports and invoices. Caltrans District 7 was responsible for administering the VCTC contracts and expenses including those for the project manager, and executing contract amendments. The project manager, Jackie Bacharach and Associates, was hired by VCTC.

1.7 ORGANIZATION OF VOLUME 1

The remainder of this Final Report is organized as follows. Chapter Two presents an overview of the project and a description of the FOT. Chapter Three presents the technical performance evaluation. User response is discussed in Chapter Four, and the institutional response is presented in Chapter Five. Chapter Six summarizes our research findings, presents overall conclusions on the Phase III demonstration, and provides recommendations for future new technology field operational tests.

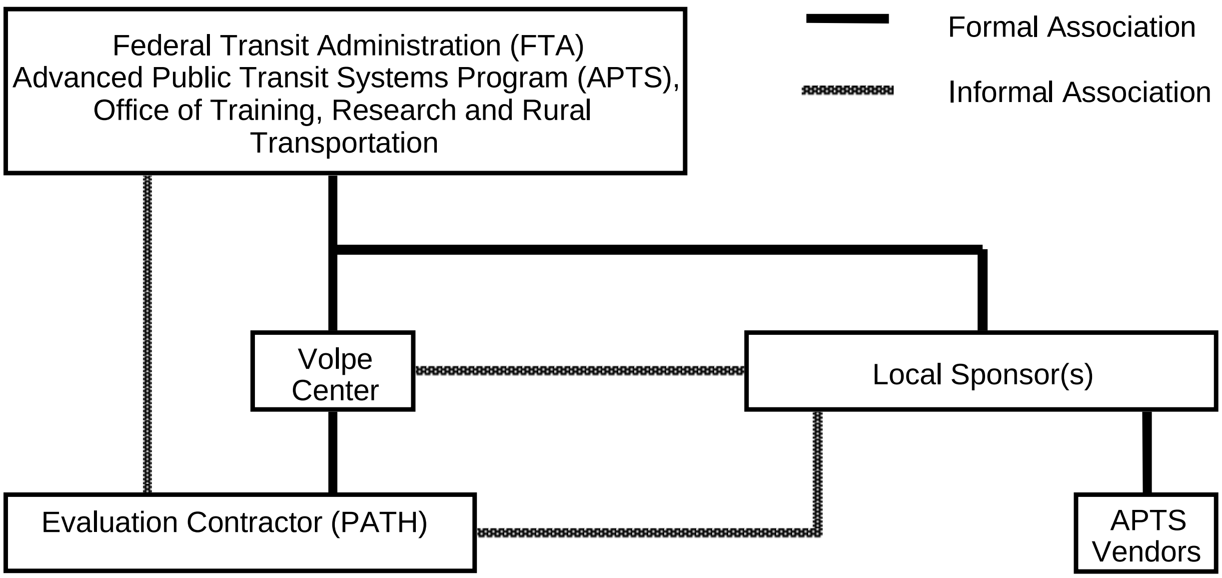

Figure 1.1 Evaluation Relationships for Advanced Public Transportation Systems Operational Tests

Source: Casey and Collura (1994) Exhibit 2, p. 6

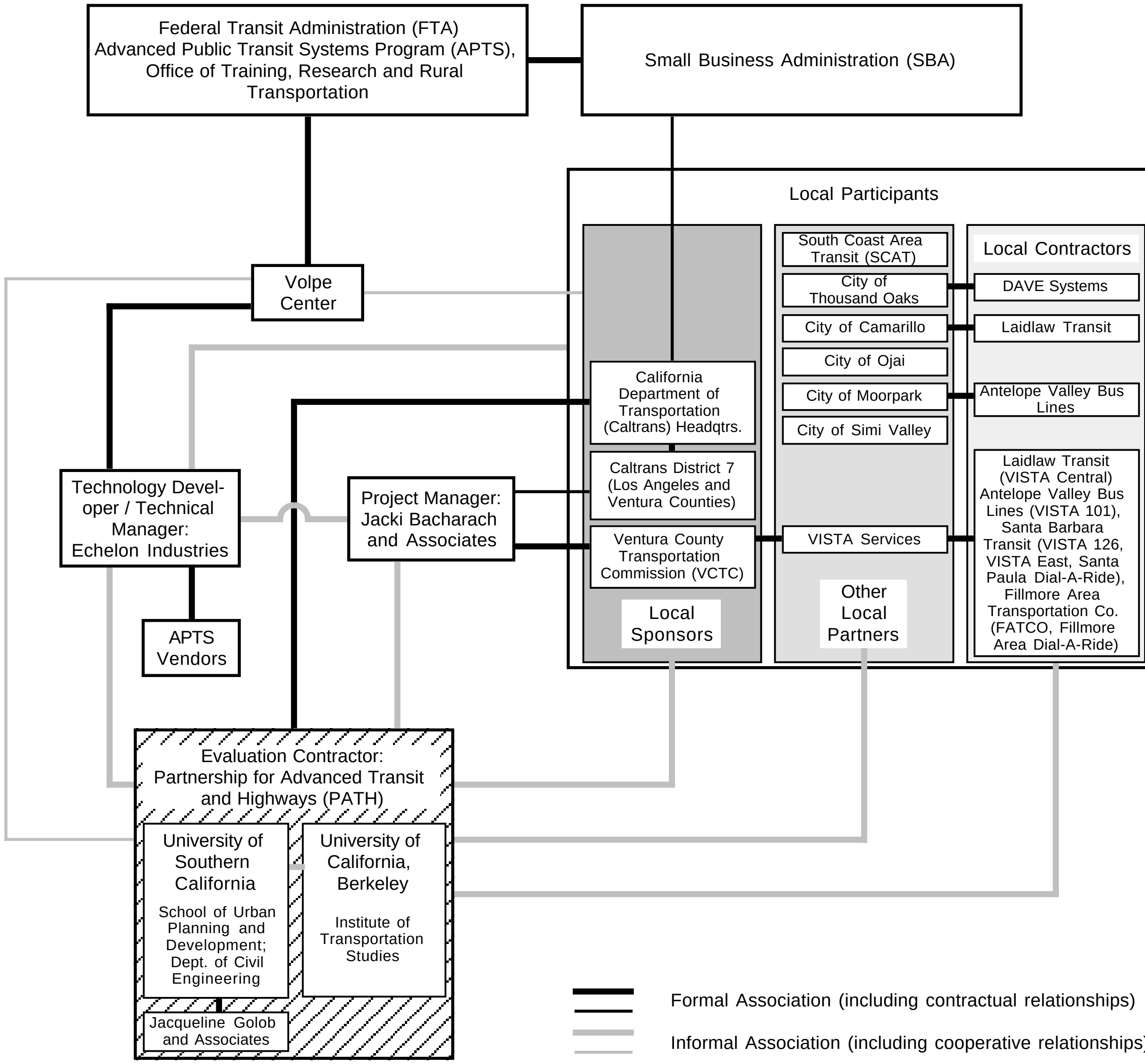

Figure 1.2 Evaluation and Project Relationships for Phase III of the FareTrans VMS Field Operational Test

CHAPTER TWO
DESCRIPTION OF THE PROJECT AND OVERVIEW OF THE FIELD OPERATIONAL TEST

Chapter Two provides a description of the project and its context, and an overview of the system deployed in Phase III of the field operational test. The results provided by Phase I of the FOT indicate that the FareTrans VMS should be considerably more than a fare collection tool. A cashless fare system is desirable, but ultimately the system should enhance transit productivity by providing transit operators with new levels and kinds of management information. The Phase III deployment fields a system that has the potential to provide much of this information.

2.1 PROJECT DESCRIPTION

This section describes the Ventura County area and the participating transit operators, and provides a chronology of the FOT.

2.1.1 Ventura County

The FOT took place in Ventura County, which is part of the five-county greater Los Angeles Consolidated Statistical Area (CSA). Located to the west of Los Angeles County, Ventura County has, until recently, remained isolated from the explosive growth of the region. The county population was 669,000 in 1990 and an estimated 710,000 in 1995. With an average density of 385 persons per square mile, Ventura county remains a sparsely populated area with the metropolitan region. Population and employment are dispersed among several cities and communities located along three corridors defined by major highways (see Figure 2.1). Outside these corridors, the county is mainly rural. SR-101, the major inter-city coastal route between Los Angeles and northern California, is the most extensively developed corridor. The cities of Ventura, Oxnard, Camarillo, and Thousand Oaks are located in this corridor. SR-118 connects the west San Fernando Valley (Los Angeles County) with Ventura. This corridor has the communities of Simi Valley and Moorpark, which effectively are affluent suburbs of Los Angeles. To the north is the SR-126 corridor, which traverses the main agricultural area within the county. This area continues to be sparsely populated. The old core of the county is the Ventura-Oxnard area. Other cities are relatively isolated, and distances between them are in some cases significant.

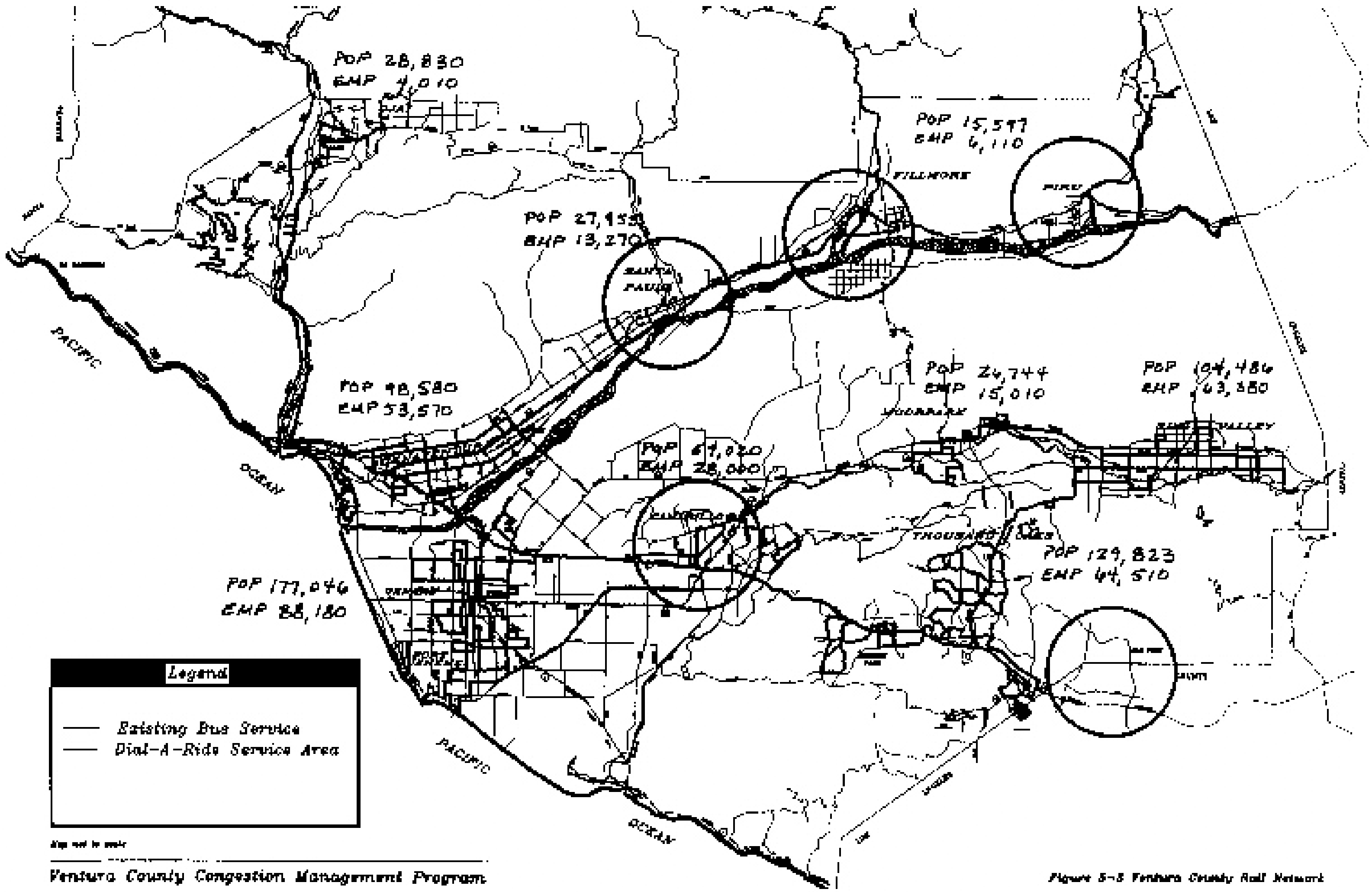

Figure 2.1 Major Population Corridors in Ventura County

Table 2-1 provides some basic information on Ventura County communities drawn from 1990 census data. The single largest population concentration is in the Oxnard-Ventura area; other concentrations are in the eastern suburbs of Thousand Oaks and Simi Valley. The population is diverse, with the greatest concentrations of low-income and immigrant households in the farm communities of Santa Paula, Fillmore-Piru, and Oxnard. Oxnard has the highest proportion of recent immigrants, and also has a larger-than-average proportion of low-income households. In contrast, the eastern suburbs (Thousand Oaks, Moorpark, Simi Valley) are characterized by relatively high median household incomes.

Employment growth has been robust in Ventura County; employment totaled 383,100 in 1997. Like the population, jobs are also dispersed throughout the County, as illustrated in Figure 2.2. Major job centers include Oxnard, Thousand Oaks, Simi Valley, and Ventura. Thousand Oaks and Simi Valley have emerged as high-tech employment centers, while Oxnard has a more diversified employment base. Ventura is a government center.

2.1.2 Public Transit

Public transit plays a minor role in commuting. According to the 1990 U.S. Census, the journey-to-work mode shares in Ventura County are as follows: drive alone, 76.0 percent; carpool, 15.5 percent; public transit, 0.66 percent; walk or bike, 3.6 percent; work at home, 3.0 percent; and other means, 1.15 percent. The drive alone share is higher and the transit share is lower than the regional average.[1] Limited availability and dispersed travel patterns likely explain the low transit share.[2]

Transit service in Ventura County includes several local services — some fixed-route and some demand-responsive — limited commuter services, and county inter-city service. The commuter services include commuter rail, which provides service from Moorpark and Simi Valley to Los Angeles; and commuter bus, which provides service from Thousand Oaks and Simi Valley to Los Angeles. These services were not part of the FOT.

The largest transit operator is SCAT, which provides service in Oxnard, Ventura, and the surrounding communities. SCAT is a transit authority formed by several cities and the County. Annual ridership is just under 3 million. SCAT has a fleet of 35 vehicles and operates fixed route service on 13 routes. Headways range from 20 to 60 minutes, and service operates from 5 A.M. to 9 P.M. daily.[3]

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[1] 1990 mode shares for the region are drive alone, 72.4%; carpool, 15.5%; transit, 4.6%.
[2] Additional services have been introduced since 1990, including Metrolink commuter rail service and the VISTA services.
[3] The fleet has since been increased to 43 vehicles.

Table 2-1 Ventura County Population Characteristics, by Census Division, 1990

Census Division	Population	Percent Total County Population	Median Household Income	Percent Households With < $30K Income	Percent in U.S. 5 or Fewer Years
Oxnard	177,046	26.5	$36,334	39.0	7.3
Ventura	98,580	14.7	$39,894	35.2	1.7
Camarillo	54,020	8.1	$50,462	24.7	2.4
Thousand Oaks	129,823	19.4	$57,295	21.0	2.9
Simi Valley	104,486	15.6	$54,239	17.8	2.6
Moorpark	26,744	4.0	$60,014	15.0	3.3
Santa Paula	27,955	4.2	$31,695	47.2	6.2
Fillmore – Piru	15,597	2.3	$34,796	42.2	6.0
Meiners Oaks – Ojai	28,830	4.3	$36,535	40.7	2.0
Other Divisions	5,935	9.0	N/A	N/A	N/A
Total County	669,016	100.0	$45,612	29.6	4.0

Source: 1990 U.S. Census

VCTC provides the VISTA service, which includes both fixed route inter-city service and local paratransit. VISTA paratransit serves mainly the eastern parts of the county. All services are operated by contractors. As noted in Chapter One, VISTA was established in 1994. There were four inter-city routes at the time of the test:

- Vista-101: Oaks Mall (Thousand Oaks) - Oxnard - Buenaventura Mall (Ventura) via SR-101; operated by Antelope Valley Bus Lines
- Vista-126: Fillmore - Santa Paula - Buenaventura Mall (Ventura) via SR-126; operated by Santa Barbara Transportation
- Vista-Central: Camarillo - Pt. Mugu - Oxnard Transportation Center (Oxnard); operated by Laidlaw Transit

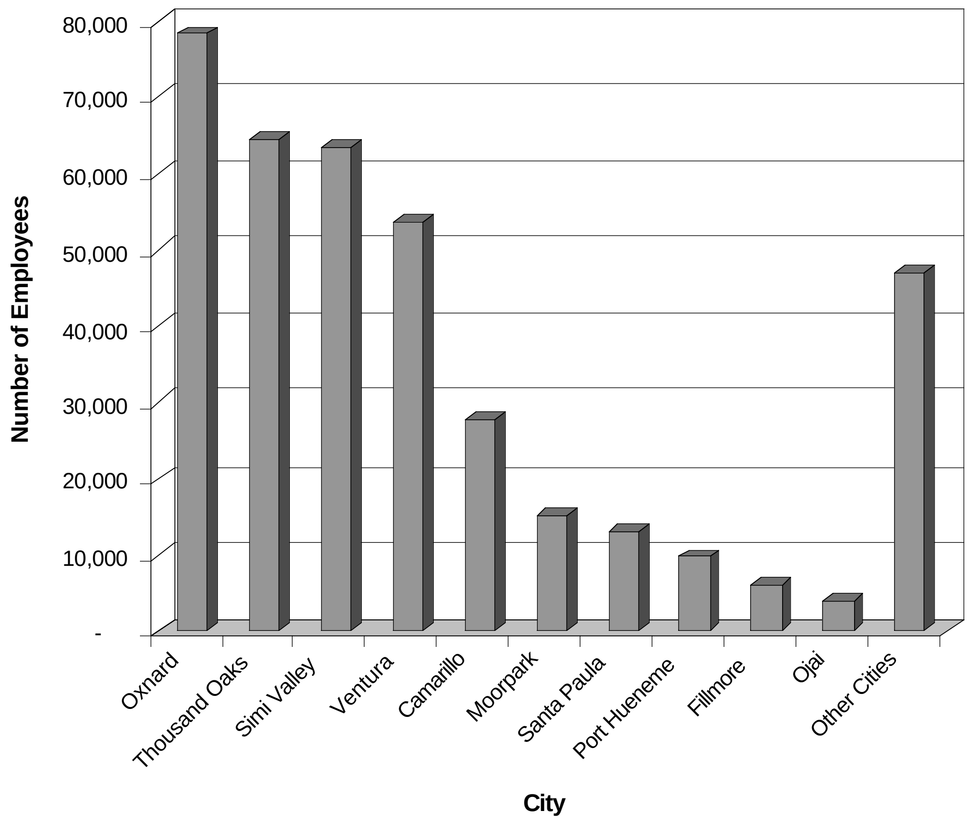

Figure 2.2 Employment Distribution in Ventura County

- Vista-East: Moorpark - Simi Valley - Thousand Oaks; operated by Santa Barbara Transportation

VCTC also provides the Santa Paula and Fillmore Dial-A-Ride services. Santa Barbara Transportation operates Santa Paula, and Fillmore Area Transit Corporation (FATCO) operates Fillmore. There are direct connections between the Dial-A-Ride and fixed route VISTA services. VISTA-126 drivers communicate by radio with the Dial-A-Ride services to coordinate transfers.

The cities of Thousand Oaks, Simi Valley, Moorpark, Camarillo, and Ojai operate local municipal transit systems. Simi Valley operates within the city and has connections to commuter services provided by the regional bus operator, Los Angeles County Metropolitan Transportation Authority (MTA). The city owns and operates its fleet of nine vehicles. The service operates Monday through Saturday, from 4:30 A.M. to 8 P.M. Of these small municipal systems, Simi Valley Transit has the largest annual ridership, about 352,000.

Thousand Oaks Transit provides service within the city of Thousand Oaks. Buses are owned by the city and operated by Laidlaw Transit and Dave Systems. Three routes operate Monday through Friday from 6:30 A.M. to 6:30 P.M. The system carries about 114,000 annual passengers. Thousand Oaks Transit has connections with MTA Route 161, and Los Angeles Department of Transportation (LADOT) Route 422. The city of Moorpark provides service on a single fixed route with one bus. The service is operated by Antelope Valley Bus Lines. Headways are 60 minutes, and the service operates from 7:15 A.M. to 4:40 P.M. Monday through Friday. Annual ridership is about 12,000. Camarillo also provides service on a single fixed route; headways are 90 minutes, and service is available from 7:15 A.M. to 6:15 P.M., Monday through Saturday. Annual ridership is about 32,000. This is also a contract service operated by Laidlaw Transit. Finally, Ojai owns and operates the Ojai Trolley, a two-vehicle, single-route service that operates daily from 7:30 A.M. to 5:30 P.M. The service is rather unique; the vehicles are rubber-tired trolleys and oriented to tourists. The fare is just 25 cents, and tokens are offered for even less. Although Ojai was included in the FOT, the system effectively but unofficially dropped out by early 1997 as a result of equipment problems and lack of Passport sales. Their low fare precluded effectively marketing a monthly pass costing $20 to $30.

A primary objective of the FOT was to develop an integrated fare transaction and vehicle management system. Implicit in this is service integration. It is therefore important to describe the actual extent to which these services are integrated in terms of transfer opportunities and fare policies.

VISTA inter-city routes provide connections between the various local systems, hence transfer opportunities between different operators are primarily determined by the extent to which VISTA is integrated with other services. Table 2-2 lists all possible transfer points between the VISTA inter-city routes and other services. There is at least one transfer point for each of the municipal services. In addition, there is a transfer point for VISTA 101 and 126 (Buenaventura Mall), and VISTA 101 and VISTA East (Oaks Mall, not shown in Table 2-2).

Because of the long distances and lengthy headways of the VISTA routes, there is some question as to whether any significant demand for transfers between services exists. A 1997 VISTA on-board survey indicates that 22 to 37 percent of those surveyed transferred, depending on the route. Of these, 30 to 85 percent transferred to non-VISTA services, implying that about 15 percent of all VISTA passengers transfer to other services. Since VISTA is designed to connect with other services, transfer rates for other operators are likely much lower. As noted earlier, the Fillmore and Santa Paula DAR systems communicate directly with VISTA 126 to arrange transfers between the services, and the DAR systems do function as feeders to the VISTA route. This is not the case in other locations. For travel between Oxnard and Ventura, there are several SCAT routes available.

Table 2-2 Available Inter-Agency Transfers, VISTA Inter-city Routes

From	To	Transfer Point
VISTA-101	Camarillo Area Transit Thousand Oaks Transit SCAT	Carmen Plaza (Camarillo) Oaks Mall (Thousand Oaks) Buenaventura Mall (Ventura)
VISTA-126	Santa Paula DAR Fillmore DAR SCAT	Santa Paula Fillmore Senior Center Buenaventura Mall Wells Center (Ventura)
VISTA-Central	Camarillo Area Transit DAR SCAT	Camarillo (Ventura Boulvard/Arneill Road) Oxnard Transportation Center “C” Street Mall, Oxnard
VISTA-East	Thousand Oaks Transit Moorpark City Bus Simi Valley Transit	Oaks Mall Moorpark College Country Club Drive (Simi Valley)

Simi Valley Transit has connections with the VISTA East route. No special efforts have been made to coordinate schedules with VISTA services, in part because VISTA services began operating after Simi Valley routes and schedules were in place. Thousand Oaks Transit has connections with VISTA 101 and VISTA East, but does not honor VISTA transfers, and schedules are not coordinated.

Participation in the FOT also required that the transit operators agree on a common fare. The Smart Passport monthly pass is offered at $40 regular adult, $30 student, and $20 elderly and disabled. All participating operators accept the Smart Passport passes at these rates. The debit card is offered in $10 increments, with each increment credited with an additional $1 (purchaser gets $11 value for $10 purchase). Debit card users pay the cash equivalent fares applying at each transit agency. Children under five ride free.

How do the Passport fares compare with the fares of other services? Table 2-3 summarizes fare structures for the seven participating operators, including VISTA. Monthly passes are for unlimited trips unless otherwise noted. Definitions for “elderly” vary, from 62 years of age in Thousand Oaks to 75 years in Ojai. Table 2-3 shows that for local trips, monthly passes provided by individual transit operators are cheaper than the Passport for all local services except Simi Valley (adult and student). SCAT’s ticket books and passes are the best value for SCAT patrons. For those who do not transfer between services, there is little incentive to purchase the Smart Passport pass. The additional discount on debit cards makes them more economical than paying cash fare.

Table 2-3 Transit Agency Fare Structures

Agency	Media	Purchase Price/Unit			
		Adult	Student	Elderly	Disabled
Camarillo Area Transit	Cash	$1.00	$0.50	$0.50	$0.50
Moorpark City Bus	Cash	$0.75	$0.75	$0.50	$0.75
	Pass	$27.00	N/A	N/A	$27.00
Ojai	Cash	$0.25	$0.25	Free	$0.25
	Token	$0.20	$0.20	Free	$0.20
South Coast Area Transit (SCAT)	Cash	$1.00	$0.75	$0.50	$0.50
	Token	$1.00	$0.75	$0.50	$0.50
	Pass	$30.00	$24.00	$12.00	$12.00
	10 Ride Ticket	$7.50	$6.00	$3.00	$3.00
	20 Ride Ticket	$14.00	$11.00	$5.50	$5.50
	30 Ride Ticket	$20.00	$16.00	$8.00	$8.00
Simi Valley Transit	Cash	$1.00	N/A	$0.35	$0.35
	Pass	$45.00	$33.25	$15.50	$15.50
Thousand Oaks Transit	Cash	$0.75	$0.75	$0.40	$0.40
	Pass (40 trips)	$26.00	$26.00	$14.00	$14.00
Ventura Inter-city Service Transit Authority (VISTA)	Cash	$1.00	$0.75	$0.50	$0.50
	Pass	$40.00	$30.00	$20.00	$20.00
PASSPORT Multi-Agency Fare Media	Pass	$40.00	$30.00	$20.00	$20.00
	Debit card	$1.00	$0.75	$0.50	$0.50

Although all participating agencies agreed to accept the Smart Passport fare structure, they did not agree on policies affecting the Passport. Three issues emerged: recharges (adding value to an existing card), debit card balances, and lockout times on cards. For recharges, the general policy was to allow recharges of Passports on the bus, with payment by check or money order. Camarillo accepts cash as well as check or money order. SCAT and Moorpark do not allow any onboard recharging. For debit card balances, the issue was whether cards should be allowed to "go negative" (charge the ride to the debit card even if balance is insufficient). The general policy was to allow a negative balance of up to $5, but SCAT opted not to allow any negative balance. SCAT, the largest transit operator, imposed the most constraints on Passport usage. Lockout times on cards are a way to prevent fraudulent usage, for example by passing one's card to another passenger boarding the bus. The general policy established was a six-second lockout. However, Simi Valley opted for a four-minute lockout period. This issue was resolved by placing a six-second lockout on debit cards and a four-minute lockout on passes. While the basic parameters of an integrated fare medium were established, these differences, together with the various fare structures, could have made use of the Passport less attractive on some services, though VCTC contends the absence of fare integration was not a source of problems for passengers.

2.2 PROJECT CHRONOLOGY

The sequence of events before and during the FOT provide background for the many technical, user and institutional issues that emerged in this FOT. We present here a chronology of FOT events. We emphasize major activities and make no attempt to be comprehensive. Where appropriate, we note task accomplishments relative to the original proposed schedule. The chronology is intended to be used as a reference resource for the subsequent chapters of this report.

JUN 1994 — VCTC agrees to participate in the Smart Card Phase III Demonstration. Expected FOT start date is November 1994.

JUL 1994 — VISTA services are established; Plastic Passport launched. Plastic Passport is monthly pass, can be purchased at any location where transit passes are sold, and is good on any Ventura County transit service.

AUG 1994 — Echelon proposal date.

APR 1995	Funding for FOT acquired, and project officially begins.
MAY 1995	Echelon completes first round of visits to participating transit agencies. Jackie Bacharach & Associates retained as Project Manager.
JUL 1995	Acquisition, testing, and prototype development of equipment begins.
AUG 1995	First project team meeting. Discussion of fare policies, reporting issues, project schedule. Work on garage-bus communications, control systems, enclosure design, passenger and driver interfaces. Decision to order 3,000 Smart Cards.
OCT 1995	Fare policy decisions finalized. Begin development of media campaign for expected Smart Passport launching in December 1995. 3,500 Smart Cards ordered. Decision to use infrared beam technology for APCs. Card initialization software completed. Echelon announces delays expected in implementation due to vendor supply problems. Scheduled completion date for Section 15 reporting software, management and reporting software, and test diagnostic software.
NOV 1995	Garage computers ready for installation. Echelon gives agencies requirements for outlet and garage computer connections. Scheduled completion date for all user training (management, driver, operator, and staff) and all equipment installation.
DEC 1995	Media campaign for Smart Passport. Both monthly passes and debit cards are offered, effective 1/1/96.

	Card reader/writer units ready for installation at card sales outlets.
	Computers and local area radios begin to be installed at SCAT, Thousand Oaks, Simi Valley, Antelope Valley Bus, Ojai, and Camarillo.
	Driver keyboard design continues; software design continues. Problems with bus to garage and garage to VCTC communications force development of special purpose communications software.
	Decision to include VISTA DAR services in FOT, thus requiring additional hardware and software, design adjustments for smaller DAR vehicles.
JAN 1996	Smart Passport must be available for sale at outlets and honored on buses, but equipment installation is not complete. Passports (passes and debit cards) are distributed and will be honored through the end of the month. Outlets will transmit paper copies of sales. VCTC will receive and maintain all card sales information.
	Installation delayed due to FCC permission approval process, delivery of some parts.
FEB 1996	PTUs assembled and tested; installation continues.
	Software development continues; further work necessary to convert to Windows 95; communications and clearinghouse problems begin to be identified.
	Passports are marked with sticker to indicate validity for the month of February. Debit cards continue to be honored.
	Passport sales information from outlets continues via fax to VCTC.
MAR 1996	Equipment installed on most buses.
	Passports continue to be honored on all systems.
	Passport sales information from outlets continues via fax to VCTC; recharges via bus not yet operational.
	Echelon performs clearinghouse function.
APR 1996	Echelon discovers that VCTC computer system is protected, hence clearinghouse function not possible via VCTC computer system.

	Some outlets have computers, but communications problems continue; information exchange continues via fax and hard copy.
	Communications problems with buses continue; Echelon must conduct garage to bus updates.
	Incompatibilities between different versions of software cause operational problems.
	Problems emerge with card sale and transaction data.
	Problems with debit card deductions, lockout periods on buses.
	Begin installation of APCs.
MAY 1996	Problem of garage computer lock-ups.
	Many on-bus equipment problems; more hardware and software changes.
	Problems with card expiration dates.
	Extension of FOT beyond 10/96 discussed.
	Estimate of about 500 cards in circulation, mostly passes.
JUN 1996	APC operation conflicts with fare card operation; redesign of hardware and software.
	Echelon reports problems with training at some sites, and with access to buses.
	Outlet activities continue to be reported to VCTC via fax; Echelon retains master files for customer database and transaction database.
	Continued problems with bus-garage communication, particularly at SCAT and SBTC.
AUG 1996	Retraining of drivers, supervisors, and outlet staff.
	All outlets now have computers and modems, but protected networks prevent information exchange at some sites.
	Problems with data communications: power problems, loss of transaction data, card recharge, and initialization problems.
	Final testing and review of printers.

Testing of speech system.

FOT extension to 12/96.

SEPT 1996 Equipment and software upgrades installed on buses.

DEC 1996 APCs installed on seven additional buses.

Equipment installed on four additional buses at SBTC.

Continued work on APC system.

VCTC announces extension of FOT through June 1997.

FEB 1997 VCTC announces intent to retain the FareTrans VMS system after completion of FOT, and contract with Echelon to maintain equipment through July 1998. The contract has been extended until 1999.

APR 1997 Battery problems on buses cause several computers to fail; replacement of onboard computers.

Echelon provides sample graphics demonstrating reporting capability of system.

JUN 1997 FOT concludes.

2.3 FULL FUNCTION FARE TRANSACTION AND VEHICLE MANAGEMENT/ MONITORING SYSTEM (FARETRANS VMS)

A diagram summarizing the bus components of a full function FareTrans VMS appears in Figure 2.3. The core of the system is the passenger transaction controller (PTC). This control unit receives, modifies, stores, and transmits data from and to a variety of sources. The driver interface unit (DIU) reports transaction status to the driver, but also allows the driver to recharge fare cards in exchange for payment, and to provide information to the system that can be important in post-processing the information accumulated by the passenger transaction controller.

Bus fleet management practices can be complex. Each bus is assigned a fixed number that serves as a vehicle code; but vehicles can be taken out of service unexpectedly, drivers and vehicles can be rotated independently across routes, and route deviation can occur formally or informally depending on the nature of the service.

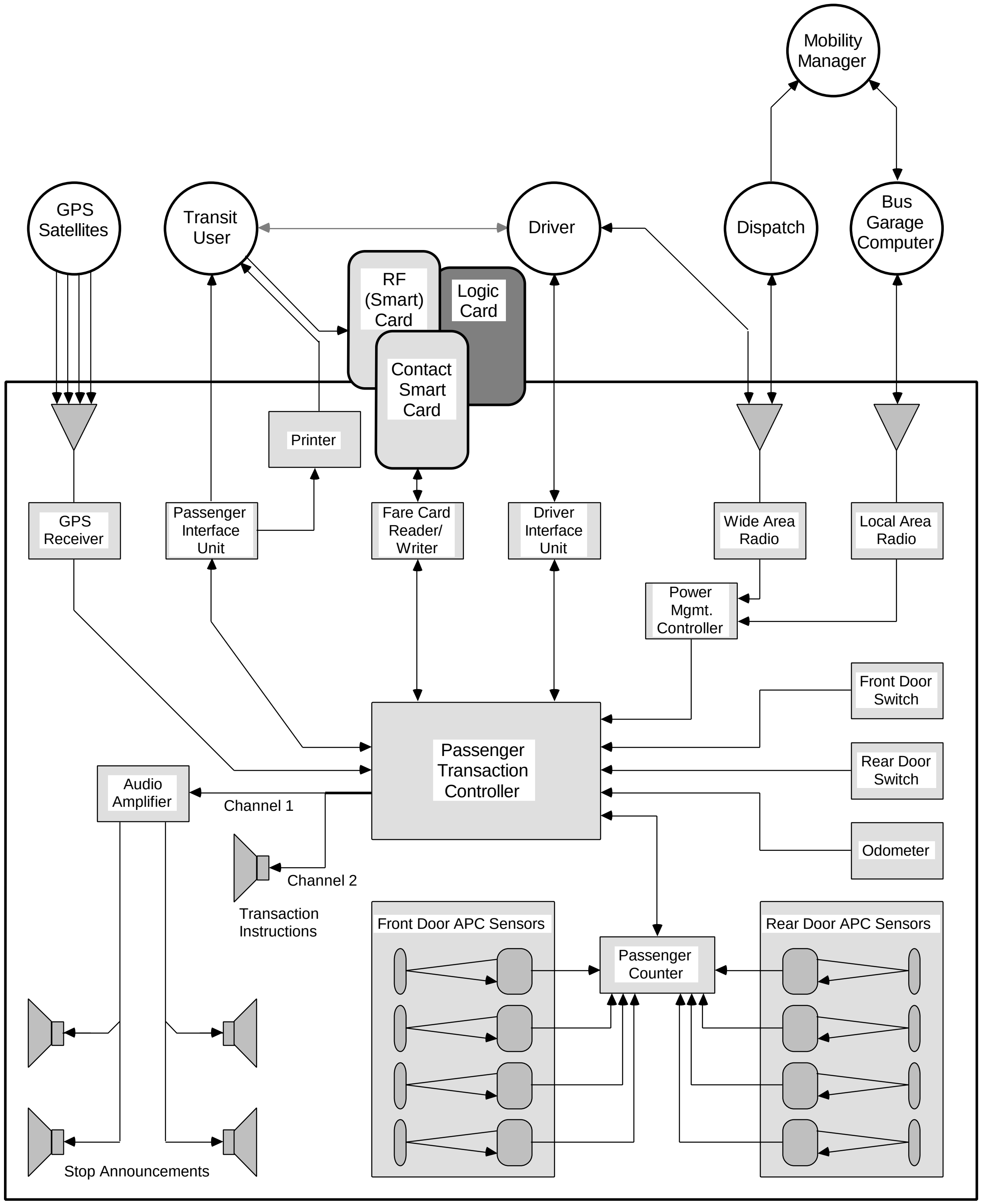

Figure 2.3 Full Function FareTransaction and Vehicle Management/Monitoring System (FareTrans VMS)

Records of day-to-day operational changes and adjustments are not always made, which can greatly complicate efforts to post-process transaction data. Thus drivers can be an important source of operating information, including driver identification numbers, route numbers, property numbers, service type, and fare classification tallies. These requirements and opportunities contradict other elements of the design philosophy underlying the FareTrans VMS, which is to simplify fare transactions and other functions without increasing the cognitive burden imposed on the driver.

The passenger transaction unit (PTU) reads and writes to stored value fare cards, typically either a Smart Card or wired logic card. The PTU could include a keyboard, but might be as simple as a target for RF cards or a slot for contact cards, and a display for acknowledging transactions, reporting remaining values, and providing instructions in special circumstances. A printer is required to issue receipts and transfers. The back of these documents could also be an important advertising revenue. The capability for synthesized speech is related to the PTU functions. Instructions can be given redundantly in synthesized speech, in the language for which the card is coded, but could also be used to announce stops.

The geo-positioning system (GPS) operates by acquiring signals from at least three of four GPS satellites. The time for a satellite transmission to reach the GPS receiver and the satellite's identification number are used to determine one dimension of the receiver's location. Signals from three GPS satellites are sufficient to provide longitude and latitude. Acquiring a signal from a fourth satellite also gives altitude, for a more accurate three-dimensional fix. The GPS is polled by the passenger transaction controller to record the location of fare card transactions, boardings, alightings, and at other preset times that can be used to measure performance. If route information from drivers is unavailable, the data provided by the GPS is the default source for supporting post-processing needs. In theory, the GPS might be used to identify routes dynamically, while the vehicle is in service, but this is difficult in practice.

Automatic passenger counters (APCs) are usually laser or other high energy sensors outfitted to front and rear doors. These sensors and the control system processing their signals must be discriminating enough to identify individuals breaking the sensor beams, even when the individuals are boarding in a dense queue. This can be accomplished with the redundancy provided by multiple sensors operating simultaneously. This also permits differentiation between boardings and alightings. These, like fare card transactions, are recorded with a time and GPS location stamp when written to the record maintained by the passenger transaction controller. Automatic passenger counts are accumulated by the counter and written to the passenger transaction controller at 10- to

15-second intervals, depending on the level of competing requirements imposed by fare transactions. Fare transactions are processed first by the PTC to avoid communication conflicts between signals from the APCs and the PTU. The PTC provides the set of boardings and alightings written by the APC with a time stamp, polls the GPS for location, and adds this information to the boardings and alightings record written to the passenger transaction controller.

The local area radio supports automatic data uploads and downloads between the FareTrans VMS onboard each bus and a garage computer. Accumulated fare transactions, boardings, and alightings data stored by the passenger transaction controller are uploaded whenever the vehicle is sufficiently close to the garage spread spectrum radio antennae. Each bus normally returns to the garage at least once each day, providing an opportunity for data uploads and downloads. This can occur much more or much less frequently, depending on bus practices and the location of the garage relative to bus routes. A bus might upload data several times during the day if its route takes it past the garage repeatedly.

Every time data is successfully uploaded from the bus, the records maintained by the passenger transaction controller are erased, and the automatic passenger counter is reset to zero. This data is appended to a file maintained by the garage computer. The garage file is subsequently uploaded to a central computer and post-processed to determine ridership counts and fare card use.

A card status database is also written from the garage computer to the FareTrans VMS onboard the bus. This identifies lost or stolen cards, updates settings for control variables such as fare structure and transfer structure, and provides new trip or dollar balances for cards that have been paid for but not recharged at outlets. This permits the new card trip or $ balances to be written by the passenger transaction unit on any bus the next time the fare card is used. If the bus is turned off prior to data communication with the garage computer, the APC writes any pending boarding and alighting counts to the passenger transaction controller, the current passenger transaction control file is saved, and the automatic passenger counter is reset to zero.

Wide area radio supports voice communication between the transit agency and the driver. It is technically feasible for drivers to use wide area radio to request extra updates of the fare card status database. However, this function was not part of the Phase III deployment.

The mobility manager is an interagency entity providing central data bank services to all agencies interested in providing integrated service via FareTrans VMS technology. The mobility manager could include a financial clearing house function, but at a minimum must provide a central node of communications between entities selling fare cards and agencies providing transit services. A full service mobility manager would also work with individual transit properties to improve intra- and inter-service coordination and integration strategies, and to make best use of the management information provided by the FareTrans VMS.

2.4 FARE TRANSACTION AND VEHICLE MANAGEMENT/MONITORING SYSTEM (FARETRANS VMS) DEPLOYED IN PHASE III OF THE FIELD OPERATIONAL TEST

Once in the field, Echelon pursued three objectives in sequence:

- Deploy the equipment to ensure at least a minimum level of acceptable operability.
- Test equipment from competing vendors under reasonably uniform conditions, while simultaneously responding to agency concerns and objectives.
- Continuously improve the reliability of a system consisting of the most reliable **commercial** components.

2.4.1 Onboard System Configuration

Figure 2.4 is a diagram summarizing the bus components of the FareTrans VMS deployed in Phase III of the field operational test. Most of the functions associated with the full function version of the FareTrans VMS are included in the Phase III system. These represent substantial advances relative to the system deployed in Phase II (Giuliano and Moore, 1996; Chavala and Coifman, 1996), particularly with respect to the inclusion of automatic passenger counters, and automatic data communication between vehicles and garage computers.

One of the lessons provided by Phase II of the field operational test is that radio frequency cards are more reliable in these applications than contact cards. The cards used in Phase III are radio frequency Smart Cards that can be configured for use as full-function electronic purses. However, Phase III required no higher-order electronic purse functions, and Echelon elected to vest most logic functions in the passenger transaction units instead of the cards. These PTUs' read/write function requires substantial logic capability, regardless of additional functions assigned to cards. Calculations are completed more quickly by the passenger transaction units than by the Smart Cards. Thus vesting most logic functions in the PTU simultaneously increases transaction speed and reduces system cost. More intensive use of the Smart Cards' central processing units and multiple functions is certainly feasible, and may be necessary, as Smart Cards enter routine use as debit, credit, or electronic benefit transfer instruments.

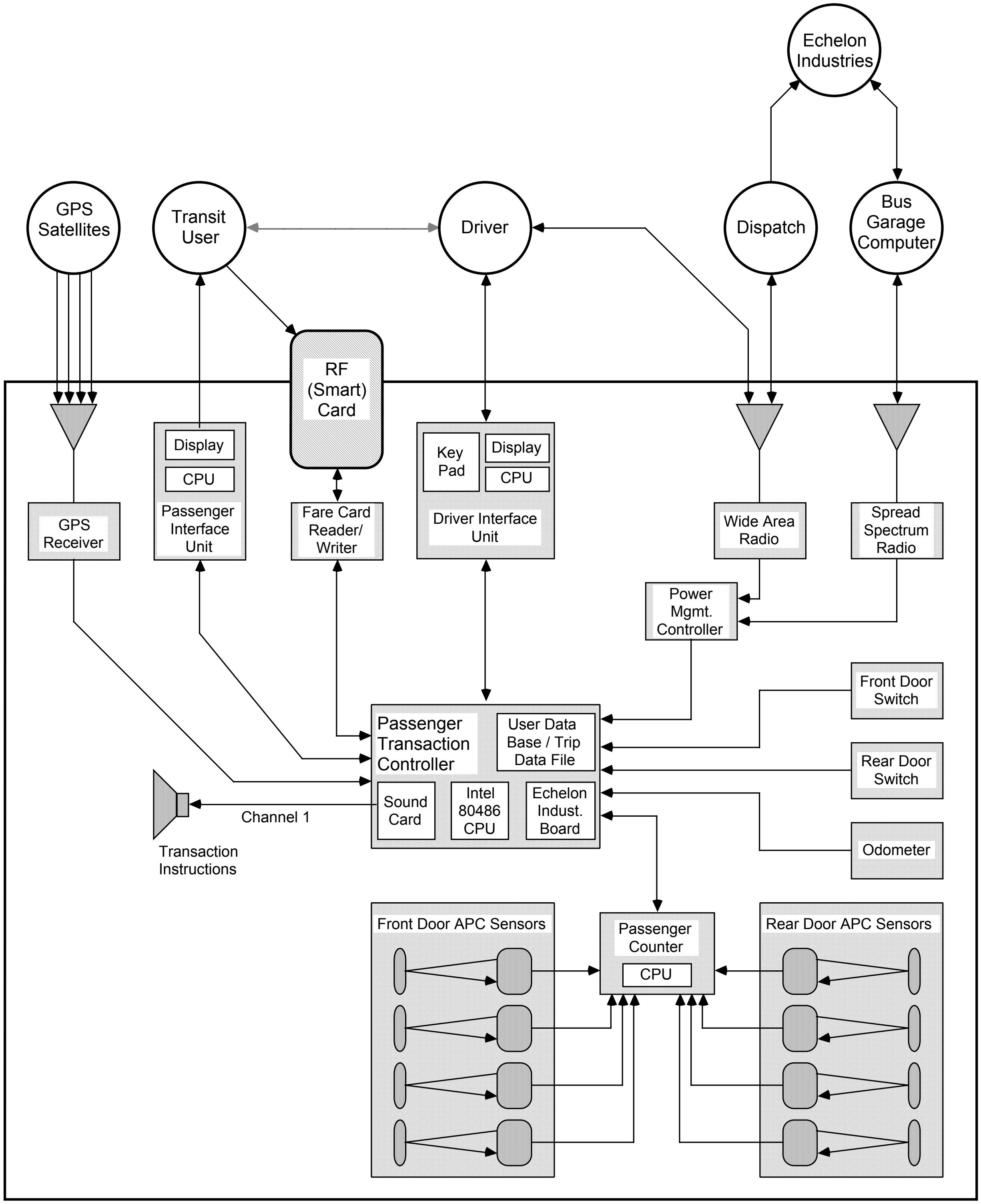

Figure 2.4 FareTrans VMS as Deployed in Phase III of the Field Operational Test

delayed as attention shifted to testing and improving the performance of other components. Some instructions are provided via synthesized speech, but the Phase III deployment includes no stop announcements.

The passenger transaction and driver interface units were kept relatively simple. See Figures 2.5a and b. The PTU has no keyboard. Early efforts to provide drivers with the opportunity to provide such information as property and route numbers, and to perform fare transaction classifications with the DIU led to subsequent efforts to minimize what was asked of the drivers. Echelon ultimately concluded that it is important to have access to accurate route numbers, but that the system should not increase the cognitive load on drivers. Drivers routinely set the route information shown on bus blinds, which display this information to waiting passengers. Some older bus blinds are mechanical, but many of these panels are electronic. Echelon plans to connect these panel inputs to the FareTrans VMS as a means of verifying route assignments without burdening drivers, but this extension was not part of the demonstration.

The onboard bus equipment deployed for the field operational test is summarized in Table 2.4. Most operators associated with the test instrumented all of their vehicles to some degree. South Coast Area Transit did not instrument nine new compressed natural gas (CNG) vehicles that were added to its fleet after the test began.[4] A total of 80 vehicles were equipped with card readers. Of these, 18 vehicles were also equipped with automatic passenger counters. One of these APC vehicles was retired from service during the test.[5]

Overall, the most technically and operationally challenging elements of the full scale FareTrans VMS were deployed during Phase III. Higher order management information functions were not developed as the part of the FOT, though ridership counts estimated by Echelon from APC data are used by some test participants to respond to federal Section 15 reporting requirements. However, this is a relatively limited function. The focus of Phase III remained on deploying and improving a system that could provide the information necessary to support new functions, and permitting the agencies involved to react to this information. Echelon retained the role of central data bank manager during the test, providing VCTC with information necessary for financial management of operations. This is particularly relevant if riders use more than one bus system during their trip, transfer buses within a system, or if users purchase fare cards from one agency and renew them at another.

[4] The CNG buses were equipped after the test ended.
[5] VCTC reports APC equipment was deployed on buses countywide following the test.

Figure 2.5a FareTrans VMS Passenger Transaction Unit Installed on a SCAT Bus

Figure 2.5b FareTrans VMS Driver Interface Unit Installed on a SCAT Bus

Table 2-4 Summary of Onboard Bus Equipment Deployed During the Field Operational Test

Agency	Operator	Service Type	Buses Equipped With Card Readers and Automatic Passenger Counters	Buses Equipped with Card Readers but Without Automatic Passenger Counters	Buses with Neither Card Readers nor Automatic Passenger Counters
Thousand Oaks Transit	Dave Systems, Laidlaw Transit	Fixed Route	554025, 554026	554014, 554023, 554024	None
Ventura Inter-city Service Transit Authority (VISTA)	Santa Barbara Transit	Fixed Route	T-5	T-3, T-4, T-10	None
	VISTA Route 126				
	Santa Barbara Transit	Fixed Route	None	W-46, W-47, W-48, W-49	None
	VISTA East				
	Santa Barbara Transit	Dial -A-Ride	None	W-39, W-40, W-41	None
	Santa Paula Dial-A-Ride				
	Santa Barbara Transit	All purpose	None	W-45	None
	Antelope Valley Bus Co.	Fixed Route	808 (retired from service 8/26/97)	817, 888	None
	VISTA 101				
	Laidlaw Transit	Fixed Route	CAT-3, CAT-6	None	None
	VISTA Central				
	Fillmore Area Transit Co.	Dial-A-Ride	None	12, 17, 18	None

Agency	Operator	Service Type	Buses Equipped With Card Readers and Automatic Passenger Counters	Buses Equipped with Card Readers but Without Automatic Passenger Counters	Buses with Neither Card Readers nor Automatic Passenger Counters
	Fillmore Dial-A-Ride				
Simi Valley Transit		Fixed Route	4509, 4510	4506, 4507, 4508, 4511, 4512, 4513, 4514	None
Moorpark City Bus	Antelope Valley Bus Lines	Fixed Route	None	1 bus (unnumbered)	None
Camarillo Area Transit	Laidlaw Transit	Fixed Route	1 bus (unnumbered)	None	None
		Dial-A-Ride	None	3 buses (unnumbered)	None
South Coast Area Transit (SCAT)		Fixed Route	3500, 3502, 3507, 3509, 3511, 3514, 4000, 4004, 4007	3100, 3101, 3102, 3103, 3104, 3105, 3106, 3107, 3108, 3501, 3503, 3504, 3505, 3506, 3508, 3510, 3512, 3513, 3515, 3516, 3517, 4001, 4002, 4003, 4005, 4006, 4528, 4529, 4532, 4534, 4535, 4542	3100, 3101, 3102, 3103, 3104, 3105, 3106, 3107, 3108 (all new CNG vehicles)

2.4.2 Fare Transaction Data Flows

The FareTrans VMS onboard each bus is part of a larger communications and data processing system. Figure 2.6 summarizes the standard information flows that make it possible to purchase fare cards, update fare card balances, and complete fare card transactions. It also identifies the system components deployed to support these functions. Cards are purchased at designated outlets, which must then forward information about the purchase to a central data bank. This data is organized into a common database, and forwarded to the Ventura County Transportation Commission.

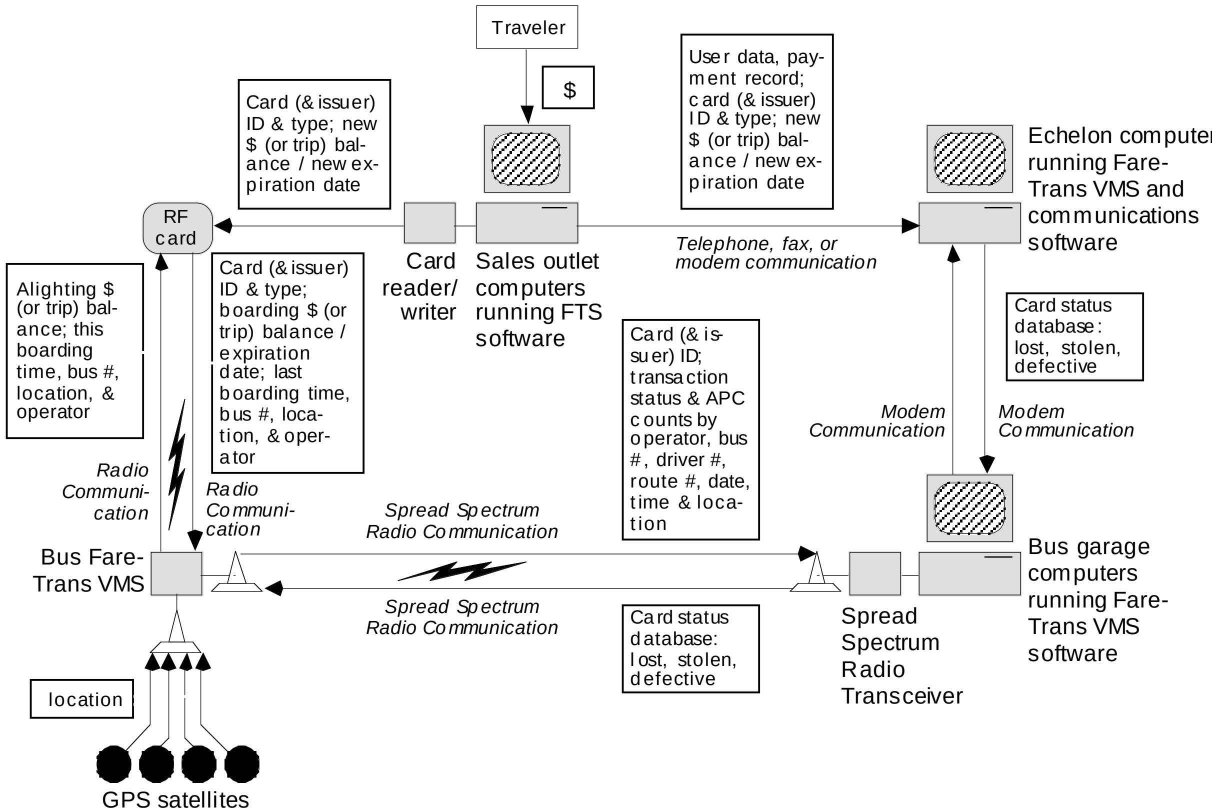

Figure 2.6 Base Case Information Flows Permitting the Purchase of Fare Cards, Updates of Fare Card Balances, and Fare Transactions

In the base case, fare cards are purchased and fare card balances are updated at card sales outlets. The passenger transaction unit then recognizes, decrements, and updates the balance of the card every time the card is used. The PTU also writes additional information to the card, including when, where, on which bus, and on which bus company the transaction is occurring. This permits correct assessment of transfer charges for passengers taking trips involving multiple routes or multiple carriers. Echelon reports outlets provided about 85 percent of all card recharge services.

New card sales require a card read/write unit at the point of sale so that the card can be initialized with user data and a trip or dollar balance. The read/write units used to initialize cards can also update card balances when the card is renewed, but this is not the only procedure for doing so. Consequently, it is not necessary to couple card sales and card recharge activities. Figures 2.7 and 2.8 show how card balances can be updated in use via the card read/write function of the passenger transaction units onboard the buses. This permits users to update fare card balances in transit. In Figure 2.7, the transaction takes place entirely on the bus. Drivers accept payment and update card balances manually using

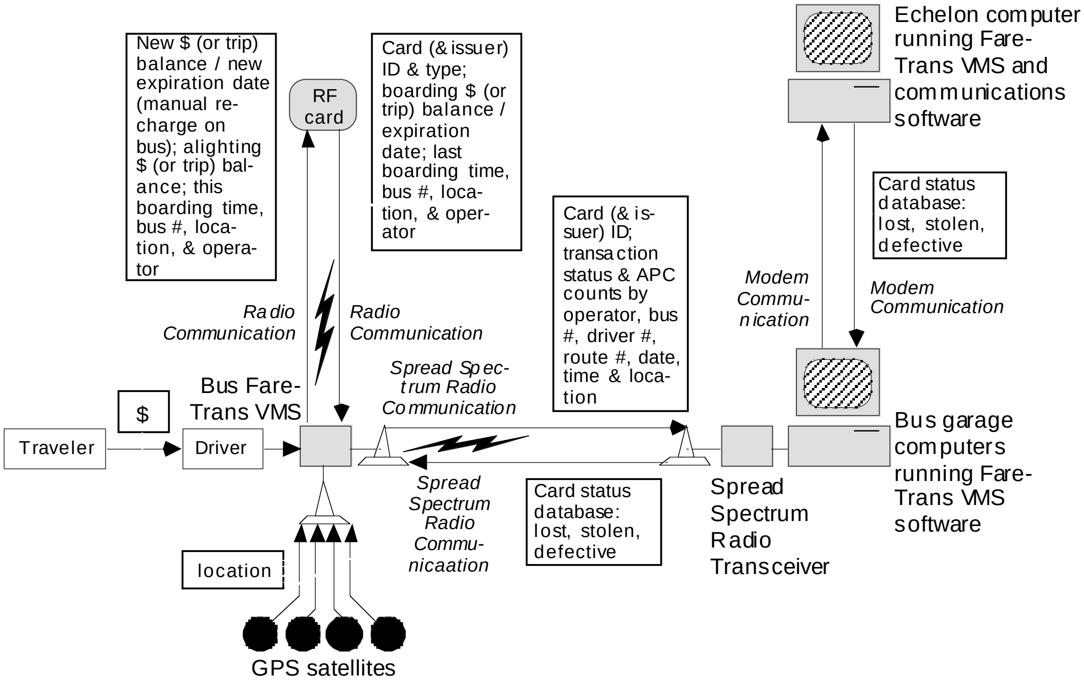

Figure 2.7 The Special Case of Updating Fare Card Balances Manually on the Bus

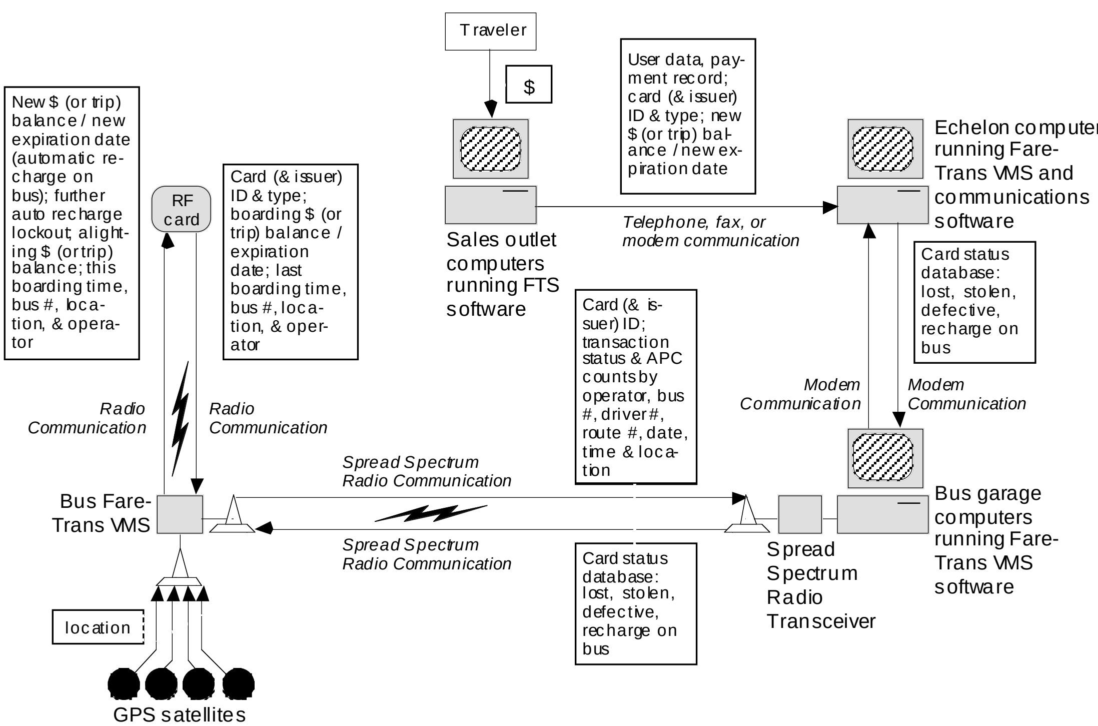

Figure 2.8 The Special Case of Updating Fare Card Balances Automatically on the Bus

the keypad on the driver interface unit. This sort of update accounted for about 14 percent of all recharge activities. Figure 2.8 summarizes an automatic card recharge procedure. The automatic procedure permits card users to pay by mail, or at agency sites not equipped to issue cards. The card balance is updated the next time the user boards any bus. Automatic recharges accounted for about 1 percent of all card recharge activity. Onboard card updates were enabled only briefly during the demonstration because of the difficulty encountered in integrating the Faretrans VMS data links.

Automatically recharging cards provides considerable user convenience, but has the potential to become problematic if subject to wide use. This option requires that the list of cards to be recharged be included in the database routinely downloaded to the buses. Each card presented to the PTU is checked against every entry in the card database. If use of the automatic recharge option remains limited, the database remains relatively small, consisting mostly of identifiers for lost and stolen cards. However, extensive use of the automatic recharge option would greatly increase the size of the card status database, and this would increase the time needed to complete each transaction. Further, it is impossible to immediately update all relevant system records. Communications between sales outlets and the central data bank, the central data bank and garage computers, and garage computers and the Fare Trans VMS onboard each bus all take place separately, approximately daily. In addition, communications between garage computers and buses can be irregular, depending on bus practices. It is possible that a user might pay at a participating transit agency to recharge his or her card, presume the card balance will be updated automatically in use, and then try to use the card before information has been conveyed to the bus he or she boards.

System performance was not degraded by automatic card updates during the field operational test, but the potential for transaction delays or missed transactions exists under other reasonable conditions. Precluding automatic updates of card balances eliminates both the problem, and a convenient user option. Without automatic card updates on buses, outlets unable to initialize cards had to complete a form and send it to VCTC. VCTC then entered the data, initialized the card, and mailed the card to the buyer (Rebeiro, 1996).

2.5 INTEGRATION OF FARETRANS VMS DATA LINKS

Phase III of the field operational test of the FareTrans VMS is distinguished by an ambitious set of data system integration objectives, and a corresponding set of lessons. The planned test system includes data processing systems distributed across buses, bus garages, fare card sales outlets, the Ventura County Transportation Commission, Echelon, and the University of Southern California. One of the original goals for the system was to establish automatic modem communications links between agencies, between garages and

VCTC, and between outlets and VCTC (Rebeiro, telephone interview with Moore, April 11, 1996).

All aspects of FareTrans VMS operations are managed by the Fare Transaction System (FTS). FTS communication software presumes the existence of modem communications between bus garage computers and a central facility. Echelon equipped garages with computers and modems for this purpose, though it was initially difficult for Echelon to acquire access to dedicated phone lines in these facilities. Table 2-5 lists the garage sites at which Echelon installed computer, modem, and spread spectrum radio equipment.

Data transfer between garage computers and a central computer to have been located at VCTC was intended to be fully automated, but this proved to be infeasible. The necessary data links were established and used, but the process could not be made automatic. Figure 2.9 summarizes the ideal FTS configuration for the field operational test. Figure 2.10 summarizes the actual deployment of equipment and communications links. Electronic links between computers at sales outlets and the central computer were established incrementally and remained incomplete because many project partners did not have sufficient resources to support communications.[6]

2.5.1 Bus-to-Agency Communications

The FareTrans VMS onboard the buses communicates with a computer in each bus garage via a local area, spread spectrum radio signal. This constitutes a radio network. Episodes of simultaneous two-way communication create the potential for signal conflict. Echelon tested spread spectrum radio equipment from a variety of vendors and identified constraints and trade-offs with respect to range, speed of transmission, signal conflict management practices. Correct antenna placement is important with respect to both vehicle and equipment. Initially, data for four to eight South Coast Area Transit (SCAT) buses often could not be found in the data uploaded from the SCAT garage. This proved to be an antenna problem.

The data retrieved from the buses must be post processed. GPS data, driver inputs, APC data, and transactions data must be compared and reconciled before passenger counts can be computed. The garage computers are polled daily to upload data accumulating from the bus fleet to a central computer. Post processed data files are placed in a Microsoft Access database. This data is erased from the garage computers once the

[6] VCTC reports these links were completed following the demonstration.

Table 2-5 Locations of Garages and Garage Computers

Garage	Agency/Contractor (Service)	Address
Antelope Valley Bus, Inc.	Antelope Valley Bus, Inc. (VISTA Route 101 and Moorpark City Bus)	498 Lambert St., Oxnard, CA 93030
Camarillo Corporation Yard (Police facility)	Laidlaw Transit (VISTA Central and Camarillo Area Transit)	283 S. Glenn Dr., Camarillo, CA 93010
Fillmore Area Transit Corp. (FATCO)	Fillmore Area Transit Corp. (Fillmore Area Dial-A-Ride)	234 Central Ave., Fillmore CA 93015
Santa Barbara Transportation Terminal	Santa Barbara Transit (VISTA Route 126, VISTA East, VISTA Central, and Santa Paula Dial-A-Ride)	224 W. Santa Maria St., Santa Paula, CA 93060
City of Simi Valley Transit Maintenance Facility	Simi Valley Transit	400 W. Los Angeles Ave., Simi Valley, CA 93065
South Coast Area Transit (SCAT)	South Coast Area Transit (SCAT)	301 E. 3rd St., Oxnard, CA 93030
Thousand Oaks Municipal Service Center	Dave Systems and Laidlaw Transit	1993 Rancho Conejo Blvd., Thousand Oaks, CA 91328

garage computers are polled. This polling process was to have been automated and placed under the control of VCTC. VCTC's computer system is part of the Ventura County computer network. Echelon produced a network version of the FTS Program for card initialization and recharges. Initial efforts to use the network version of FTS program resulted in numerous error conditions (cause unknown) that proved frustrating for VCTC staff (Echelon, 1996a; 1996b). Echelon determined that VCTC's networked computer could not be used to poll garages or sales outlets because the County does not permit the system modem to auto-answer incoming telephone calls. Security requirements made it impossible to change this policy.

Echelon requested that VCTC provide a separate computer for the project (Rebeiro, 1996). VCTC made a separate computer available, but Echelon continued to emulate the central computing role originally ascribed to VCTC; in part because, even with a stand-alone computer, complete automation of the garage polling process proved difficult. Even with garage equipment in place, the vehicle data upload/download procedure did not initially function reliably. Echelon was able to incrementally identify and overcome several problems related to the availability of phone lines, inadvertent interruptions of automatic

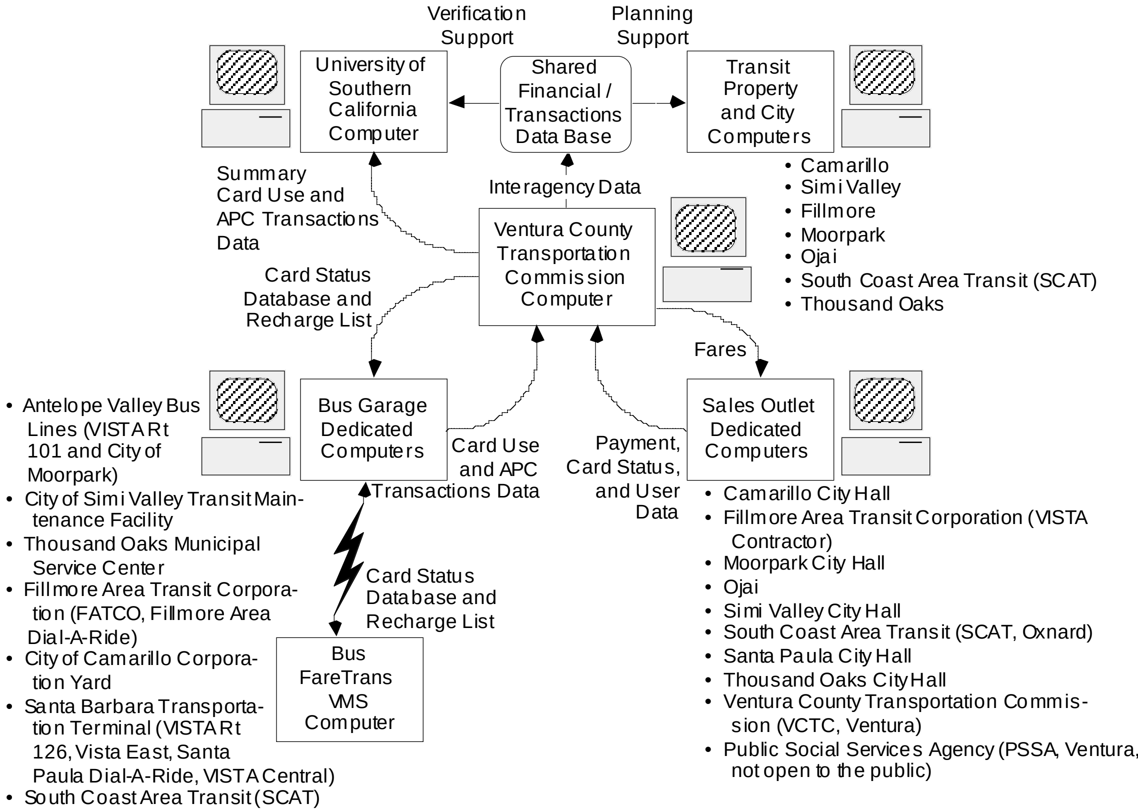

Figure 2.9 Ideal FTS Configuration for the Field Operational Test

communications by electrical noise, garage personnel, and power fluctuations; but ultimately could not anticipate the full range of problems and special cases presented by variations in bus fleet management practices. Consequently, Echelon concluded it was necessary to keep an operator in the loop to verify modem connections between garage computers and the central computer. The operator was needed to verify that file transfers to and from garage computers have occurred, and to identify and verify the status of any buses for which none of the anticipated transactions data were obtained.

2.5.2 Agency-to-Bus Communications

The second element of the FTS permits electronic communication between card sales outlets and the central computer. The original plan was that VCTC would automatically collect electronic information accounting for all fare card transactions performed by fare card issuance/recharge outlets. The intent was to support interagency financial record keeping. This element was only partially deployed as part of the field operational test. Echelon did not propose and did not have the resources to equip sales

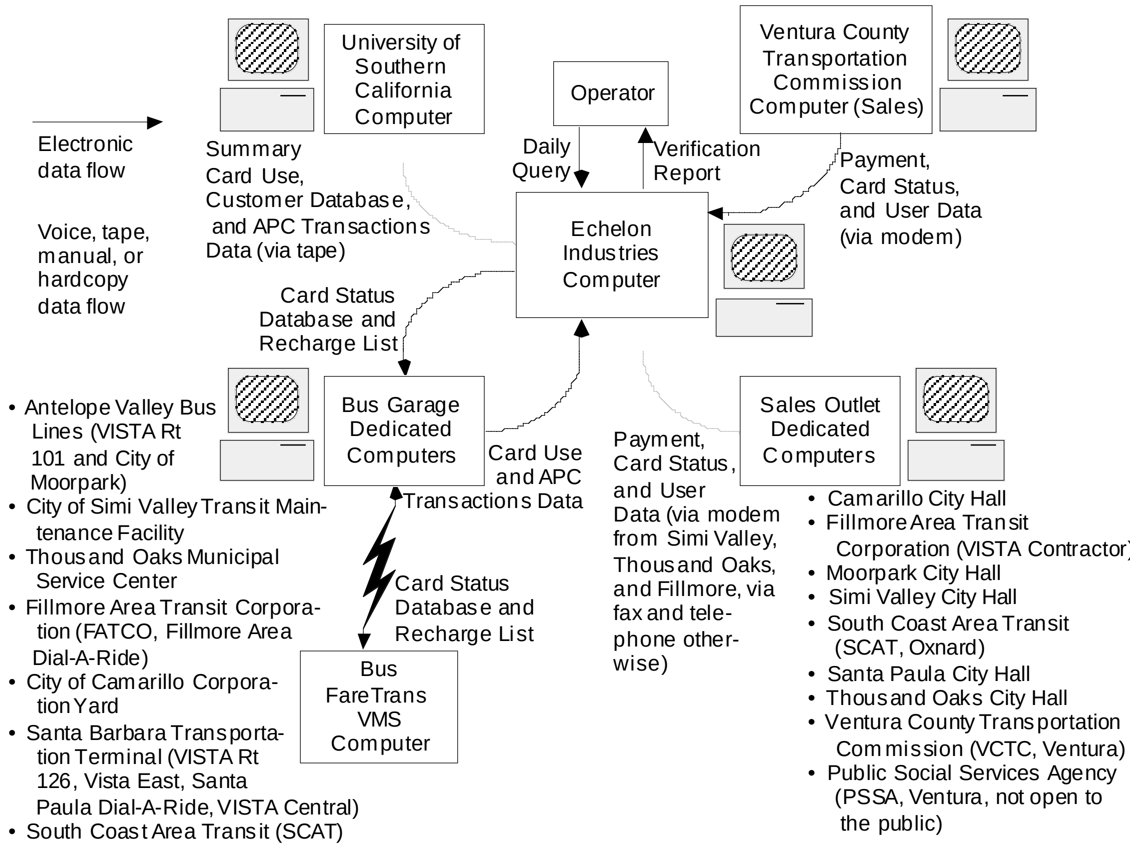

Figure 2.10 Actual FTS Configuration for the Field Operational Test

outlets with computers, which were needed to support the data communications required for this function. VCTC could not absorb this expense. Consequently, the cities, transit properties, and contractors participating in the test equipped their sales outlets to permit transactions and, in most cases, to recharge cards; but often could not accommodate data links.

Outlet locations are listed in Table 2-6. Since it was not feasible to equip each outlet with a modem and a dedicated telephone line, another process was developed. All of these outlets have computers; and some, including the Simi Valley, Thousand Oaks, VCTC, and Fillmore sites, did eventually establish modem communications with the central computer at Echelon. Network protection problems at some sites continued to discourage computer use (Rebeiro, 1996). In some cases, payments are recorded on paper. These records were

Table 2-6 Fare Card Sales Outlets

Fare Card Sales Outlet (Service)	Address
Camarillo City Hall (Camarillo Area Transit)	601 Carmen Drive, Camarillo, CA 93010
Fillmore Area Transit Corp. (FATCO, Fillmore Area Dial-A-Ride	524 Sespe Ave., Fillmore, CA 93015
Moorpark City Hall (Moorpark City Bus)	799 Moorpark Ave., Moorpark, CA 93021
Santa Paula City Hall	970 Ventura St., Santa Paula, CA 93060
Simi Valley City Hall (Simi Valley Transit)	2929 Topo Canyon, Simi Valley, CA 93063
South Coast Area Transit (SCAT)	301 E. 3rd St., Oxnard, CA 93030
Thousand Oaks City Hall (Thousand Oaks Transit)	2100 East Thousand Oaks Blvd., Thousand Oaks, CA 91362
Ventura County Transportation Commission (VCTC)	950 County Square Drive, Suite 207, Ventura, CA 93003
Public Social Services Agency (Not open to the public, service to welfare clients only)	625 S. Ventura Rd., Oxnard, CA 93030

then faxed to VCTC, and VCTC recoded the card data that was originally coded by the outlet (Echelon, 1996a).[7]

2.5.3 Agency-to-Agency Communications

Some users purchase cards at one agency's sales site and then recharge them at another. This is an unanticipated outcome that requires all card issuers to have access to common data. Third and final element of the FTS is agency-to-agency communication, which is intended to allow cooperating agencies to review limited portions of each other's data in a standard format. There are a variety of ways the necessary information can be compiled.

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[7] VCTC reports purchasing computers and arranging for modem connections for most of the fare card outlets following the demonstration.

- VCTC could compile the information manually based on paper records provided by cities and transit agencies.
- Agencies could send computer disks to VCTC.
- Agencies could establish data links to the VCTC computer and update VCTC electronically on a periodic basis.
- Agencies could maintain a dedicated, modem-based network and remain in real time contact with VCTC.

None of these options is completely satisfactory, requiring either too much attention from agency personnel, or too much additional training and expense, or both. Consequently, Echelon modified the design of the system to permit cards to be updated in use based on the information resident on the card, thus eliminating any need to refer to a shared customer sales database. This required subsequent, systematic transfer of data from outlets to VCTC (Echelon, 1996b). Recharging requires access to a computer. Those agencies without computers could only issue recharges by (Echelon, 1996c) allowing cards to recharge automatically onboard any bus (Rebeiro, 1996).

2.6 SUMMARY

Ventura County transit serves a highly transit-dependent segment of the population. The operators involved in the FOT have distinct service areas with little opportunity for transfers. The FOT involved no changes in service schedules or stop location to encourage the sort of multi-agency trips an integrated fare medium can accommodate.[8]

The deployment was reconfigured at the request of VCTC and other operators to serve Dial-A-Ride services in addition to fixed route services. The participating agencies agreed to accept a common Smart Passport fare structure, but did not develop a common set of policies regarding the pass, though several informal agreements were reached. The new fare medium was advertised and used before the FareTrans VMS bus equipment could be fully deployed.

The FareTrans VMS configuration ultimately deployed included GPS, APC, RF Smart Card, automatic transaction data upload and download, and related subordinate capabilities. Transaction instructions were issued to passengers with automatic audio messages. There were no automatic stop announcements. Smart Cards could be recharged manually at sales outlets, manually onboard the bus, or automatically onboard the bus if a prepayment was made to a sales outlet or other location.

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[8] VCTC reports changes were made to accommodate transfers, but the nature and scope of these changes are unknown.

The Fare Transaction System deployed in the FOT was a scaled back version of the FTS proposed by Echelon. Instead, Echelon retained the role of the central data bank function. This function was not internalized by VCTC. Card purchase and recharge records were collected by a number of means rather than solely via automatic modem communication between the central computer and outlet computers. No modem data link was established between the evaluation team and the central computer: Echelon forwarded transaction and cards sales records to the evaluators on computer tape.

The difficulty in configuring the FTS was driven by a series of unanticipated requirements requiring different responses, some of which entailed additional expense. These include lack of spare telephone lines for data communications at the offices of contract operators, lack of computers at agencies and contract operators, lack of furniture for computer equipment in operator offices and garages, low computer literacy among VCTC and operator staff responsible for sales and support, security policies prohibiting communication with secure local government computer networks, and environmental problems affecting garage computers.

Agency-to-agency communications were weakest. Echelon did not propose and did not design a system to perform a central financial clearinghouse function. Instead, the system was designed to provide participating operators with new joint planning options that would help enable and support clearinghouse activities. These elements were not deployed, primarily because of low computer literacy among participants. It fell to VCTC to perform financial clearinghouse functions, and to develop and negotiate ad hoc procedures for doing so.

The FareTrans VMS is designed to help answer transit management questions the participants cannot easily address at present. Who is being served? Where do travelers board relative to where they live and work? When do they travel? How long are their trips? How do these behaviors vary with demographic information? What is ridership between stops? Which stops provide the largest number of boardings? How good is schedule adherence, by vehicle, driver, or route? Answering these questions would provide operators with opportunities to better configure service and fares. Echelon designed the FareTrans VMS to provide unique information, but the FOT necessarily focused on identification of requirements for improved design, deployment, and maintenance. Verifying that the information being provided is the most useful and appropriate, and using this data to change transit operations requires a much longer-term exercise.

CHAPTER THREE
TECHNICAL PERFORMANCE

3.1 INTRODUCTION

Successful technical performance is necessary for deployment of FareTrans VMS technology. In this section we evaluate the technical performance of the FareTrans VMS in Phase III of the Ventura Field Operational Test. Technical performance in this test is best characterized in three broad categories:

- field logistics,
- operational (component) performance, and
- functional (system) performance.

A detailed list of equipment problems and responses appears in Appendix 3A: Equipment Problems and Responses.

Ultimately, technical performance of the system depends on more than access to reliable components, good design, and Echelon' technical expertise. Knowledge is also part of the system. How knowledge is organized and delivered to the participants in the Field Operational Test, when these efforts are effective, whether these efforts are resisted, or why resistance might occur, are institutional questions. However, the role of knowledge in system performance is a technical issue. In this test, the level of operator knowledge proved to be a constraint on system performance.

The technical evaluation of the FareTrans VMS provides considerable information, but is in some ways inconclusive. The system is an ambitious design, and the test shows that the FareTrans VMS can work as intended. It often did not during the test period. Some performance objectives were routinely met, some were occasionally met yet remain technically feasible, some were rarely met and may be infeasible, and some objectives were discovered to be clearly infeasible. This is inherent in the nature of a field test, and the test offers evidence that failure to meet all system performance targets is not the result of an inappropriate design or choice of the wrong technology, though deficits may well exist in APC technology. These failures depended more than anything else on the level of knowledge imparted to the operators.

Some knowledge deficits were very fundamental. The FareTrans VMS deployed for the FOT was not a fully mature design, though most of the operators participating in the test perceived it to be. A number of questions, some anticipated and some not, were answered during the course of the test; but the operators did not understand that these questions remained open. Operators sometimes were required to develop knowledge on their own as unanticipated or undesired outcomes occurred. The decisions that flowed from these states of information sometimes created constraints on technical performance that Echelon could not relax.

The evaluation team relied on several means to assess the operational and functional performance of the FareTrans VMS. These methods include:

- onboard equipment surveys;
- periodic interviews with the agencies and Echelon via telephone and during on-site visits;
- reviewing Echelon and agency meeting documents and Echelon's reports on recent technical performance of the deployment;
- attending monthly technical committee meetings;
- analysis of field records and fare transaction files downloaded from buses; and
- extensive reviews of operator and Echelon problem and repair records, some of which were kept at the request of the evaluation team.

Table 3-1 summarizes the quantitative data sources used for the operational and functional evaluation.

3.2 FIELD LOGISTICS

System installation, integration and maintenance across multiple transit properties and multiple vehicle types are challenging. Echelon anticipated many of the requirements for a successful deployment, and failed to anticipate some others. Also, circumstances arose during the test that greatly increased the logistical burden associated with the deployment.

3.2.1 Deployment Prior to Non-revenue Tests

The Ventura County Transportation Commission sold fare cards on an aggressive schedule, beginning in December 1995. This was unfortunate, because Echelon had to rush to keep pace and place an operational system in the field. Consequently, tests of the equipment in non-revenue service were not conducted before or after installation (Echelon, 1996a; 1996b). There was no time to bench test or burn in equipment (Rebeiro, December 14, 1996). This situation also contributed to incompatibilities across software written to perform different tasks. Software incompatibility resulted in fare cards not always reading or writing as designed, transaction records not being organized as expected, and related problems.

Table 3-1 Summary of Quantitative Data Sources Used for the Evaluation

Description of Data	Transit Operator or Agency	Period
Data Provided by Echelon Industries		
Fare Card Transaction Files	All	3/1/96 - 8/31/97
Card User Database	All	3/1/96 - 8/31/97
Passenger Boarding and Alighting Estimates	SCAT bus 3511, Thousand Oaks bus 25	5/19/97 - 5/21/97
Standard Data Provided by Transit Operators		
Equipment Defect Reports	Simi Valley Transit	10/1/96 - 9/30/97
	South Coast Area Transit	3/1/96 - 5/31/97
Echelon Repair Logs	Simi Valley Transit	10/1/96 - 5/31/97
	South Coast Area Transit	2/1/95 - 4/30/97
Bus Assignment Records	Simi Valley Transit	5/1/97 - 6/30/97
	South Coast Area Transit	5/1/97 - 6/30/97
Vehicle Hold List	South Coast Area Transit	5/1/97 - 6/30/97
Special Data Provided by Transit Operators		
Daily Vehicle Mileage	Simi Valley Transit	1/97 - 6/97
FareTrans VMS Maintenance Logs	Antelope Valley Bus Co.	8/97
	Santa Barbara Transportation	7/16/97-8/12/97
	Simi Valley Transit	1/97 - 6/97
	Thousand Oaks Transit	6/1/97 - 8/31/97
Data Obtained From Field Observations		
Onboard equipment survey	South Coast Area Transit, Thousand Oaks Transit, Antelope Valley Bus Co. (VISTA 101), Santa Barbara Transportation (VISTA 126)	5/19/97 - 5/21/97
Boarding and alighting counts	South Coast Area Transit, Thousand Oaks Transit, Antelope Valley Bus Co. (VISTA 101), Santa Barbara Transportation (VISTA 126)	5/19/97 - 5/21/97

Pass Card Reads	South Coast Area Transit, Thousand Oaks Transit, Antelope Valley Bus Co. (VISTA 101), Santa Barbara Transportation (VISTA 126)	5/19/97 - 5/21/97
Debit Card Reads	All South Coast Area Transit	6/26/97

3.2.2 Delays in Component Deliveries

Complications presented by the rush to deploy were compounded by delays in the supply of products such as modems, sensors, radios, power supplies, and processing boards (Echelon, 1995a; Rebeiro, 1997). These delays had important consequences. The software for the passenger, driver, and central logic elements of the system was written simultaneously.

Some hardware components were missing because they had not yet been delivered, and software had to be written to operate the system without these elements. Software updates needed to accommodate subsequent hardware deliveries produced multiple versions of the software, and some of these were incompatible (Moore, telephone interview with Ray Rebeiro, April 11, 1996). Older versions of software running on buses had to be updated incrementally, vehicle by vehicle. This was problematic because Echelon often had only limited access to vehicles (Echelon, 1996a).

3.2.3 Changes in Agency Requirements

Ongoing software changes needed to address changing user needs and to increase functionality also accounted for several software conflicts. Dial-A-Ride (DAR) operations in Santa Paula and Fillmore were not originally part of the deployment program. The operators involved in the test were under the impression that a mature system was being deployed, and they understood their DAR operations to be an important service for their clients. Consequently they did not hesitate to require additional functionality to support DAR services. This required substantial changes, because addition of DAR services to the FOT made it necessary to rewrite some of the system software (Echelon, 1996a). Changes were made in the card initialization and card recharge programs, but appropriate changes were not initially made on the bus control hardware, and this caused a lingering problem: some cards were not being recognized (Echelon, 1996b).

Not all agency changes introduced software problems, because the software was written to allow the participating agencies opportunities to customize their services. The system was initially designed to lock out a debit cash fare card from use for six seconds following a transaction. Simi Valley Transit requested a lockout period of four to five minutes to prevent students from passing the monthly pass through the bus window to other students for immediate reuse (Echelon, 1996a; 1996b). Debit cards transactions are now locked out for six seconds after a transaction. Passes are locked out for four minutes

(Echelon, 1996c). Agency-specific lockout periods are feasible (Rebeiro, December 14, 1996).

3.2.4 Variable Requirements across Fleets

There were also a variety of equipment installation problems. There is considerable variation in the 15 different bus types used by the transit properties participating in the test. FareTrans VMS component layouts and arrangements, installation, and (in some cases) design had to be customized across properties. The placement of Automatic Passenger Counter (APC) sensors, displays, and stanchions required special consideration.

> *"In addition to physical constraints, agencies placed special constraints on equipment installation and placement, e.g., the color and position of the stanchions (Echelon, 1996b), which precluded standardization of components and their location. Each bus layout had to be done separately; these special requests and objections further delayed/complicated installation"* (Rebeiro, January 27, 1997).

3.2.5 Access to Vehicles

Echelon needed access to buses for installation, trouble shooting, routine maintenance, software changes, technology testing, and equipment change-outs. For example, jumpers are equipment used to complete circuits in buses not equipped with automatic passenger counters. These inform the PTU control unit that no APC sensor is available. The process of installing the jumpers took over seven weeks because Echelon could not get to the buses (Rebeiro, December 14, 1996). Some transit properties restricted vehicle access to weekends, and some smaller operations sent vehicles home with drivers overnight. In the case of one operator, Echelon could not get to the buses at all for about 2-1/2 months (Evaluation Team's Summary of the Technical Committee Meeting, August 9, 1996).

> *"Echelon was not able to access the buses in a consistent, predictable way which further impeded loading new software"* (Rebeiro, January 27, 1997).

3.2.6 Operator Maintenance, Problem Reporting, and Repair Policies

The FareTrans VMS requires very little preventative maintenance, but does sometimes fail in service. Consequently, problem reporting and response procedures are important determinants of system availability. However, Echelon invested little attention in problem reporting procedures. The operators experienced very different kinds of problems, and established very different problem reporting procedures. Problem reporting was more direct in some agencies than in others. In some agencies, the party who identified a problem also contacted Echelon. In others, he reported it to a supervisor who contacted Echelon. Echelon would subsequently visit the site to check the system and replace any components that were not working. Echelon documented its visits to all properties. Once Echelon verified that the FareTrans VMS was functioning, the Echelon technician logged an "OK" in a garage repair record.

3.2.6.1 Thousand Oaks

When a problem occurred, the agency supervisor responsible for FareTrans VMS equipment in the agency called Echelon. Echelon could have access to the bus on any day, weekends included. Thousand Oaks has encountered FareTrans VMS problems relatively infrequently.

3.2.6.2 Simi Valley

If a driver detected a problem with the FareTrans VMS, he reported it to the Transit Supervisor before the bus left the bus yard. The transit supervisor would try to rectify the problem. If he could not rectify it, he filled out a defect report, and faxed it to Echelon. The transit supervisor also scheduled a maintenance appointment with Echelon for any of the next six days. Both Thousand Oaks and Simi Valley report Echelon's written "OK" is a reliable indicator that the FareTrans VMS equipment is in full working order.

3.2.6.3 South Coast Area Transit

SCAT management developed an aggressive problem-reporting procedure. Drivers were directed to check the FareTrans VMS each morning. If a driver identified a problem, he reported it to the Operations Department Field Supervisor via radio. The supervisor reviewed the driver's description of the problem, assigned the appropriate problem number, and filled in a defect report. This report went to the Transportation Planner, who then faxed these reports to Echelon. The fact that this procedure was defined by SCAT management and neither Echelon nor the garage staff is significant. There was considerably more enthusiasm for the deployment in SCAT's office than in SCAT's garage.

This resulted in unnecessary constraints on technical support of the system. Echelon personnel were not allowed access to a malfunction FareTrans VMS until the first weekend following a problem report. Echelon was not allowed to respond to the problem report during the work week because SCAT garage personnel believed that this would disrupt garage activities, and because the equipment was on vehicles that were normally in service or undergoing other maintenance. The SCAT garage supervisor reported that the FareTrans VMS did NOT function on approximately 80 percent of the buses assigned an "OK" by Echelon. Part of the problem was undoubtedly that Echelon had to rely on a written problem report that might not be thoroughly descriptive, and that there was no opportunity for Echelon to interview drivers with first hand knowledge of the problem because these personnel were off for the weekend.

3.2.6.4 Comparing operators

Overall, direct problem reporting and the operators' willingness to permit Echelon rapid access to vehicles contributed to improved performance. Both Thousand Oaks, which experienced the best equipment performance; and Simi Valley, the agency with second-best equipment performance, had more direct problem reporting paths than most other operators. Also, both Thousand Oaks and Simi Valley kept their vehicles relatively accessible to Echelon. SCAT reported equipment problems much more frequently, and was often dissatisfied with the quality of repairs. The frequency of SCAT's problem reports is partially a function of the SCAT Transportation Planner's efforts to support the test with thorough reporting, but some of these reports undoubtedly reflected the difficulty Echelon experienced in accomplishing repairs at SCAT. SCAT is a large operation relative to the other participants, but provided Echelon with the lowest level of access to its fleet.

There is considerable variance in the operators' perceptions of both system performance and the promptness of Echelon's responses to problems. Overall, Echelon remained ready to respond to problems at any facility. But as the test proceeded, Echelon seems to have invested attention in those operators with which it was developing some rapport, and became less responsive to other operators. Repair logs indicate it took an average of 6.7 days to fix a problem at Simi Valley.[9] Antelope Valley management reports that it took Echelon only about two to three days to address the equipment problems reported there. At the other extreme, Santa Barbara Transportation reports that their equipment problems were usually not addressed, that the FareTrans VMS usually did not work, and that Echelon was largely unresponsive.

There were also differences with respect to how in-house maintenance responsibilities evolved across operators. Some operators, such as Simi Valley Transit, tried to solve problems themselves, and some, such as SCAT, left all responses to Echelon. The range of experiences across agencies suggests that operator participation in maintenance, even to a small degree, can have a positive effect on system performance.

[9] VCTC reports this interval has been reduced to two days.

Responsibility implies ownership and interest. In the long term, agencies that want to continue use of the FareTrans VMS should have some in-house responsibility for maintaining the system.[10]

Garage personnel's understanding of the FareTrans VMS is also important. In some cases, garage personnel made technically incorrect responses to problems. In one instance, SCAT personnel disconnected cables to stop the system from beeping during data uploads and downloads. The next driver assigned to the vehicle made a good faith attempt to reconnect the system, but forced the cables into the wrong sockets, damaging circuitry. In another instance, SCAT maintenance personnel smelled something burning, and immediately called for all units to be disconnected. While some degree of in-house responsibility is desirable, this responsibility should be well defined. Agency personnel should have an opportunity and willingness to learn basic trouble shooting, which kinds of problems to attack, and which problems are outside their training.[11]

3.3 OPERATIONAL PERFORMANCE

Operational performance is determined from a component perspective. Operational performance relates to whether the components deployed function correctly on an individual basis. This must occur for the components to ultimately function as a system. If a complex system demonstrates successful operational performance, this suggests that unanticipated problems inevitably associated with any deployment of new technology have been identified and addressed. Identification of problems follows from field experience. Given successful installation and configuration of equipment, initial constraints on FareTrans VMS performance occurred across seven categories:

- Echelon's equipment tests,
- wiring practices,
- voltage incompatibility and power supplies,
- card initialization,
- man/machine interface and training,
- APC/fare card integration,
- data communication, and
- data management.

[10] VCTC reports such procedures were established following the test.
[11] VCTC reports additional agency training for diagnosing problems with and replacing driver and passenger transaction units was completed between November, 1998 and January,1999.

3.3.1 Equipment Tests

Echelon acknowledges using the deployment to test equipment from a variety of manufacturers. This is a reasonable objective for a field operational test. The knowledge these component tests provided is needed to ensure development of a fully functional Fare Transaction and Vehicle Management/Monitoring System. Requiring Echelon to deploy FareTrans VMS equipment without bench tests forced Echelon into a situation in which components would necessarily have to be tested in the field. However, Echelon embraced this strategy to a degree its management chose not to explain to VCTC, the operators participating in the test, nor the evaluation team. Echelon sometimes changed components in functioning systems to see what would happen, and these changes sometimes caused degraded performance. This changed the conditions of the field operational test in ways that further contradicted the expectations of the other participants. The information provided these tests were of value to Echelon's efforts to develop the capabilities of its systems, and thus ultimately consistent with the objectives of the FOT.

Unfortunately, this strategy also produced new constraints. The mismatch between Echelon's expectations and the operators' expectations was already too large. Had Echelon shared its agenda, the other participants in the test might have begun to re-approach the field operational test with different expectations and responses to problems. Instead the gulf between expectations was widened, and the operators' incentives to support the deployment with active cooperation were further diminished. Efforts to evaluate the FOT were also complicated in nontrivial ways by the way Echelon proceeded in this respect, but the evaluation was not jeopardized.

3.3.2 Wiring Practices

Many FareTrans VMS units exhibited intermittent operations beginning a few weeks after installation. This was the result of poor wiring practices. Echelon reports that this resulted from use of a specific crimping tool. Echelon resolved the problem by reworking the wiring onboard the buses (Echelon, 1996c).

3.3.3 Voltage Incompatibility and Power Supplies

About 1/3 of the buses involved in the field operational test have 12-volt electrical systems, and 2/3 operate at 24 volts. Many of the 12-volt buses are older vehicles that cannot maintain acceptable voltage levels at start up. The older, smaller vehicles used as demand-responsive vans are particularly unlikely to provide a reasonably constant 12V operation. The PTU displays proved intolerant of voltage drops, which caused them to blink or go blank. An inspection of agency defect reports reveal that the most frequently observed and verifiable problem with the FareTrans VMS was blank or blinking displays. Initially, two to three incidents of display problems occurred per week. These circumstances dictated that the power supply system be substantially redesigned to permit 12V operation, and to protect the system from transient changes in voltage (Echelon, 1995d; Rebeiro, December 14, 1996).

3.3.4 Card Initialization

The test identified three sources of bad card initializations. These include:

- problems with the card write software,
- problems with card expiration dates, and
- problems with data entry.

Drivers and passengers complained of debit transactions that charged too much money for the fare, and of cards that were not being recognized onboard buses (Echelon, 1996d). Echelon reported approximately 80 percent of transaction failures were due to bad data stored on the cards. Most of this bad data was created during the initialization of the cards sold during the first month of sales. There were bugs in the card manufacturer's software and in the software written by Echelon. These were corrected as problems were identified (Rebeiro, December 14, 1996). Current initialization procedures are correct. The flawed cards remained in circulation, presumably to have been corrected during the recharging process (Echelon, 1996d).[12]

3.3.5 Man/Machine Interface and Training

Personnel involved with the operation of the FareTrans VMS must be proficient with its use for the system to function effectively. This includes drivers, outlet personnel responsible for issuing and recharging cards, supervisory personnel, maintenance and garage personnel, and finally, passengers. Echelon reported that training was often problematic. For example, Echelon reported that neither drivers nor outlet personnel knew how to recharge cards (Echelon, 1996d). These activities were infrequent, and in many instances supervisors trained by Echelon were giving the wrong information to their subordinates. Echelon maintains that most failures encountered throughout the test can be attributed to lack of adequate information on the part of drivers and other personnel, and the behaviors this lack of information led to.

The most important training deficit in the test was also the least obvious, largely because it was unanticipated. Garage personnel did not know how to support the FareTrans VMS equipment. When the test began, the FareTrans VMS was as much a mystery to garage personnel as operator-specific bus practices were to Echelon. Consequently, Echelon could not easily tailor training objectives to the roles of garage and maintenance personnel. Instead, Echelon depended on individual operators to use internal administrative authority to elicit support, cooperation, and appropriate technical responses from the various garages.

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[12] VCTC reports returning approximately 500 defective cards to Echelon Industries for replacement.

3.3.5.1 Driver training

Echelon conducted initial SCAT training sessions with the bus supervisors, videotaped these training sessions, and then asked bus supervisors to train their drivers. This approach was ultimately deemed unsatisfactory. Echelon corrected the situation by conducting additional training sessions in which drivers were trained directly.

Echelon recommended one to two-hour reviews to train outlet personnel and 15 to 30-minute reviews to train drivers, and that outlet personnel be instructed to remind passengers how to use their cards upon recharge. Garage personnel were trained on the card recharging process at least twice, and outlet personnel between two and four times. The training and retraining process was frustrating for the staff involved because they still remained responsible for other regular tasks.

Despite additional training, repeated modification of system settings by drivers routinely caused the FareTrans VMS to record incorrect information concerning routes, agency designation, bus number, and related data (Echelon, 1996d). Route numbers were wrong 15 percent of the time (Evaluation Team's Summary of the Technical Committee Meeting, August 9, 1996). Checks against APC data indicated that incorrect route numbers were being coded 30-50 percent of the time for some systems (Rebeiro, January 27, 1997). Driver ID numbers were wrong 20 to 30 percent of the time (Rebeiro, December 14, 1996). Echelon eventually redesigned the control software to prevent drivers from changing anything except their route numbers. Drivers were also precluded from processing excessively high value card recharges, or from changing a pass card to a debit card.

The FareTrans VMS was designed to operate with a single keypad dedicated to the driver unit, with the option of accommodating a second keypad dedicated to the passenger transaction unit. The DUI keypad permitted the driver to recharge cards, and could be used to input the number of passengers boarding at each stop, classified by fare type (Echelon, 1995d; Evaluation Team's Summary of the Technical Committee Meeting, August 9, 1996). This feature was requested by one of the operators (Rebeiro, December 14, 1996). However, full use of tally passenger counters required even more attention on the part of the drivers. And in some cases, agencies had designated locations for the driver key pads that were not sufficiently accessible to permit routine use (Evaluation Team's Summary of the Technical Committee Meeting, August 9, 1996). Consequently the tally feature of the driver key pads was never used (Rebeiro, December 14, 1996).

3.3.5.2 Passenger training

There is considerable anecdotal evidence that many of the passengers did not know how to use the fare card. For example, passengers were reported

- saying that they cannot find the slot to put the card into (there is no slot),
- giving the cards to the driver, and
- withholding the card until queried by the driver (Echelon, 1996e).

There is general agreement among the participants that a brochure should be developed explaining the nature of the program, and explaining how to use the card. The brochure should be handed out when the card is initialized or recharged, and should be available on the bus. English and Spanish brochures were developed as part of the marketing program, however, these were not widely distributed[13].

3.3.5.3 Administrative staff training

As described in Chapter Two, fare cards are initialized and recharged by the Fare Transaction System software. The FTS software is a menu-oriented program designed for interactive use. Echelon spent considerable time working with VCTC staff to fine tune and improve the program, including

- improvements in reporting,
- addition of modules for communication, and
- addition of modules for card recharging without immediate references to databases.

Initial problems with FTS data entry included incorrect zip codes, misplaced roads and avenues in addresses, apartment numbers and PO Box numbers in the wrong fields, use of an incorrect initialization sequence, incorrect dollar amounts, incorrect fare type, incorrect card type, and other errors (Rebeiro, December 14, 1996). These errors were likely due to human error at the point of sale, or when paper transactions were re-coded. Retraining outlet personnel responsible for recharging cards greatly reduced the frequency of incorrect expiration dates.

3.3.5.4 Garage staff training

As noted above, garage staff training requirements went largely unaddressed. Echelon did not have detailed knowledge of procedures at each garage, and the largest facilities were not terribly interested in making their procedures known. Echelon hoped that administrative authority in the participating agencies would be sufficient to ensure appropriate support in the garages. In some cases, this approach worked, but only with the

[13] An update brochure was developed in 1998.

smaller operators. In most cases, it did not work with operators of any size, and should not be expected to.

This approach intensified the problems associated with the participating agencies' and operators' perception that they were involved in the deployment of a mature system. Management did not realize unusual efforts would likely be required to accomplish effective technical support of the system in their garages. Further, garage staff sometimes exhibited considerable administrative autonomy within their organizations. A commitment to the test on behalf of a specific operator did not necessarily translate into a commitment from garage personnel. And lastly, Echelon's approach did not enable appropriate trouble-shooting and problem reporting procedures. Garage responses to the same problem could vary widely across organizations, trouble reporting channels ranged from direct to convoluted, and Echelon sometimes could not be assured of timely access to vehicles needing attention.

3.3.6 APC/Fare Card Integration

Sixteen buses were equipped with automatic passenger counters. Unlike tally keys, this equipment requires no input from the drivers. Echelon experienced initial difficulties integrating the automatic passenger counters with the other FareTrans VMS components. After the installation of five APC units, Echelon discovered that APC operation periodically interfered with fare card transactions. Buses with passenger counters incorrectly treated all boardings and alightings following use of a fare card as transactions. When a card user crossed a passenger counter, the card ID was replicated for following passengers crossing the counter, hence some transactions were recorded when in fact no cards were involved. Also, conflicts between the APC and the PTU caused five to seven percent of cash passengers to be missed by the system (Echelon, 1996c).

Federal standard SAEJ1708 defines how bus companies should interface computers on buses. Unfortunately, the standards for communications speeds (9600 baud) and priorities proved inconsistent with the needs of the field operational test. The automatic passenger counter and fare card transactions are measured in milliseconds, and cannot be written to the passenger transaction control unit continuously. Writing APC data continuously interferes with fare transactions. Echelon redesigned the FareTrans VMS hardware and software to store passenger count data in a buffer so that the passenger transaction unit and the APC never write to the control unit simultaneously. The automatic passenger counters continue to monitor passenger counts continuously, but the APC computer writes counts to the main computer only every 10 to 15 seconds (Echelon, 1996d; Rebeiro, December 14, 1996). This problem was resolved as of July 1996, at which point Echelon reported that relatively few boardings are card transactions. Most users boarded without cards (Evaluation Team's Summary of the Technical Committee Meeting, August 9, 1996).

3.3.7 Data Communication

Data communication between buses and garages was fairly rapid. Once the vehicle is sufficiently close to the garage antenna, communication is likely to proceed successfully
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> *"The duration of data transfer ranges from 2 to 12 seconds, with 5 to 6 seconds being the typical duration, depending on the number of days worth of data being transmitted. The PTUs do not need to remain operational after the bus power has been turned off. Initially, the drivers would hear multiple beeps during uploading or downloading. At the drivers' requests, this has been changed to simply a visual display."* (Rebeiro, January 27, 1997).

The frequency of communication between bus and garage computers is primarily a function of bus fleet management practices. One potential problem is related to the storage location of buses. Buses provided by VISTA Central and East contractors are park-outs: drivers take these buses to their home, and do not necessarily take them back to the same garage. This means data cannot be uploaded daily from the FareTrans VMS to garage computers. Echelon requested additional route planning on the part of these operators to address the problem.

Communications between the computers in the garages and the central computer at Echelon were not initially reliable due to

- power fluctuations,
- telephone connection problems and line availability,
- garage computer failures (computer lock-up problems), and
- interference with equipment.

Power fluctuations due to SCAT's use of a large compressed natural gas (CNG) compressor resulted in both interruption of communication and computer lock-up problems (Echelon, 1996c). This interference did not affect communication between the FareTrans VMS and the garage computer, but did affect communication between the garage computer and the central computer (Rebeiro, December 14, 1996). Telephone connection problems resulted in interruption of communication (Echelon, 1996c). Problems included availability of a telephone line; competing use of the telephone; telephone system noise sufficient to interrupt modem communication on a dedicated line, including electronic interference from answering machines and voice mail systems; or any of these problems in combination (Rebeiro, December 14, 1996).

Fluctuations in voltage are one pervasive and important source of garage computer problems, but Echelon could not conclusively identify the primary source(s) of computer lockup problems. Consequently, Echelon responded with a range of measures to improve performance. These included installation of additional timer systems, uninterruptible power supply (UPS) systems, surge and transient spike protection, watchdog timers, modem filters, locks on computers and modems, removing keyboards, and other measures (Rebeiro, December 14, 1996). Echelon's strategy was to prevent computer lockups, and to make certain the system was rebooted if a computer failure occurred.

Communication between garage computers and the central computer was occasionally interrupted by personnel who interfered with equipment (Echelon, 1996d). This interference was sometimes incidental and sometimes intentional (Rebeiro, December 14, 1996). For example, the telephone connection to the Simi Valley garage computer was contaminated with dirt, causing the computer to return a continuous busy signal when polled by the central computer.

Even with additional garage equipment in place, Echelon could not completely automate collection of transaction data. Rare events continue to present problems a fully automated system cannot cope with. For example, the SCAT garage experienced a two-day power failure that interrupted data collection. More importantly, bus practices have proved difficult to anticipate. Unforeseen scheduling changes made it impossible to know how many buses will actually be fielded and when. Consequently, a computer operator must be kept in the loop to audit results, determine whether anticipated data has been collected, and if not why not. The great majority of the data accumulated onboard buses can be collected if the electronic collection system is monitored at least daily (Evaluation Team's Summary of the Technical Committee Meeting, August 9, 1996).

3.3.8 Data Management

Data collected by the FareTrans VMS is rarely lost before it can be uploaded. If a bus is not in service, or if the onboard system is not operating, no new data is collected. But if the FareTrans VMS is operating, it is designed to retain any data it cannot upload. Further, there are relatively few ways for data to be corrupted during file transfers. Packet communications and check sum procedures make file transfers via modem very safe. If communication between any garage computer and the central computer is interrupted, the file being transferred is retained at its source. The same is true of file transfers between bus and garage computers.

There are, however, two ways in which loss of data proved to be a significant threat. These are: on site trouble shooting involving equipment exchanges and post processing of garage files by the central computer.

The FareTrans VMS has a modular design. Echelon replaces components in the field rather than repairing them. If a malfunctioning passenger transaction controller is removed from a bus and exchanged with a functioning unit, any transaction data stored onboard the malfunction PTC will be lost unless this data is downloaded before the PTC is disassembled for repair. Echelon modified its shop practices at the end of 1997 to preclude this sort of data loss.

Late in 1997, Echelon also discovered that transactions, boardings, and alightings data was being lost after the data files had been successfully uploaded to the central computer. The post processing procedure for creating a Microsoft Access database summarizing system transactions was very sensitive to any anomalies in transaction records. Unless the files uploaded from the garage computers were in perfect condition, the files were deleted from the central computer without successful creation of an Access database. Given the number of transactions, boardings, and alightings uploaded from each bus, given that this data could be uploaded from each in several small increments during each day, and given the number of buses operating each day, there is a high probability of minor anomalies in the data ultimately uploaded to the central computer. This has resulted in substantial data losses, which Echelon has taken steps to correct. Figure 3.1 is an event tree summarizing the various ways in which the flow of transactions data from buses might be obstructed or delayed, and identifying counter measures implemented by Echelon.

3.4 FUNCTIONAL PERFORMANCE

"Functional performance" is expressed in terms of the equipment's capacity to operate as a system, the system's availability in service, and the system's ability to deliver the desired outputs. How frequently was the system available for intended use? Was the system able to deliver planned outputs? In some cases, the FareTrans VMS did operate largely as intended, but it frequently did not. The most important information comes from the occasional success. A complex system that never operates as intended probably never will. A system that sometimes does meet its objectives can probably be improved once key constraints are identified. In this case, the key constraint appears to be the technical knowledge of the system imparted to the operators.

3.4.1 Onboard Equipment Survey, Test Card Transactions, and Manual Passenger Counts

FOT deployment began in March 1996. The evaluation team conducted an onboard equipment survey on May 19-21, 1997. This provided enough time for the FareTrans VMS and related garage equipment to be made as fully operational and stable as possible. Also,

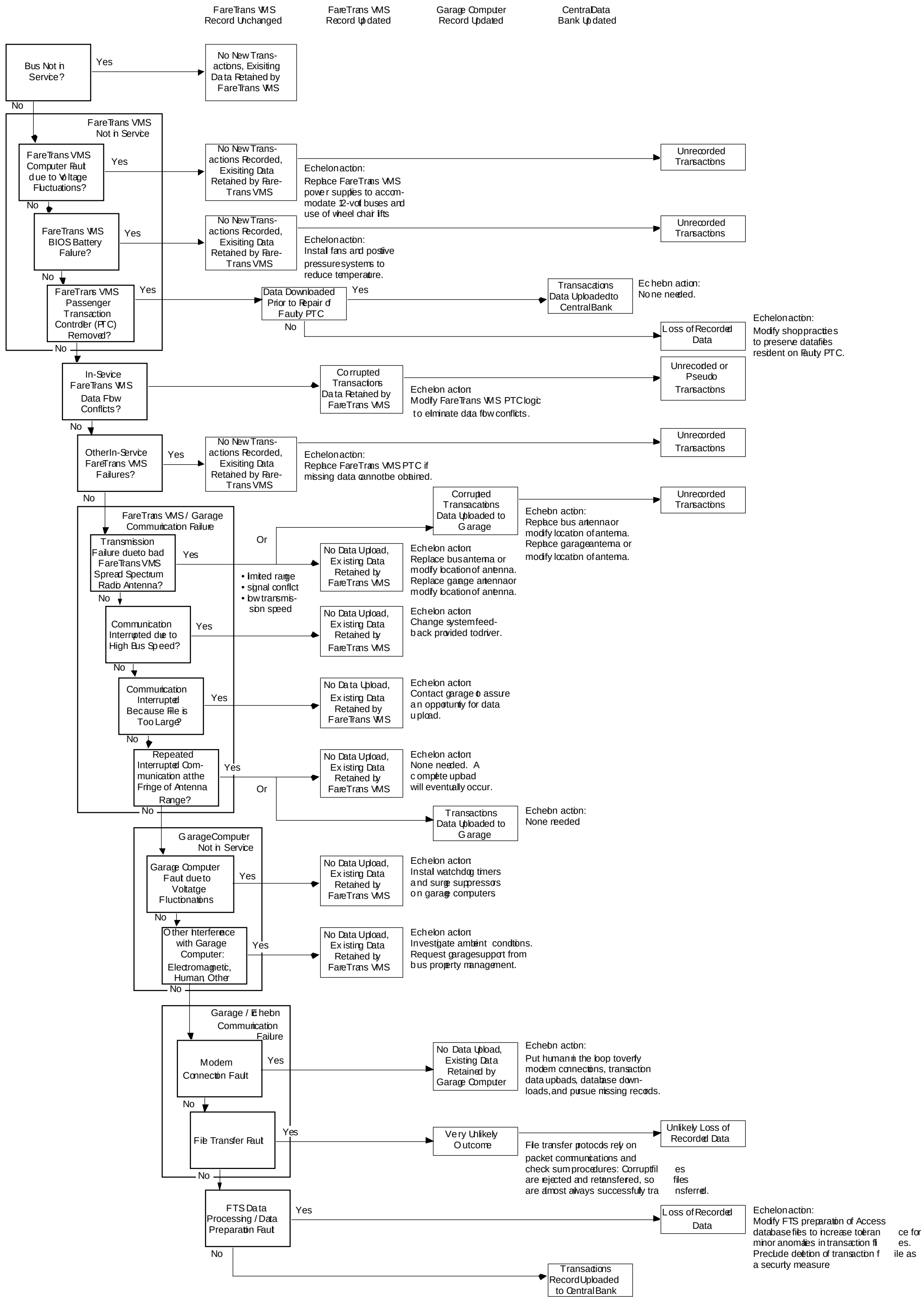


Figure 3.1 Event tree summarizing the various ways that the flow of bus transactions data can be obstructed

schools were still in session, and few people were on vacation. The survey was conducted from Monday to Wednesday – workdays that are unlikely to include unusual circumstances. Morning and afternoon peak hours were surveyed to catch as many passengers as possible. Finally, surveying the buses for three consecutive days allowed the team to account for day-to-day variations in equipment performance.

During the field study, the evaluation inventoried the working condition of bus FareTrans VMS card readers, passenger and driver displays, and automatic passenger counters; completed test card transactions onboard buses; and recorded any apparent uploads from the FareTrans VMS to garage computers. The team also manually counted passenger boardings and alightings on 12 buses over a total of 32 runs on buses equipped with automatic passenger counters.

The survey included a total of 32 buses fielded by SCAT, VISTA contractors, and Thousand Oaks Transit. The field survey schedule appears in Appendix 3B. The survey excluded the smallest operators such as Camarillo, and those that had relatively few vehicles equipped with automatic passenger counters such as Simi Valley. Instead, the equipment survey focused on routes that were reported to have the heaviest ridership, such as SCAT Route 6, and VISTA Route 126. Buses not equipped with FareTrans VMS equipment were not surveyed.

3.4.1.1 Comparing field transactions and electronic data records

An Access data file provided by Echelon in August 1997 contains all available data retrieved by polling Fare Trans/VMS-equipped buses through August. This includes data collected during the evaluation team's field study, making it possible to compare the evaluation team's field records with electronic transaction records for the same period. Appendix 3C is a summary of Echelon's transaction file record format.

Table 3-2 lists the buses on which observations were taken, whether the buses were equipped with APC, whether the FareTrans VMS equipment onboard the bus appeared to be functioning during the field test, and the corresponding transactions data reported by Echelon. A close comparison of field records and the Echelon transaction data file shows a number of small differences. Some card transactions are missing from the Echelon database. In some cases, the card reader/writer worked, as confirmed by the increment in the number of trips made on the test card, but the transaction did not appear in the Echelon database. During the course of the field study, it became apparent that buses communicate with their respective garage computers at very different intervals. This interval is largely a function of how often the routes take vehicles past the garage. This makes it difficult to estimate how long it takes transaction data recorded onboard the buses to become available

Table 3-2 Condition of FareTrans VMS Equipment Observed in the Field, Pass Card Activity, and Corresponding Electronic Data Records

	Observed in the Field[a]	Appearing in the Echelon Data File
Buses with Passenger Transaction Units, but No Automatic Passenger Counters		
SCAT 3501	Verified[b] May 20	Test card data present[c]
SCAT 3504	Verified May 20	Test card data present
SCAT 3505	Verified May 20	Test card data present
SCAT 3506	Verified May 19, and 20	Test card data present
SCAT 3508	Not working May 20	No data present for this bus
SCAT 3510	Working May 20	Test card data present
SCAT 3512	Working May 19, but not May 20	No data present for this bus
SCAT 3513	Working May 20	Test card data present
SCAT 3515	Working May 19, verified May 20	Test card data present
SCAT 3516	Verified May 19, 20	Test card data present
SCAT 3517	Verified May 20	Test card data present
SCAT 4002	Dim display May 19	Test card data present on May 19
SCAT 4002	Not working May 20	No data present for this bus on May 20
SCAT 4003	Working May 20	Test card data present
SCAT 4005	Working May 20	Test card data present
SCAT 4006	Working May 20	Test card data present
SCAT 4535	Verified May 20	Test card data present
Thousand Oaks 24	Dim display May 21	Test card data present, incorrect bus number
VISTA 126 bus 3	Not working part of May 19	Test card data present
VISTA 126 bus 4	Working May 19	Test card data present

	Observed in the Field[a]	Appearing in the Echelon Data File
Buses with Passenger Transaction Units, but No Automatic Passenger Counters		
SCAT 3500	Verified May 19, 20	Test card data present, no APC data present
SCAT 3502	Working May 20	Test card and APC data both present
SCAT 3507	Verified May 20	Test card and APC data both present
SCAT 3509	Working May 19	No data present for this bus
SCAT 3511	Working May 19, verified May 20	Test card and APC data both present
SCAT 3514	Verified May 19, working May 20	Test card data present, no APC data present
SCAT 4000	Not working May 19	Test card data present, no APC data present on May 19
SCAT 4000	Verified May 20	Test card data present, no APC data present on May 20
SCAT 4004	Working May 20	Test card and APC data both present
SCAT 4007	Not working May 20	No data present for this bus
VISTA 101 bus 808	APC sensor missing May 20	Test card data present, no APC data present
VISTA 126 bus 5	Verified May 20	Test card and APC data both present
Thousand Oaks 25	Verified May 21	Test card and APC data both present
Thousand Oaks 26	Not working May 21	No data present for this bus

Notes: a Field assessments were cross-checked against the SCAT drivers' daily reports on the condition of FareTrans VMS equipment. The evaluation team's field observations were in good agreement with the drivers' problem reports.

b Passenger transaction units are verified to be working when test card transaction times recorded by the evaluation team are successfully matched to times appearing in the electronic transaction record provided by Echelon. Units listed as "working" were reported as such in field records, but the times of test card transactions could not be verified. This could be due to a lack of field precision on the part of observers, and does not imply that the FareTrans VMS was functioning incorrectly.

c The presence of test card data also implies the presence of other card data.

in the master database. As of August 1997, one bus had not successfully communicated with its garage computer since March 20, 1997. If no automatic accounting method is in place to check for missing data, outcomes such as this can go undetected for long periods of time.

Results are further summarized in Table 3-3. Test card transaction data was successfully transmitted from the bus to Echelon's master database 83 percent of the time across all buses. Test card data for buses without automatic passenger counters appeared relatively more frequently (87 percent) than test card data for APC-equipped buses (77 percent), though this difference is not statistically significant. APC buses tended to collect test card data even when the APC equipment was not working. Passenger count data was missing from records for APC-equipped buses 54 percent of the time, or more often than not.

3.4.1.2 The quality of electronic transaction records

The following is a summary of the data fields in the transaction database file provided by Echelon, and the accuracy of the information appearing there.

Date of Recording Data

Some of the dates associated with transactions made during the field test are incorrect. This persists even though Echelon reports drivers can no longer change the PTU date or time using the driver's keypad.

Time of Recording Data

There are a few significant discrepancies between when observers recorded a field transaction and the time given in Echelon's data file. Cross checking with the trip number for the test card indicates that the field observations are generally accurate. Of 17 cases in which time of a test card transaction could be verified, 14 were recorded in the field at the correct time to within +/- 10 minutes. In one of these cases, the FareTrans VMS time was off by almost exactly one hour.

Drivers sometimes use the driver unit menu to make time adjustments. One menu option is to adjust for Daylight Savings Time. If time adjustments are made incorrectly, the GPS eventually updates the setting to the correct time, but not necessarily before all transactions are time stamped.

Table 3-3 Summary Frequencies Across Buses of Test Card and APC Data in Electronic Records Expected to Include This Data

	No Data Present	Test Card Data Present: No APC Data	Both Test Card and APC Data Present	Buses with and without APC
Buses without Automatic Passenger Counters	2.5 13.2% of Row Total	16.5 86.8% of Row Total	Not Applicable	19 59.4% of Total
Buses with Automatic Passenger Counters	3 23.1% of Row Total	4 30.7% of Row Total	6 46.2% of Row Total	13 40.6% of Total
Buses with and without Data	5.5 17.2% of Total	26.5 82.8% of Total		32 100.0%

Bus Company (Buscomp)

The Buscomp or bus company field was consistently correct and complete in Echelon's database.

Driver ID Number (Driverid)

The Driverid was hardly ever entered and was highly unlikely to ever be correct. This is consistent with comments from drivers during the field test. Some of the SCAT drivers polled knew their FareTrans VMS ID numbers, which differ from their SCAT Driver ID numbers. Only one of the drivers queried by the evaluation team could correctly enter his driver number into the system.

Bus Number

Bus numbers were correct with only one exception.

Route Number

Route numbers are also provided by the drivers. These were missing more than half the time; and, when provided, were correct about 65 percent of the time.

Farecard ID Number

Transactions involving test cards were readily and consistently identifiable.

Transaction Status

Only two types of transactions were recorded for the field test cards, “Transaction OK” or “Re-use pass within lockout.” This feature consistently worked well, except in one instance where a lockout alert was not given for a pass re-used within three minutes. This could be due to a lack of synchronization of PTU clocks across different buses.

Number of Trips (Numtrips)

The Numtrips column correctly recorded the cumulative number of trips the observers made on each observer pass. Numtrips reads “0” and does not increment if the transaction is not successfully completed. There were some inconsistencies between the sequence of trips as recorded on the field data sheets, and the time of transaction and number of trips reported in the Echelon database.

3.4.1.3 Comparing field counts and automatic passenger counts

The evaluation team requested counts generated by Echelon from APC data for several buses monitored during the May field tests. The team’s manual counts were compared with the APC counts. In addition, the team requested counts for some buses they had not monitored, and some that did not have APC equipment. Historical ridership data is available for these routes. If Echelon had provided APC counts for buses that have no APC equipment, these counts would necessarily have been synthetic, and Echelon’s other APC counts would become suspect. The buses, times, and dates for which the evaluation team request APC counts appear in Table 3-4.

Eight of the 11 buses listed in Table 3-4 were equipped with automatic passenger counters and a Faretrans VMS that appeared to be working during the field tests. The other three buses had passenger transaction units that appeared to be working, but no APC equipment. Echelon correctly identified the three buses with no APC equipment, but was able to provide the evaluation team with an estimated number of boardings and alightings by bus stop for only two of the remaining eight buses: SCAT bus 3511 (six runs) and Thousand Oaks bus 25 (three runs). A review of the raw data furnished by Echelon shows that no data at all was collected from two of the eight APC-equipped buses observed by the evaluation team, and that only data related to fare card transactions was collected on the remaining four APC buses. Echelon’s inability to provide automatic passenger data on several buses strongly suggests that this data was not being consistently collected or transmitted to the master database during the test.[14]

[14] VCTC reports that all buses will be equipped with APC equipment, and that SCAT buses were so equipped by the end of March, 1999.

Table 3-4 Buses for which Automatic Passenger Counts were Requested from Echelon Industries

Date	Time	Operator	Bus Number	Route Number	Equipped w/APC?[b]
May 19, 1997	7:20A-10:10P [a]	SCAT	3511	16 and 6	Yes
May 19, 1997	2:20P-5:10P	SCAT	3514	6	Yes
May 19, 1997	3:30P-4:20P	SCAT	3509	16	Yes
May 19, 1997	4:20P-5:50P	SCAT	4000	6	Yes
May 20, 1997	7:30A-11:20A	SCAT	3500	1	Yes
May 20, 1997	7:40A-11:10A	SCAT	3511	2	Yes
May 20, 1997	8:30A-11:30A	SCAT	4000	6	Yes
May 20, 1997	2:00P-7:10P	Vista 101	808	101	Yes
May 21, 1997	7:00A-10:55A	Vista CE	47	Central	No
May 21, 1997	7:00A-1:00P	Vista SP	41	East	No
May 21, 1997	3:00P-6:50P	Thousand Oaks	25	2	Yes
May 21, 1997	3:10P-4:20P	Thousand Oaks	26	4	Yes
May 22, 1997	2:00P-4:00P	Simi Valley	4512	B	No

Notes: a SCAT bus 3511 appears twice in Table 3-4, once for May 19 and once on May 20. The May 19 date is a dummy observation. No field observations were taken on this bus at the time identified in the evaluation team's data request. Unfortunately, this was one of the few buses for which Echelon Industries could make APC based counts available. SCAT bus 4000 also appears twice, but both observations are real.

b These appear to be functioning automatic passenger counters. The evaluation team did not request counts for buses on which APC equipment did not appear to be working.

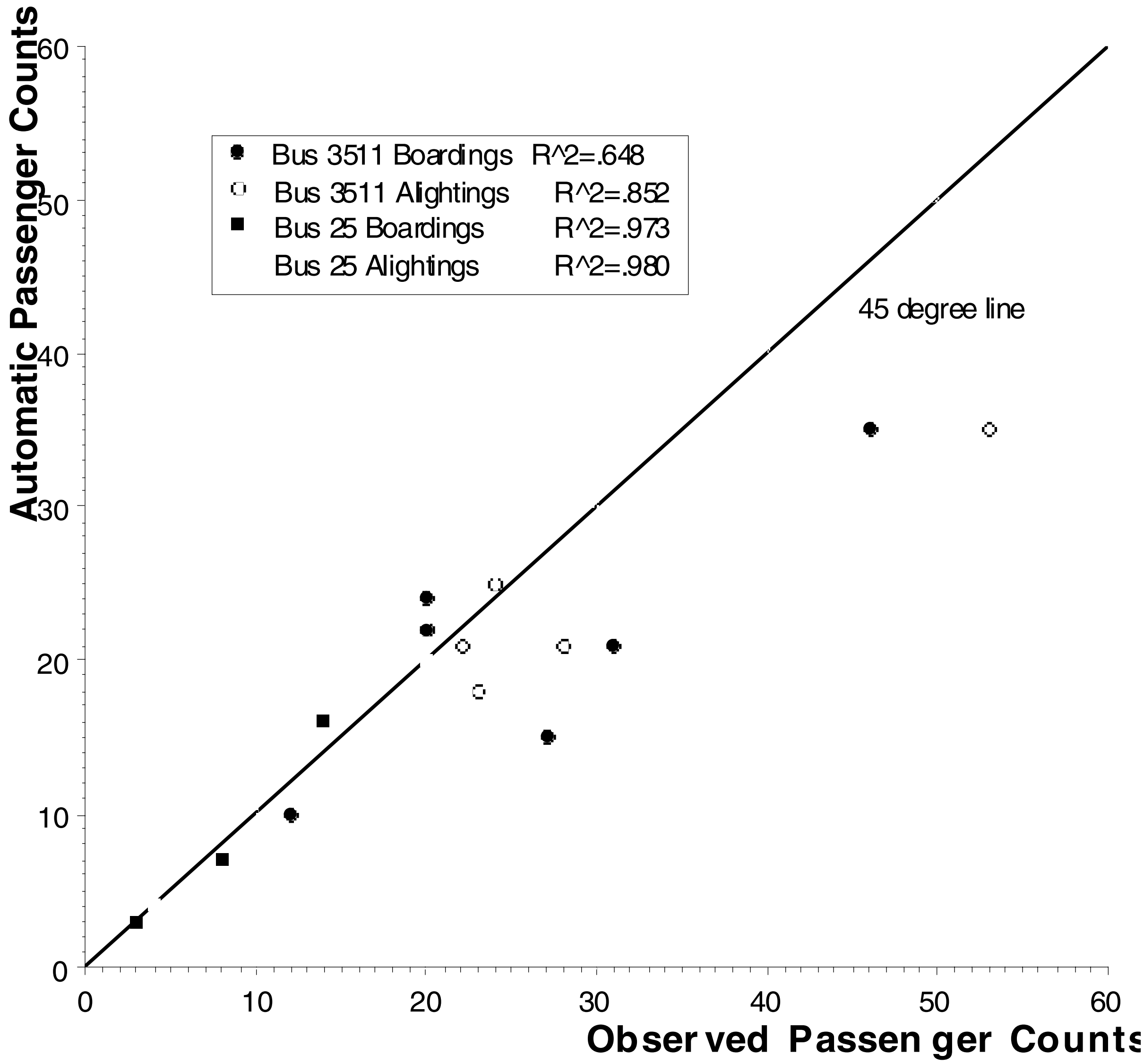
A comparison of the automatic and manual passenger counts appears in Table 3-5 and Figure 3.2. Ideally, the automatic and manual counts should be identical. They are not. Even if the APC equipment was working correctly, and Echelon was using the best algorithm available for converting raw APC counts into boarding and alighting estimates, there would still be some differences between observed and estimated counts. For example, some of the passenger activity recorded by the evaluation team on Thousand Oaks bus 25 has no corresponding record in Echelon's data. This includes one boarding and two alightings between 4:40 PM and 5:00 PM. This is a type I error: activity that is intended to be measured goes unaccounted for.

Table 3-5 APC vs. Observed Boardings and Alightings

Run	APC Boardings	APC Alightings	Observed Boardings	Observed Alightings	Observed Already on Board	Observed Remaining on Board
Thousand Oaks Bus 25						
1	16	20	14	20		
2	7	9	8	11		
3	3	4	3	4		
Sum	26	33	25	35		
SCAT Bus 3511						
1	10	21	12	22	11	0
2	24	21	20	22	2	0
3	15	21	27	28	1	0
4	22	25	20	24	4	0
5	21	18	31	23	1	9
6	35	35	46	53	9	3
Sum	127	141	155	172	28	12

Note: Logically, passenger and driver alightings – passenger and driver boardings – passengers already onboard when observations begin + passengers remaining onboard when observations end = 0 for each run. Field observations are off by a count of 172 - 155 - 28 + 12 = 1.

Automatic equipment sometimes overcounts. This is a type II error: events that should not be treated as passenger activity but are. For example, the automatic passenger counters record boardings and alightings that occur between runs and at the end of the day. These boardings and alightings were not recorded by the evaluation team. Field observations indicate this additional interim activity can be significant, amounting in this case to a total of six extra boardings and three extra alightings. Echelon reports its automatic data tallies were adjusted to account for such driver and extraneous activity. Echelon also provided the evaluation team with the cumulative APC counts in addition to the



derived number of boardings and alightings by bus stop. The cumulative APC counts in Echelon's

Figure 3.2 Boardings and alightings derived from APCounts versus observed values (results are available for only two of eight APC-equipped buses)

raw data appear to be incrementing correctly. The automatic passenger counters take readings at frequent intervals, as often as every second. These do not necessarily correspond to passenger or bus activity. The method Echelon uses to convert the APC data to passenger counts is unknown and remains undocumented.

The limited data available in Figure 3.2 suggests that the algorithm Echelon uses to process APC data into passenger counts tends to underestimate the largest values for boardings and alightings. Simple regressions of the boarding and alighting data for bus 3511 both produced positive intercept terms and slopes less than one, suggesting a tendency for estimates of larger values to include increasing deterministic error. The number of boardings and alightings associated with Thousand Oaks bus 25 are smaller than for SCAT bus 3511. The regressions for Thousand bus 25 demonstrate greater accuracy in the estimated values for this bus, but the sample is too small to conclude anything of substance about the process generating the APC estimates.

In contrast to the Thousand Oaks results, some riders are clearly missing from the automatic SCAT counts. The evaluation team recorded 172 alightings compared with Echelon's 141. Actual boardings also appear to be underestimated, on one run by as much as 36 percent. Some of the missing boardings could be attributed to previously boarded passengers (12, including the driver). These riders may have boarded before the bus power was turned on and system was initialized. However, total alightings, which Echelon reports are the most accurate means of measuring ridership, are still 18 percent lower than the field count.

This undercount is surprising. Type I errors can occur. Five babes in arms were observed in the field, and we presume the automatic passenger counters cannot recognize these children as boarding passengers. However, field observations suggested that there are more ways for type II errors to occur than for type I errors to occur. For example, on two occasions, the evaluation team observed a significant amount of activity in front of the APC equipment during the operation of wheelchair lifts. Thus we expected Echelon's APC data to overestimate ridership by capturing driver and passenger activity between runs.

An analysis by fare type was not feasible. Echelon reports that the fare type fields in the transaction records are present for experimental purposes, and have not been succesfully integrated with APC data collection.

3.4.2 Assessing Communications between Vehicles and Garage Computers: Verification of Transactions

The evaluation team also attempted to verify that cards the team observed being read onboard buses were appearing in the transaction records uploaded from the vehicles to garage computers, and ultimately in the records uploaded to the central computer at Echelon Industries. To better assess the likelihood of FareTrans VMS transactions being transmitted to the master database, debit cards purchased from SCAT were read by card readers on all of SCAT's FareTrans VMS-equipped buses entering operation on the morning June 26, 1997. These tests were conducted as the vehicles left the garage for their first run of the day. The test procedure was to visually check if the Fare Trans/VMS equipment was working, to execute a transaction, thus creating an onboard data file consisting of (usually) one transaction; and then to observe the PTU as the vehicles departed to determine whether each bus appeared to transmit this single transaction data file to the garage computer. The evaluation team recorded the time and any other relevant information about the transaction as each card was read. These field records were then also compared with the transaction database provided by Echelon. Comparing Echelon's transaction records with field records made it possible to assess the system-level reliability of electronic data transfers. Unlike the pass cards used during the May field tests, the June test cards were debit cards with shorter lockout periods.

Detailed results are listed in Table 3-6. The evaluation team boarded 18 buses the morning of June 26. Three of the Fare Trans/VMS were obviously not operational, and one had a frozen PTU display that made it appear to not read cards. No data was transmitted to the database from two of the four malfunctioning bus systems.

One of these four units incorrectly debited the fare and incorrectly incremented the number of trips taken on the card, issuing a credit of $1.20 instead of debiting a student fare of $0.75. The bus with the frozen display was actually reading and correctly debiting the test cards. However, it did so multiple times within a one-minute period because the evaluation team could not tell if the PTU was accepting the fare, and used the card multiple times in rapid succession to try and prompt a change in the frozen PTU screen.

The date and bus company were correct in the database for each transaction. However, the bus number, which was supposed to be permanently programmed in the PTU to provide a unique identifier, was incorrect on two buses. One of these, bus 3503, was being recognized as bus 3508, which also exists and was in service, but which did not have a functioning FareTrans VMS on June 26. The other bus for which an incorrect bus number appeared in the data record was bus 3514, which appeared as bus 3515 in Echelon's data file. Bus 3515 may also exist, but if it does, it did not leave the SCAT yard on the morning of June 26.

In summary, the passenger transaction units usually appeared to the evaluation team to correctly process transactions and transmit data to the SCAT garage computer. But accurate reports of the fare card ID, bus numbers, dates, and fares appeared in the Echelon database for only eight of the 18 SCAT buses. Five of these eight reported the correct transaction time. Two of the eight were outfitted with APC equipment. The Fare Trans/VMS malfunctioned to some degree on ten of the 18 buses. Five of these had APC equipment. Six transactions on four different buses could not be traced in the database under the test card ID numbers, even though in these cases the Fare Trans/VMS appeared to be operating when the evaluation team boarded the bus, and the system appeared to be successfully

Table 3-6 SCAT Debit Card Reading and Downloading Activity on June 26, 1997

Bus	Time of Card Use Observed	Time of Download Observed	Equipment Status Observed	Time of Card Use Echelon Data File	Transaction Status Echelon Data File	Cumulative No. of Trips on Card Echelon Data File	Remarks
Observer: Diaz, Fare Card ID 04000652044111							
3508	N/A	N/A	Not working	N/A	N/A	N/A	
4003	4:40 AM	4:40 AM	Working	3:38 AM	Transaction OK	1	
4002	4:44 AM	4:45 AM	Working	4:43 AM	Transaction OK	2	Long download message
4003	5:02 AM	5:02 AM	Working	4:02 AM	Transaction OK	3	
3505	5:12 AM	5:12 AM	Working	5:12 AM	Transaction OK	4	
3511	5:20 AM	Frozen display	Frozen display	5:20 - 5:21 AM	Transaction OK (2 times), improper card process,	5, 6	Display read "Amount 2697"
3514	5:21 AM	5:21 AM	Working	No record for this bus number			See 3515 below
3507	5:28 AM	5:31 AM	Working	No record			Trip 8 is missing from Echelon data file
3509	5:40 AM	5:40 AM	Working	No record			Trip 9 is missing from Echelon data file
3504	No record	5:41 AM	Working	5:41 AM	Transaction OK	10	
3503	5:55 AM	5:55 AM	Working	No record for this bus number			See 3508 below
4001	N/A	N/A	Not working	N/A	N/A	N/A	
4004	6:01 AM	N/A	File Transferring	N/A	N/A	N/A	
3000	6:08 AM	6:08 AM	Working	6:08 AM	Transaction OK	12	
3512	6:27 AM	6:27 AM	Working	No record			Trip 13 is missing from Echelon data file
4006	6:30 AM	6:30 AM	Working	6:30 AM	Transaction OK (2 times), improper card process	14, 15	Two trips intentionally debited.
4007	6:54 AM	6:54 AM	Working	No record			Trip 16 is missing from Echelon data file

3515	See 3514 above			4:22 AM	Transaction OK	7	Wrong bus number in Echelon data file
3508	See 3503 above			5:56 AM	Transaction OK	11	Wrong bus number in Echelon data file

Observer: Karsi, Fare Card ID 04000651041111							
4002	4:45 AM	Not observable	Working	4:44 AM	Transaction OK	1	Long download message
4002	4:45 AM	Not observable	Working	4:45 AM	Transaction OK	2	Long download message
4003	5:02 AM	5:02 AM	Working	4:02 AM	Transaction OK	3	
3505	5:12 AM	5:12 AM	Working	5:12 AM	Transaction OK	4	
3511	5:20 AM	Frozen display	Frozen display	5:20 - 5:21 AM	Transacation OK (3 times)	5, 6, 7	Display read “Amount 2697”
3514	5:23 AM	5:23 AM	File Transferring	No record for this bus number			See 3515 below
3507	5:29 AM	5:31 AM	Working	No record			Trip 9 is missing from Echelon data file
3509	5:40 AM	5:41 AM	Working	No record			Trip 10 is missing from Echelon data file
3503	5:55 AM	Did not appear to download	Working	No record for this bus number			See 3508 below
4004	6:01 AM	6:01 AM	Working	5:01 AM	Transaction OK	12	
3510	6:08 AM	Did not appear to download	Not Working	6:08 AM	Transaction OK	14	Incorrect debit and trip increment to card
3000	6:10 AM	Did not appear to download	Working	6:10 AM	Transaction OK	15	
4000	6:30 AM	6:32 AM	Working	5:30 AM	Transaction OK	16	
3515	No observations for this bus number. See 3514 above			4:24 AM	Transaction OK	8	Incorrect bus number in Echelon data file
3508	No observations for this bus number. See 3503 above			5:58 AM	Transaction OK	11	Incorrect bus number in Echelon data file

transmitting data to the garage. One bus (4004) recorded a transaction for one test card but not the other. Thus, on June 26, the Fare Trans/VMS system met the highest standard of performance only 42 percent of the time, and was substantively correct (bus numbers aside) only a little more than half the time. Results are summarized in Table 3-7.

Echelon inspected several of the SCAT buses on June 28, 1997 as part of the regularly scheduled maintenance program. Several, but not all, of the problems identified by the evaluation team were also identified by Echelon. As was usually the case, Echelon did not have access to all SCAT buses. The incorrect debit and increment problem was not identified. The clock was corrected on one of the four passenger transaction units reporting

Table 3-7 Summary of Transaction Tracing Results from June 26, 1997

	Fully Functional FareTrans VMS: Correct Transaction Record [a]	**Functioning FareTrans VMS: Transaction Record Includes Wrong Bus Number**	**Partially Functioning FareTrans VMS: Anomalous Transaction Record**	**No Transaction Record: FareTrans VMS Appears Powered**	**No Transaction Record: FareTrans VMS Dark**	**Row Totals**
Buses with Automatic Passenger Counters	1.5[b] 21.4% of Row Total	1 14.3% of Row Total	1 14.3% of Row Total	3.5[b] 50.0% of Row Total	0 0.0% of Row Total	7 38.9% of Total
Buses without Automatic Passenger Counters	6 54.5% of Row Total	1 9.1% of Row Total	1 9.1% of Row Total	1 9.1% of Row Total	2 18.2% of Row Total	11 61.1% of Total
Column Totals	7.5[b] 41.7% of Total	2 11.1% of Total	2 11.1% of Total	4.5[b] 25.0% of Total	2 11.1% of Total	18 100% of Total
	9.5 52.8% of Total		8.5 47.2% of Total			

Note: a Transactions time stamps were incorrect in three of the eight (7.5) cases in this category. Overall, The time of transaction was incorrect in a total of four cases, but in a systematic way. In all four buses, the transaction time reported in the data file was an hour earlier than actual time of the transaction.

b Bus 4004 successfully delivered only one of two transactions on different cards to the transaction file.

incorrect times. Two days after Echelon's visit, SCAT's garage maintenance personnel reported one of the PTU associated with the missing transactions to be inoperable.

3.4.3 Failure Frequency Analysis

We summarize performance of the FareTrans VMS equipment by calculating the mean-miles-to-failure (MMF) and average equipment downtimes across operators. Mean-miles-to-failure is a more relevant indicator than conventional mean-time-to-failure (MTF) measures because the total time elapsing between two FareTrans VMS failures may not be a good indicator of equipment use. Miles between failures provides more accurate estimates of system field use. Average downtime is the average time inoperable equipment is estimated to be unavailable for scheduled revenue service.

Statistics for Simi Valley, SCAT, Thousand Oaks, Antelope Valley (Vista Route 101), and Santa Barbara Transportation (Vista Route 126, Vista Route East and Vista DAR service) are based on multiple sources of information, including a comprehensive review of Simi Valley and SCAT problem reports and defect logs. These sources ordinarily report the date of the problem, bus number, a brief description of the FareTrans VMS equipment failure, and the date of equipment repair.

Thousand Oaks Transit, Antelope Valley Bus Lines, and Santa Barbara Transportation did not ordinarily keep defect logs. These are contract operators, and their contracts do not require such logs to be kept. They reported problems by calling Echelon Industries. These operators maintained special failure logs for one month at the request of the evaluation team.[15]

3.4.3.1 Simi Valley

Simi Valley records indicate a total of 24 equipment failures across nine Simi Valley buses in the interval between January 14, 1997 and June 25, 1997 (see Table 3-8). The number of failures per bus varied substantially, ranging between one and six. Seventeen of these 24 failures occurred between January 14 and March 31. The remaining seven failures occurred between April 1 and June 25. More miles accrued on the equipped buses in the second period than in the first. Consequently this second-period reduction in the rate and number of failures indicates an improvement in the performance of the equipment.

Simi Valley kept daily vehicle mileage records. Dividing mileage by the number of failures for each bus gives mean-miles-to-failure across vehicles. For the interval January 14, 1997 to June 25, 1997, MMF across the six buses ranged from a low of 2,188 to a high of 15,429. Overall, the MMF for the nine Simi Valley buses involved in the FOT was 6,993. Bus 4506 is associated with an unusually high number of failures. If bus 4506 is excluded from these calculations, the MMF value increases to 8,595. As expected, observed MMF values increased across all buses in the second period relative to the first.

[15] VCTC reports that the fiscal year 1998-1999 VISTA contracts include language requiring responsible participation in the Smart Card program, including defect reports.

3.4.3.2 Antelope Valley Bus Lines (Vista Route 101)

Antelope Valley Bus Lines operates Vista Route 101. The operator kept special FareTrans VMS performance logs for the period August 1, 1997 to September 5, 1997. Antelope Valley operated buses 808, 817, and 888 on this route during this period. Bus 808 was replaced by bus 888 on August 26, 1997. Table 3-9 lists the number of days each bus was in operation, the number of days the FareTrans VMS was functional, the number of

Table 3-8 Mean Miles to FareTrans VMS Failure (MMF) on Simi Valley Buses, January 14 to June 25, 1997

	Bus No.									Total Or Average
	4506	4507	4508	4509	4510	4511	4512	4513	4514	
January 14, 1997 – March 31, 1997										
Failures	3	3	1	1	2	2	1	2	1	17
Miles	5,889	8,887	7,948	9,018	7,424	12,564	9,821	8,541	9,642	79,734
Miles/Failure	1,963	2,962	7,948	9,018	3,712	6,282	9,820	4,270	9,642	4,690
April 1, 1997 – June 25, 1997										
Failures	3	0	0	0	1	0	1	0	1	7
Miles	7,238	7,078	6,367	6,411	12,095	12,017	13,965	10,896	12,037	88,104
Miles/Failure	2,413				12,095		13,965		12,037	12,586
January 14, 1997 - June 25, 1997										
Failures	6	3	1	1	3	2	2	2	2	24
Miles	13,127	15,965	14,315	15,429	19,519	24,581	23,786	19,437	21,679	167,838
Miles/Failure	2,188	5,322	14,315	15,429	6,506	12,290	11,893	9,718	10,839	6,993

days the equipment was not functional, and the shares of equipment uptime and downtime. The equipment installed on Antelope Valley buses was not working on 17 percent of all service days in the observation interval.

3.4.3.3 Santa Barbara Transportation (VISTA 126, VISTA East, and VISTA Dial-A-Ride)

Santa Barbara Transportation also operated 11 buses on the Vista East, Vista Central, and Santa Paula DAR routes. This operator kept special FareTrans VMS performance logs for the period July 16, 1997 to August 8, 1997. Bus and FareTrans VMS status reports for Santa Barbara Transit and SCAT are summarized in Appendix 3D. Performance results for this interval are summarized in Table 3-10. The FareTrans VMS equipment was not working 47.5 percent of service days on the Vista Route East buses,

Table 3-9 Average FareTrans VMS Downtime for Antelope Valley Buses, August 1 to September 5, 1997

	Bus No.			Total or Average
	808	817	888	
Days of Service	18	26	8	52
Days FareTrans VMS Equipment was functional	10	26	8	43
% Uptime	56%	96%	100%	83%
Days FareTrans VMS Equipment was not functional	8	1	0	9
% Downtime	44%	4%	0%	17%

30 percent of service days on the Vista 126 buses, and 40 percent of service days on the Vista DAR buses. Average downtime across the three lines was 39.1 percent of all service days.[16]

3.4.3.4 SCAT

Thirty-four of SCAT's 45 buses were equipped with FareTrans VMS Equipment during the data collection period, which included May and June 1997. SCAT does not record mileage on a daily basis, so mean-miles-to-failure estimates are not possible. The evaluation team obtained the dates of defect reports from problem logs, and obtained the number of days each bus was in operation from bus assignment sheets. These records provide mean-time-to-failure estimates of 7.81 bus service days for May, and 9.18 service days for June. It was not possible to compute average downtimes for FareTrans VMS equipment from these records, because it generally was not possible to determine how long failures persisted before repairs were completed.

3.4.5.5 Thousand Oaks Transit

Thousand Oaks transit was the operator with the best FareTrans VMS equipment performance. They reported no failures in the months of June, July, or August 1997.

[16] VCTC reports considerable improvements with respect to downtimes since the designation of new VISTA contract requirements.

Table 3-10 Average FareTrans VMS Downtime for VISTA Buses,
July 16 to August 8, 1997

	VISTA Route											Total Or Average
	DAR			126				East				
Bus No.	**W39**	**W40**	**W45**	**T3**	**T4**	**T5**	**T10**	**W46**	**W47**	**W48**	**W49**	11
Days of Service	20	20	20	20	20	20	20	20	20	20	20	220
Days FareTrans VMS equipment was functional	14	6	16	0	20	16	20	6	20	8	8	134
% Uptime	70%	30%	80%	0%	100%	80%	100%	30%	100%	40%	40%	60.9%
	60%			70%				52.5%				
Days FareTrans VMS equipment was not func-tional	6	14	4	20	0	4	0	14	0	12	12	86
% Downtime	30%	70%	20%	100%	0%	20%	0%	70%	0%	60%	60%	39.1%
	40%			30%				47.5%				

3.5 SUMMARY

3.5.1 Field Logistics

Logistical problems encountered in the field deployment included:

- the rush to deploy on a fixed schedule unrelated to technology readiness, even though Echelon Industries could not proceed as quickly as originally promised;
- lack of time for either bench testing or non-revenue service field testing;
- product delivery delays that, given the fixed deployment schedule, forced otherwise unnecessary incremental software updates resulting in multiple software versions;
- changes in agency requirements that added complexity and software updates;
- variable equipment requirements differed across the fleets; and
- lack of timely access to vehicles causing delays in hardware deployment and software updates.

Of these, the field operation test was most hampered overall by VCTC's decision to deploy the equipment on the revised schedule provided by Echelon Industries. Echelon's revised schedule included delays of approximately one year relative to VCTC's expectations, and the agency was very reluctant to accept further delays. VCTC must have hoped Echelon could proceed into the field more quickly if pressed to do so, but Echelon faced substantive constraints, and VCTC's strategy proved to be expensive. Rapid deployment came at the expense of considerable technical readiness. Substantial testing should have occurred both on the bench and in the vehicles before the system was placed in revenue service. Late equipment deliveries and unanticipated service changes led to software changes, and subsequently to incompatibility between the software on some passenger transaction units and the software used to build some cards. These latter problems were addressed incrementally, and for the most part successfully, during the early stages of the deployment.

3.5.2 Operational Performance

At an operational level, problems encountered during the test included:

- unannounced equipment tests during deployment;
- a good wiring practices learning curve;
- voltage incompatibilities (now understood but requiring power supply re-design);
- card initialization software bugs (corrected);
- drivers' knowledge and use of the FareTrans VMS (requiring re-training and additional software controls);
- card initialization and re-charge software data problems (identified as human errors and reportedly reduced through re-training);
- passengers' knowledge of card use (in spite of an initial education effort);
- integration of automatic passenger counter/fare card transaction data onboard the bus (resolved by precluding data from both sources being written to the control unit simultaneously);
- data management procedures leading to lost files (correctable in principle); and
- erratic maintenance reporting and differing transit agency trouble shooting and repair policies.

The effects of VCTC's deployment schedule were further intensified by Echelon Industries' decision to aggressively test the products of a variety of vendors. Participating operators were confused because they believed and expected the deployment to provide a technologically mature system, yet onboard equipment failures in use were relatively common. Perceived performance and measured performance of the system both varied substantially across the operators involved in the test. The availability of the system to passengers depended strongly on the level of cooperation provided to Echelon by the test participants. Those operators who reported problems quickly and provided Echelon with rapid access to vehicles for repairs tended to have the best experiences, but the reverse is also true. Violated expectations about the system eroded some of the cooperation Echelon needed to effectively maintain the system and address problems. Operators that began to expect failure became reluctant to extend support.

Initial training needs in all categories were underestimated by all test participants. Training problems were exacerbated by the fact that few cards were in use toward the end of the test. This made card transactions, card sales, and card recharge activities infrequent; and neither agency staff nor drivers remained familiar with the system. A successful commercial deployment will require the more focused, structured training and refresher sessions of the sort Echelon Industries ultimately concluded it had to and did provide. Garage training requirements remain a clear deficit. Individual operators should not be left to develop their own problem reporting procedures. Garage personnel should be provided with a framework that is integrated with normal garage operations and basic documented trouble-shooting procedures for the FareTrans VMS.

3.5.3 Functional Performance

At the functional level:

- unanticipated complexity in bus practices requiring centralized, daily monitoring of otherwise automatic data collection;
- comparing field passenger counts and automatic passenger revealed the APC estimates to be unreliable;
- debit card transactions could be reliably traced from the SCAT buses on which they occurred to Echelon's central database only 42 percent of the time on a given test day; and
- FareTrans VMS equipment failed at an unacceptably high rate for normal operating purposes.

Uploading and downloading data between FareTrans VMS and garage computers could not be completely automated due to unforeseeable variations in bus practices. However, data can be routinely transferred to and from buses over the radio network and modem communications installed by Echelon if an operator is kept in the loop to monitor results approximately daily. Most transaction and card status data were successfully communicated to and from buses and garage computers, and to and from garage computers to the central computer. Data losses did occur, even toward the end of the test. Echelon Industries reports these were largely the result of post-processing accidents, not communications problems. Echelon reports it has modified its transaction file post-processing and equipment repair procedures, and anticipates no further data loss from these sources.

The automatic passenger counters did not work reliably during the FOT. In most cases in which the evaluation team completed field counts on buses with (presumably) functional APC equipment, Echelon Industries could not provide corresponding passenger counts based on the data collected by the APC. For the two buses for which Echelon could provide estimates, there was considerable variance between the field counts and the APC estimates, with the APC-based estimates tending to undercount boardings and alightings, especially for busier stops. The algorithm Echelon Industries developed for converting cumulative APC counts into boardings and alightings estimates was not provided to the evaluation team.

The evaluation team's frequent inability to trace transactions from FareTrans VMS-equipped buses to the central database at Echelon Industries was likely the result of poor system maintenance procedures on the part of both SCAT and Echelon. The fare transaction and GPS elements of the FareTrans VMS tended to perform much more reliably in those vehicles to which Echelon had access.

3.5.4 Conclusions

The technical performance of the FareTrans VMS is dominated by four circumstances:

- the rush to deploy, and the failure to appropriately test equipment prior to deployment;[17]
- the failure to ensure appropriate technical knowledge for garage personnel, or to cultivate substantive support from garage personnel;
- the complexity of bus practices; and
- the poor performance of APC equipment and algorithms.

Had VCTC realized the implications of premature deployment, the deployment would most likely have been delayed to permit Echelon Industries to complete additional component and system tests.

Echelon Industries was sensitive to the need to engage garage personnel in the participating agencies, because this was one of the key findings from the previous phase of the FOT (Giuliano and Moore, 1996). However, the strategy Echelon pursued was flawed. Rather than relying on the management authority of the operators participating in the test to

[17] VCTC reports that permitting further delays in the deployment would likely have led to the demise of the project. The agency felt the demonstration had to proceed into the field, despite the technical risks. VCTC felt the risks were acceptable if the alternative was no project at all.

deliver what was needed in the garages, Echelon should have used the need to train these operators' garage staff as an opportunity to cultivate their mechanics' active participation and support.

The inability to overcome the operators' desire for minimal involvement in system maintenance had unfortunate implications for the both the deployment and the evaluation. The evaluation team focused considerable attention on SCAT because, as the largest operator participating in the test, SCAT provided the most efficient opportunity for observation and data collection. Unfortunately, the technical performance observed for the systems installed on the SCAT fleet was undoubtedly suppressed by the difficulty experienced by Echelon Industries and SCAT in establishing effective problem reporting, trouble-shooting, and repair procedures.

The inability to completely automate the centralized data collection scheme for the FOT is a lesson, not a failure. Bus practices are more complex than Echelon Industries understood before the test, even in a relatively small transit property such as SCAT. This constraint could not have been anticipated based on experience in the previous phase of the FOT, because Phase II did not include automatic collection of data. This result has implications for training requirements. The need to keep a technician in the daily transaction data collection loop is one reason Echelon continued to serve as the central data bank during the course of the FOT. This function was never transferred to VCTC.[18] Knowledge currently resident in Echelon would have to be transferred to any authority providing this central data function.

And lastly, the FareTrans VMS automatic passenger counting function could not be successfully demonstrated as part of the FOT. The evaluation team had planned to examine both the raw data collected onboard the bus by the APC sensors and the algorithm Echelon Industries developed to convert these raw counts to estimates of boardings and alightings at bus stops. Echelon was able to provide boarding and alighting estimates corresponding to only a small subset of the field counts made by the evaluation team, but Echelon was usually able to provide electronic evidence that the APC sensors were functioning. Echelon did not provide a summary of the algorithm used to process the data collected by these sensors.

We cannot conclude, however, that automatic passenger counts are infeasible. They sometimes were feasible, but could only be verified on a very limited basis during the FOT. This is an inconclusive result. The automatic passenger counting function of the FareTrans VMS might yet be achieved.

[18] VCTC reports that a transfer of this responsibility was made technically feasible following the demonstration, but that VCTC elected to leave this function with Echelon Industries.

CHAPTER FOUR
USER RESPONSE

4.1 INTRODUCTION

This chapter presents results of our analysis of how transit users have responded to the Smart Passport. The chapter begins with a brief review of findings from the Smart Card Phase II evaluation. We then discuss the general context of public transit in Ventura County, which helps to place our results in perspective. Following sections of the chapter describe Passport card sales and present results from two user surveys. The first was an onboard survey conducted in May 1996. The second was a telephone survey of Smart Passport card purchasers conducted in July and August 1997. Conclusions are presented in the last section.

4.2 SUMMARY OF PHASE II RESULTS

The Smart Card is an entirely new type of fare medium. The Phase II research showed that the response of transit passengers to the Smart Card was overwhelmingly positive. The Phase II evaluation also gave some indication of willingness to purchase cards, experiences with using the cards, and perceptions about Smart Cards.

The Phase II FOT tested two types of Smart Cards: a contact Smart Card that the user swipes through a card reader, and an RF Smart Card, which is read by passing it over a card reader. The objectives of the user survey were to 1) determine willingness to purchase and use Smart Cards, 2) measure satisfaction and attitudes regarding card use, 3) test for differences in responses to the two types of Smart Cards, and 4) test for relationships between social and demographic factors and card use.

The research team conducted an onboard survey of transit patrons on the three transit routes (operated by three different transit agencies) for which cards were offered for sale. The FOT took place in the I-110 corridor, which extends south from downtown Los Angeles. It bears noting that in this FOT, card purchase was not convenient: patrons were required to fill out and mail an application, and then either receive the card in the mail, or go to the downtown Los Angeles Caltrans office to pick it up. Marketing consisted of a one-time distribution of flyers and applications on the participating routes. Despite these circumstances, all available cards for one route were sold out in the second month of the FOT, probably as a result of the deep discounts (75 percent) offered with the cards.

A total of 783 valid responses were obtained from the survey, of which 150 had purchased a Smart Card. Passenger characteristics were quite different across the three routes. One route provides express commuter service, and serves affluent, full-time workers. The second route offers local and express service, and serves many young, moderate-income workers. The third route also offers local and express service, and serves a mainly transit dependent population with a high proportion of Hispanics and other immigrant groups.

Response to the Smart Card was overwhelmingly positive. Nearly all users reported being satisfied or very satisfied with their Smart Card. There were no differences across card types; Smart Card users reported few problems with using the cards, and the problems encountered apparently did not affect satisfaction with the card. Since card users were allowed to ride free when card problems were encountered, this result is expected.

The likelihood of having purchased a card varies with respondent characteristics. Spanish speaking respondents were far less likely to have heard about or purchased a card. Card purchase is also associated with higher household income and full-time employment, as expected, given that the price of a card ranged from $20 to $78, depending on the route and trip length.

4.3 ROLE OF TRANSIT IN VENTURA COUNTY

We described the geography of Ventura County in Chapter Two. We noted that population and jobs are dispersed across the county, and the various population centers are separated by large distances. The low densities and large distances between communities make the county a rather inhospitable place for traditional fixed-route transit. In addition, the County is generally affluent, with pockets of low income population in Oxnard, Ventura, and the agricultural communities in the SR 126 corridor. Recall also from Chapter Two that transit services within the county are limited; the municipal operations offer limited coverage and have generally long headways. VISTA is the connecting intercity service; it too has long headways.

Connections between the various services are constrained both by geography and lack of coordination, as in the examples of Simi Valley and Thousand Oaks. In some areas, actual physical coordination is lacking. For example, although all buses stop on the same side of the Buenaventura Mall, SCAT buses stop at one entrance and VISTA buses stop at another entrance. There is no signage that indicates which buses stop where, so the transit customer must find out in advance where to wait for the appropriate bus. At the Thousand Oaks Mall, the last VISTA 101 bus of the day stops in a different location from the other runs. Again, there is no signage on site that provides this information.

It is not surprising that the journey to work transit mode share in Ventura County is less than one percent. Transit provision is both difficult and costly in an area like Ventura County, and funding constraints no doubt determine how much transit service can be supplied. When transit service is limited, its market is restricted primarily to the transit dependent population – those who do not have access to a private vehicle, or are too young, disabled or old to drive, or who have very low incomes. From our Phase II research we know that Smart Card usage is lower among those with lower incomes. Thus the test of an advanced technology fare media for integrated service took place in an area where transit plays a very minor role in regional mobility, where much of the transit ridership may not be inclined to purchase Smart Cards, and where there is little actual service integration.

4.4 CARD SALES AND USAGE IN VENTURA COUNTY

Project participants anticipated sales of up to 2,000 Smart Cards. Expectations were based on previous sales of the Passport and estimates of the attractiveness of the new debit card option. Sales of the Passport ranged from 78 in the first month of the new service (July 1994) to a high of 355 in July 1995, and then declined through December 1995. (See Figure 4.1). Participating agencies were asked to estimate the number of cards they expected to use or sell; because of the economies involved in purchasing the cards in large lots, agencies were urged to be generous in their estimates. Ultimately, 3,500 cards were ordered for the FOT.

As described in Chapter Two, implementation of the Smart Passport got off to a slow start. Cards were advertised as scheduled in December, but could not yet be bought at many of the designated outlets, and as long as the onboard equipment was not operating, the Smart Cards could not actually be used. The decision was made to go ahead and sell the Smart Cards in January (e.g., retire the plastic Passport and replace it with the Smart Passport), but only as monthly passes. This was seen as a temporary fix, as full operation was expected to take place imminently. When the equipment problems continued to generate delays in February, renewals were handled with color-coded stickers, as with the

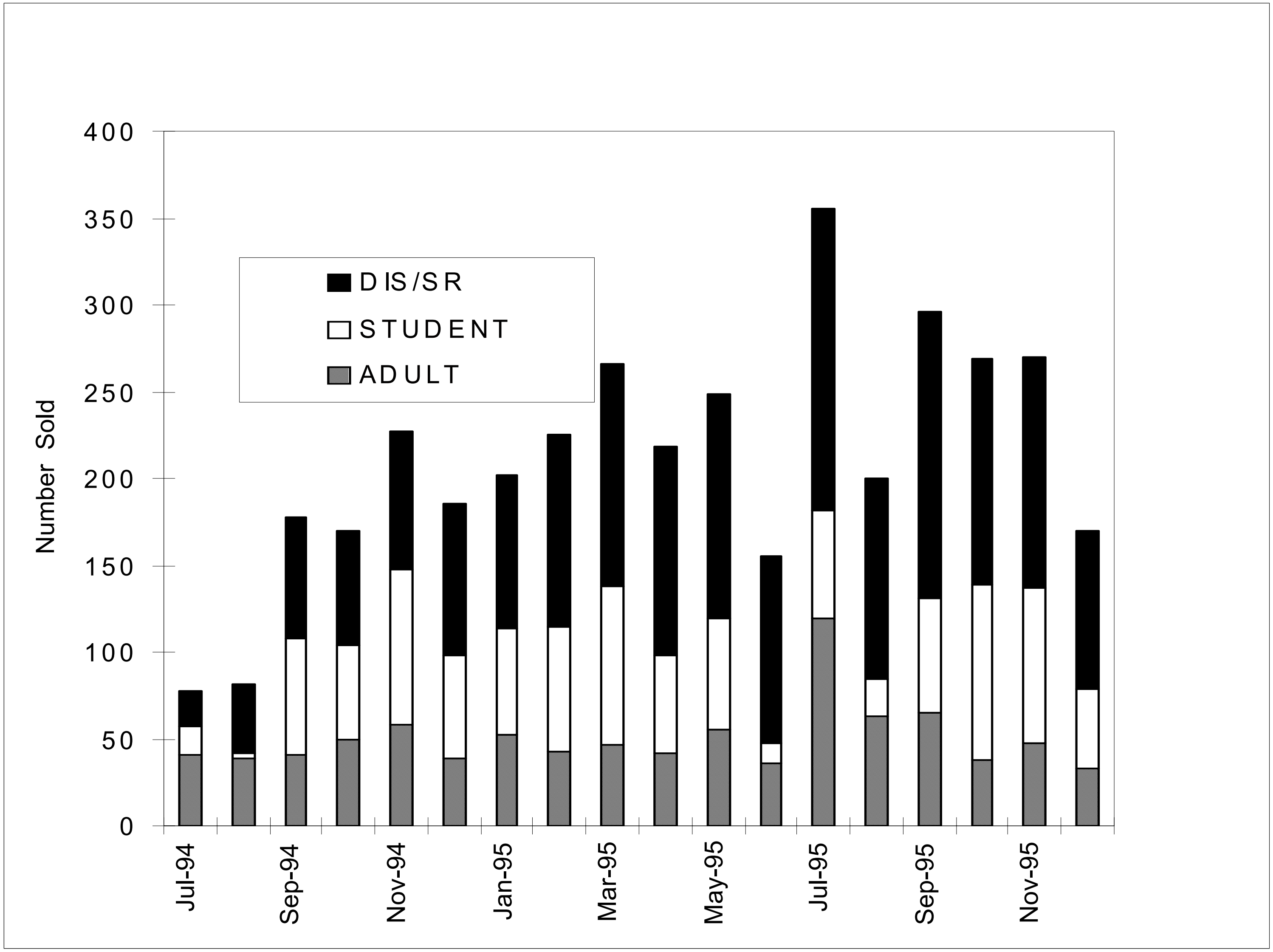


Figure 4.1 Monthly Passport Sales Before Smart Passport

old plastic Passports. Pass holders therefore had to continue to renew their passes by traveling to the transit agency or VCTC offices. Debit cards began to be sold in February by VCTC; this created the problem of how to handle the debit cards on the bus, given that they could not yet be read. The decision was made to allow patrons to use the cards as passes, meaning that these card users were given free transit service until the system became operational. Constantly changing policies regarding use of the card, changes in where cards could be purchased and what kinds of cards could be purchased may have affected card sales during this period.

4.4.1 Trends in Card Sales

A central question for this research is whether the Smart Passport had any effect on transit demand. Did the availability of a new debit card option encourage more people to use transit? Did the convenience of a fare card that could be renewed either on the bus or by telephone encourage more people to use transit? As we noted earlier, it is not possible to determine the effect of the integrated fare, because that was introduced with the new service in 1994. By the time the Smart Passport was introduced, usage of the pass (and the new VISTA service) was already established. Thus the only source of increased demand would be the greater convenience of the debit card and a card that could be renewed in many different ways.

We had intended to use the Faretrans system automated data files to examine usage of the Smart Passport. The customer database logs all card purchases, renewals, replacements, etc. The transaction database logs all card usage and all passenger counts on buses that have APCs. With these data resources, it is theoretically possible to examine such questions as, what is the market share of Passport users, do Passport users take advantage of transfer opportunities between systems, are Passport users concentrated on a few routes, are there differences in the use patterns of debit card holders vs pass holders, etc. Unfortunately, the automated data files proved to be quite unreliable. In the customer database, there were problems of duplicate card entries, test cards, and missing data. In the transaction data file, the major problem was missing data, but detailed checking of some trip sequences also revealed errors in the transactions codes. It therefore proved to be impossible to use the automated data in our analysis of user response. A more detailed discussion of the problems associated with automated data is given in Appendix 4A.

We used the VCTC card sales records to compile monthly sales data for the Smart Passport. These are based on the actual purchases as reported to VCTC from each of the outlet agencies. In the early months, debit card sales were recorded by dollar value, and not always by the number of cards sold. We determined that the average value for a debit card is about $20; we used this average to estimate number of debit cards when the actual number was not given by the reporting agency. Thus our monthly figures are subject to some error. Figure 4.2 gives total Passport sales and recharges, from the beginning of Passport sales in July 1994 through the end of the FOT in June 1997. Lost or replaced cards are not included in the numbers. Smart Passport sales began in January 1996 (noted on figure). The very high number of Passport sales in November 1996 is due to a block purchase of 250 debit cards by Camarillo State Hospital (also noted on figure). These cards were used by patients and caretakers.

With the exception of the Camarillo State Hospital purchase, Passport sales appear to be relatively flat over the period of the Smart Passport. We conducted a simple test of the trend in card sales by estimating two regression lines, one for the period before the introduction of Smart Passport, and one for the period after. Results are given in Table 4-1. As expected, the slope of the trend-line is not significantly different from zero in the period after the introduction of the Smart Passport. We also estimated the same regression removing the Camarillo State Hospital purchase; results are the same and are not shown in the table. These results suggest that introduction of the Smart Passport is not associated with increased purchase of the Passport.

Monthly debit card sales in terms of dollar value are given in Figure 4.3. Debit card sales increase gradually in the early months of sales, and then stabilize in the range of $800 to $1,000 per month, or about 40 to 50 cards per month. Once again, the very notable exception is the Camarillo State Hospital block purchase. Generally, the largest number of debit card purchases is with Antelope Valley Bus Lines, which serves VISTA routes 101 and East. Other larger purchase locations are Thousand Oaks and Camarillo. If total card sales are flat, we surmise that most debit card sales come from previous pass users. The availability of the debit card apparently did not contribute to higher overall Passport sales.

The FareTrans VMS system represents a significant capital investment for transit operators. As we have seen from Chapter Three, the system also requires extensive monitoring, maintenance and repair. It is therefore important to consider its benefits. One measure of benefits is the extent to which transit passengers use the card, e.g. its market

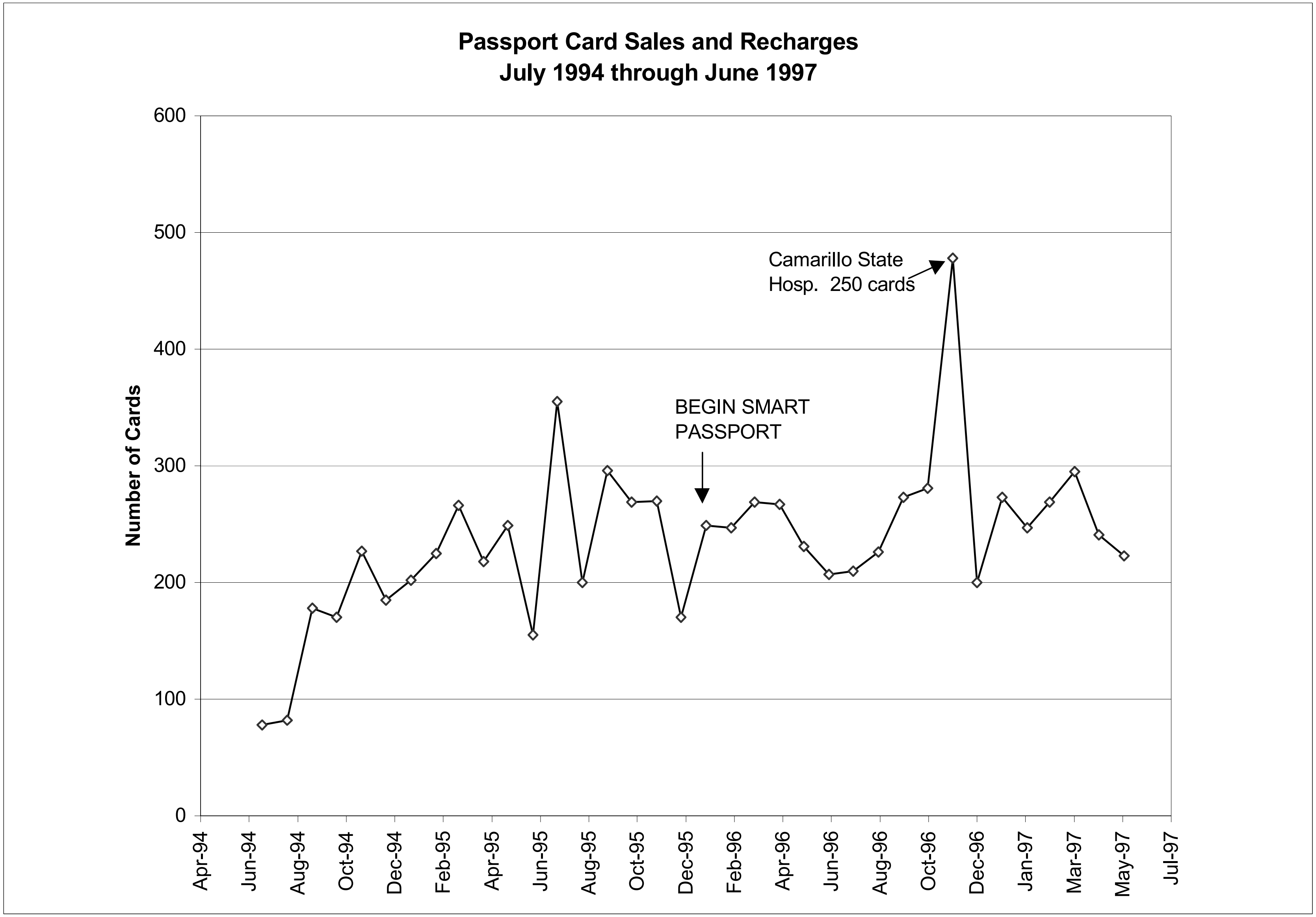


Figure 4.2 Passport Card Sales and Recharges

Table 4-1 Regression Results for Sales Before and After Smart Passport

	slope	t-stat	Sig.
Before Smart Passport	7.93	3.06	<.05
After Smart Passport	1.84	0.67	N/S

share. Unfortunately, we have no accurate means for estimating the market share of the Passport among all transit users. However, a rough approximation is possible. VCTC reports that the number of cards in circulation has remained steady at about 400. If we assume that each Passport user makes 40 trips per month every month, the number of annual Passport trips would be 192,000. Combined annual ridership for all transit systems is about 3.732 million, which implies a market share for the Passport of about five percent. Data from SCAT and VISTA provide some supporting evidence. About 26 percent of VISTA trips are made using the Passport; using the annual ridership data, this implies about 64,000 trips. About 2.7 percent of SCAT trips are made using the Passport, which implies about 78,000 trips. SCAT and VISTA account for 84 percent of all trips, and 142,000 Passport trips. We know that the Passport share is somewhere between these two extremes for all other transit operators. Thus a five percent share for the total county seems reasonable.

4.4.2 Interpreting Sales Trends

Why did the Smart Passport not attract more users? Possible explanations include transit service characteristics, incentives provided by the fare structures of each transit agency, and relative importance of the convenience of using the Smart Passport. As noted earlier, the geography of Ventura County does not lend itself to service integration. The municipal systems provide very localized service, and the communities they serve are dispersed across a large area. VISTA provides the connecting service, but there are relatively few opportunities for transfers between VISTA and other services. VISTA service is further limited by long headways and the long distances between communities it serves. Therefore the market for these services is limited.

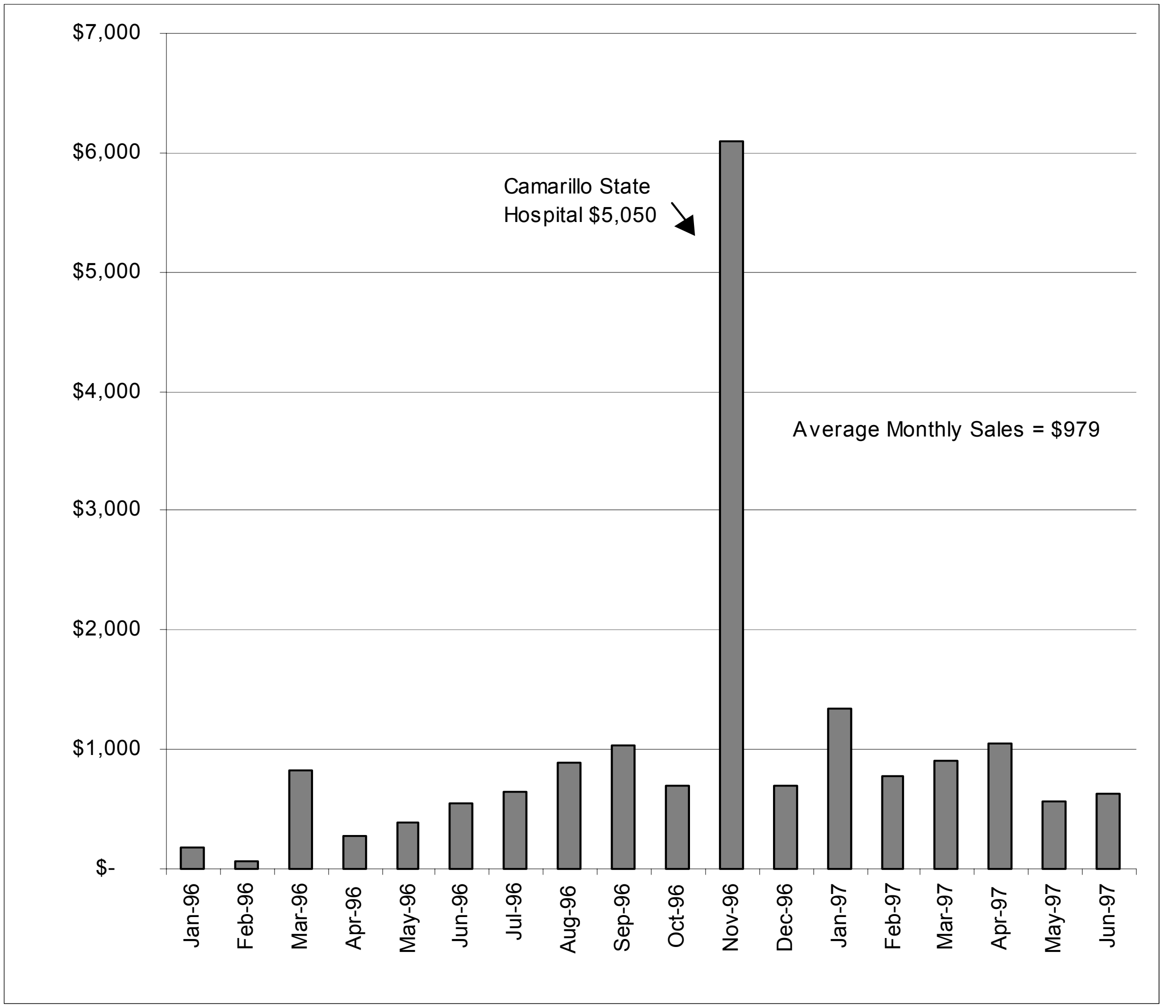


Figure 4.3 Debit Card Sales, in Dollar Value

Chapter Two described the fare structures of the participating agencies, relative to the Smart Passport. With few exceptions, paying the local transit agency fare is more economical than the Smart Passport. Not surprisingly, then, the Passport is used mainly for VISTA services. That is, the share of patrons who use the Smart Passport is highest for VISTA services. SCAT sells the next largest number of Passports, but this number represents a very tiny share of total SCAT patrons. Finally, the convenience of a Smart Passport is not likely to be a deciding factor in mode choice. An extensive literature demonstrates that the primary factors affecting mode choice are cost, travel time, and access to a private automobile; secondary factors include convenience (access to transit stops, etc.) and personal safety considerations. We turn now to our survey research.

4.5 USER RESPONSE

From the point of view of the user, Phase III differed from Phase II in the following ways: 1) cards could be used on any Ventura County fixed route service (in addition to the VISTA DAR services), rather than one specific service, 2) both monthly pass and debit cards were available for purchase, 3) cards could be purchased at many locations throughout the County, 4) cards could be renewed at both card purchase outlets and on the bus (except for SCAT), 5) the Smart Passport replaced a pre-existing monthly pass, and 6) the Smart Card Passport was available for several months during the FOT, and eventually became a permanent part of Ventura County transit operations.

The purpose of the Phase III research is to build on, but not duplicate the results generated by the Phase II research. The research team therefore expected widespread satisfaction among those using the Smart Cards, but anticipated that the longer duration and greater complexity of the field test would lead to many more card malfunction experiences. The analysis of Smart Card users has the following objectives:

- verify positive perceptions of the Smart Card under very different operating conditions,
- verify the potential market for Smart Cards,
- examine experiences using the Smart Card and encountering problems,
- examine the extent to which travelers use the Smart Card as an integrated fare medium, and
- examine differences in demographic and socio-economic characteristics and their relationship to use and perception of the Smart Card.

Because we wanted to maintain as much comparability as possible to the previous Smart Card research, we asked some of the same questions in all surveys, and utilized similar survey techniques for one of the Phase III surveys.

We conducted two user surveys over the course of the FOT to determine response to the Passport by transit users. The first survey was conducted in May 1996. At that time, the FOT was scheduled to end in December 1996; May was the latest possible time to conduct a survey and avoid the summer season, given the evaluation schedule at the time. Consequently, the survey took place only shortly after the system became fully operational. The extension of the FOT to June 1997 made it possible to conduct a second survey. Using the automated customer database, we were able to conduct a more detailed survey of Passport users. This section presents results of the two user surveys.

4.5.1 The May 1996 Survey

The May 1996 survey had the following objectives:

- examine experiences in buying, using, and renewing the Passport
- identify factors associated with Passport purchase and use,
- determine relationships between social and demographic characteristics and response to the Passport, and
- evaluate overall satisfaction with Passport,

Given that relatively few Passports were in circulation and we did not have access to the Customer Database at the time of the survey, we knew that including a sufficient number of Passport users in the survey would be difficult. The only viable possibility was an onboard survey targeting the transit routes with the heaviest Passport use. We examined ridership volumes on the largest systems (SCAT, VISTA, Simi Valley), and we discussed the extent of card use with the transit operators. SCAT has by far the greatest daily ridership, but at the time had relatively few Passport users. The survey was pilot-tested on SCAT, and we encountered very few Passport users during the pilot test. We therefore chose to survey VISTA routes 101 and 126, as these routes had the highest ridership within the VISTA services.

The onboard survey was conducted by members of the USC evaluation team. Two-person teams distributed and collected surveys on peak period bus runs for the two routes on one day (May 21, 1996). Since most passengers make round trips, we decided to cover one route in the morning and the other in the afternoon. Completed surveys were logged by route, bus run, and team. Every effort was made to persuade passengers to complete the survey, and in some instances team members assisted by reading questions and filling out the survey (some passengers could not read or write). Table 4-2 gives the distribution of completed surveys by route and bus run. Of the 193 surveys distributed, 173 completed surveys were obtained, giving a response rate of about 90 percent.

4.5.1.1 Survey instrument

The survey instrument was designed as a small six page booklet composed of three 8.5" X 11" sheets of paper folded width-wise. The survey had to be short and easy to complete so that passengers could finish them while onboard. The survey was written in

Table 4-2 Completed Surveys by Route and Bus Run

Route	Direction	Departure Time	Surveys Distributed	Surveys Complete d
VISTA 126	Westbound	6:00 AM 6:52 AM 8:00 AM 9:00 AM	21 34 22 10	19 34 15 10
	Eastbound	7:00 AM 8:00 AM 9:00 AM	11 4 5	9 3 5
VISTA 101	Northbound	2:05 PM 3:10 PM 4:15 PM 5:05 PM	12 6 5 8	11 5 5 8
	Southboun d	2:05 PM 3:05 PM 4:05 PM 5:15 PM 6:16 PM	12 25 5 13 0	10 24 2 13 0

both Spanish and English, with questions in each language on facing pages. See Appendix 4B for a copy of the survey. It consists of the following parts:

- Transit ridership: information on current trip, frequency of travel by transit, type of fare
- Screening: distinguish Passport users and non-users
- Attitudes: information on perceptions of Smart Card technology
- Card use: information of experiences and problems with Passport use
- Demographic: basic characteristics of respondents

There were some important constraints on the value of the information we could obtain in this survey. First, because the plastic monthly pass was known as the Passport, there was no way to distinguish the Smart Card Passport from the previous Passport. Retrospective information on card use could refer to either of the card types. Second, because none of these routes have heavy ridership, we knew that our sample would inevitably be small, and the number of Passport users would be particularly small. Third, these routes are not necessarily representative of Ventura County transit users.

4.5.1.2 Survey results

Seventy-five percent of the surveys were completed in English. Survey respondents were equally distributed by gender. Respondent characteristics indicate a transit-dependent population: a large proportion (41 percent) of students, very low household incomes (the median interval is $20,000 - $29,000; 1989 median household income in Ventura County is $45,612), and many respondents having no driver's license. Key characteristics are given in Table 4-3. Note that there is substantial missing information for some variables; some respondents had great difficulty answering even the simplest questions. A complete list of variable frequencies is available in Appendix 4C.

Respondents are regular transit users, and are generally making non-discretionary trips (to or from work or school). Figure 4.4 shows that the vast majority use the bus three or more times a week, and 91 percent usually use the bus for "this trip."

As expected, few respondents (38, or 22 percent) used a Passport for their fare; the remainder used cash. Of those using a Passport, 75 percent used a monthly pass, and the rest used a debit card. Of those who used cash, 20 percent reported having bought a Passport sometime in the past. As noted earlier, this could have been the plastic Passport or the Smart Card Passport.

Our previous research indicated that Spanish speakers were less likely to have purchased Smart Cards (Giuliano and Moore, 1996). We suggested that Spanish speakers are likely to have low incomes, and therefore the purchase price of the card may create a barrier. In addition, Spanish speakers may be less aware of the availability of the Passport, or may be less inclined to try using it, despite Spanish language marketing efforts. We conducted cross-tabulation tests of Passport use and Passport purchase with language. Passport use is indicated by the response to how fare was paid. For Passport usage, we include all respondents who either used a Passport to pay their fare or who stated that they had purchased a Passport previously (a total of 64 respondents). We also performed cross-tabulations for household income, using a simple bivariate variable of either above or below $20,000. Results are given in Table 4-4. Spanish speakers are significantly less likely to have used or ever purchased the Passport. Use and purchase of the Passport is also related to income. (We conducted similar tests using as our cutoff $30,000; results are the same and are not shown in the table).

Table 4-3 Characteristics of Respondents

Variable	Percent	N
AGE		
15 or younger	14.1	
16 - 24	30.1	
25 - 64	47.2	
65 or older	8.6	163
OCCUPATION		
student	41.0	
full-time employed	36.6	
part-time employed	11.2	
Other	11.2	161
INCOME		
less than $9,000	21.7	
$9,000 - $14,999	18.8	
$15,000 - $19,999	5.9	
$20,000 - $29,999	10.0	
$30,000 - $39,999	14.9	
$40,000 or more	28.7	101
DRIVER'S LICENSE (age 16 or older only)		
yes	54.6	108
no	45.4	

It is also possible that people who use other card media would be more inclined to use the Passport. We therefore asked respondents whether they had an ATM card or a credit card. Of those who answered, 33 percent had a credit card and 43 percent had an ATM card. Among Passport users or purchasers, 37 percent had a credit card and 48 percent had an ATM card; these differences are not statistically significant.

Why don't people buy Passports? Respondents were asked to identify all that apply from a list of seven items. Results are given in Table 4-5. Those who had never bought a Passport most frequently stated that they did not know about them, or didn't know where to purchase them. Those who do not know about the Passport of course do not know whether it is inconvenient to buy, too much money, etc. Once again, we test for differences across languages. Note that lack of awareness of the Passport is significantly greater among Spanish speakers. Spanish speakers have less access to the media generally, so a greater lack of awareness is not unexpected.

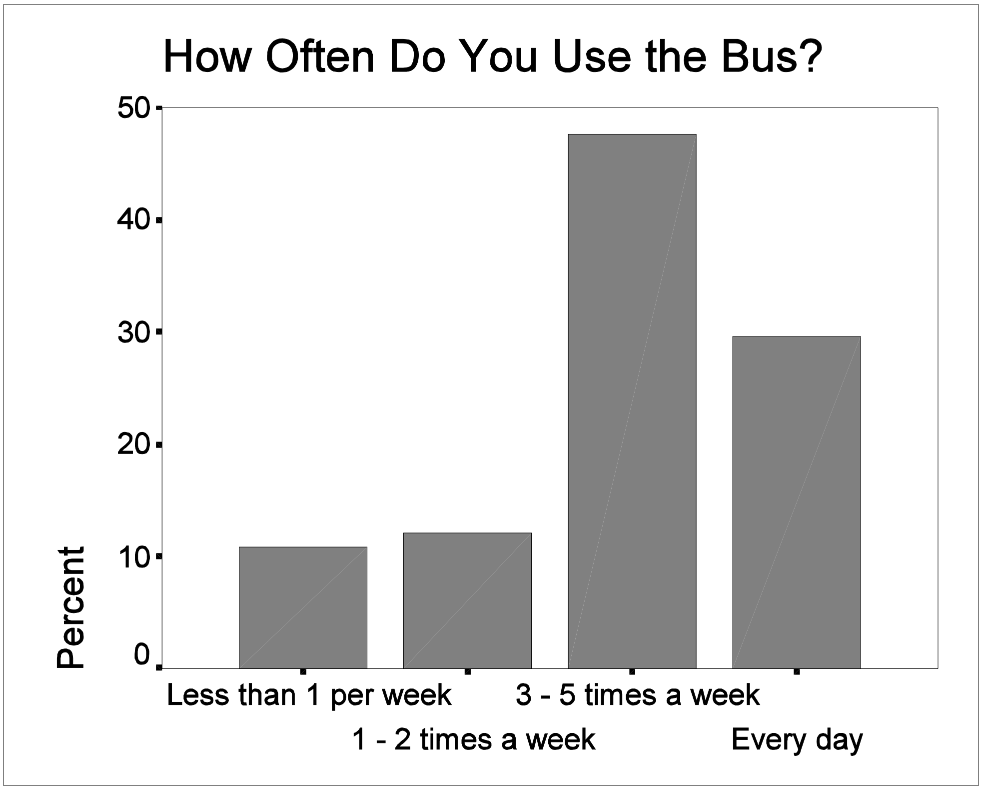


Figure 4.4 How Often Do You Use the Bus?

Table 4-4 Passport Use and Purchase vs. Language, Income

LANGUAGE	English	Spanish	Total	Sig.[a]
Share using Passport for this trip	28.3%	4.9%	22.6%	.000
Share having purchased or used Passport	42.5%	22.0%	37.5%	.010
INCOME	> $20K	< $20K		
Share using Passport for this trip	32.1%	15.2%	24.2%	.042
Sharing having purchased or used Passport	45.3%	28.3%	37.4%	.074

[a] Based on Kendall's Tau-b

Table 4-5 Why Have You Never Bought a Passport

	All	English	Spanish	Sig[a]
Don't know about them	48.5%	42.5%	63.3%	.051
Don't know where to buy them	28.6%	26.0%	36.7%	N/S
Don't need/don't use bus often	22.6%	20.8%	26.7%	N/S
Don't know what they cost	21.0%	20.5%	23.3%	N/S
Not convenient to buy	15.2%	16.4%	13.3%	N/S
Too much money to spend at once	11.7%	12.3%	10.0%	N/S
Other reason	9.5%	12.3%	3.3%	.079
N	103	73	30	

[a] Based on Kendall's Tau-b

As noted previously, 38 respondents used the Passport on "this trip," and an additional 26 respondents reported having purchased a Passport, but did not use it on "this trip." We asked how respondents renewed their cards. Of the 49 who had renewed their Passport, 32 renewed in person at an outlet office, 12 renewed on the bus, and one renewed by mail. No renewals were made by telephone or email.

Respondents were asked why they use a Passport; results are given in Table 4-6. Once again, they were asked to mark all that apply. The Passport is seen as being a good value, easy to use, and allowing one to pay the fare without carrying the exact change. Fewer Passport users cite the advantage of using the Passport on any bus, probably because relatively few riders actually transfer between different bus services. Less than one quarter of users cite the convenience of buying and renewing the Passport.

Finally, respondents were asked about their satisfaction with the Passport, and any problems they may have experienced when using the Passport. Overall, our 64 respondents who were using or had used the Passport were satisfied: 76.5 percent were either very satisfied or satisfied. We compared satisfaction levels between current and previous users. Current users express a higher level of satisfaction than previous users (80 percent vs 68.8 percent very satisfied or satisfied), but the difference is not statistically significant.

Table 4-6 Why Do You Use a Passport

Reason	Percent
Good value	50.0%
Easy to use	46.8%
Don't have to carry exact change	43.8%
Can use on any bus in County	35.9%
Easy to buy and renew	23.4%

Responses regarding Passport card problems were limited. Card problems were more prevalent among current users than previous users (21 of 34 – 62 percent – of current users who responded vs. five of 18 previous users who responded). More problems among current users is consistent with the higher potential for failures of various sorts with the Smart Passport relative to the monthly plastic pass, and with the many problems encountered in the early months of the FOT. We compared satisfaction levels between the two groups, and results are shown in Figure 4.5. None of those who reported no problem were "very unsatisfied," whereas 21 percent of those who reported having a problem were "very unsatisfied." The difference in levels of satisfaction across these two groups is significant, but due to the very small numbers involved and low response rate (especially among previous users), these results are only suggestive.

4.5.1.3 Summary of Survey 1 results

Our onboard survey of VISTA passengers indicates a highly transit-dependent population: reported household incomes are low, and a large proportion of respondents do not have a driver's license. Most respondents are regular users of transit, and most were making non-discretionary trips. As anticipated, Spanish speakers and those with very low income are less likely to use the Passport. Spanish speakers are more likely to be unaware of the availability of the Passport. The evaluation team encountered several respondents who could not read or write, hence lack of awareness is not surprising. Satisfaction with the Passport is very high among those who use it, although those who encountered problems with the card were somewhat less satisfied than those who did not encounter problems.

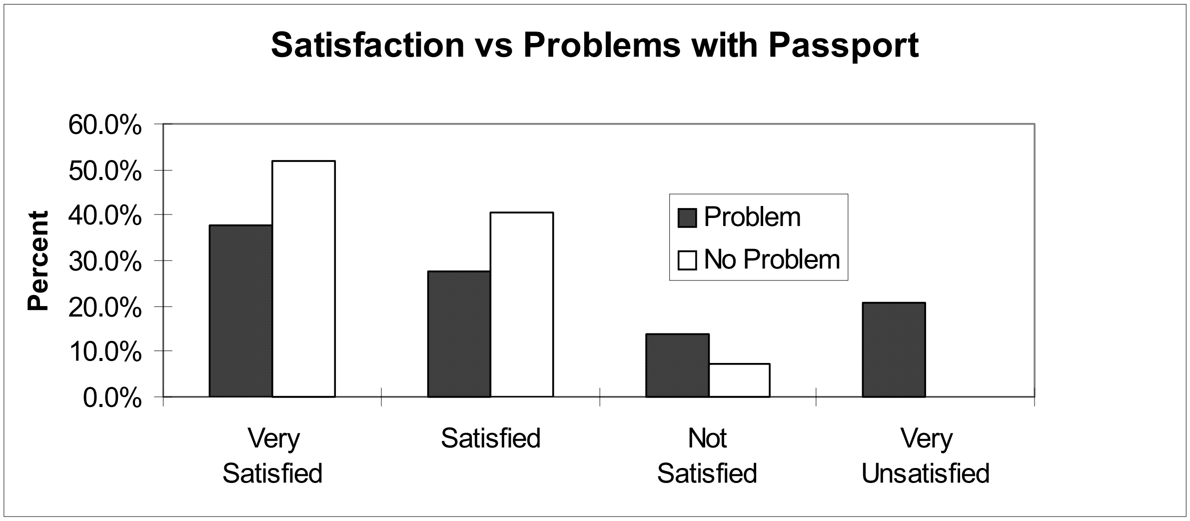


Figure 4.5 Satisfaction vs Problems with Passport

4.5.2 The July 1997 Survey

The extension of the FOT to June 1997 and the decision by VCTC and the participating operators to make the system permanent made it possible to conduct a second survey of Smart Passport users. A second survey would provide information on experiences and perceptions of the Passport after several months of relatively steady state, problem-free operation. In addition we were interested in examining the travel characteristics of Passport users, and whether the Passport had any effect on transit use (e.g., more transfers between bus systems, more transit trips). Given that we had access to the automated passenger count data, we initially planned to match up responses to the survey with the respondent's Passport use. We would then be able to compare responses regarding transit ridership to observed behavior. As explained earlier, however, the automated data was incomplete, and this approach proved to be infeasible.

4.5.2.1 The telephone sample and survey

The evaluation team was provided with a copy of the Customer Database, which made it possible to conduct a telephone survey. The survey was conducted by a subcontractor, Strategic Consulting and Research, Inc. Once again, the survey was written in English and Spanish. The survey was pre-tested in mid-July. We included questions pertaining to the respondent's last three trips in the pre-test. Our intent was to determine whether card users transfer more between services. However, few respondents were able to answer these questions, and they were consequently deleted. They were replaced with three very simple questions regarding the effect of the Passport on the respondent's use of transit. The survey was completed on August 12, 1997. The evaluation team had no alternative but to conduct the survey in the summer as a result of delays in accessing the Customer Database, from which the sample was drawn. This is not a serious problem, since respondents were being drawn from a pre-existing file; rather, the response rate was likely somewhat depressed because of the greater likelihood of people not being at home during the summer.

The survey consultant was provided a list of 960 names and telephone numbers, essentially the entire Passport customer file, after cleaning the file for duplicate names, corporate cards, etc. Of these numbers, 615 turned out to be valid. There were 306 ineligible numbers (disconnected, moved, fax, etc.), and 39 respondents spoke only Chinese or Vietnamese. Of the 615 valid numbers, 96 were never reached during the survey time frame. Thus 519 respondents were actually reached, from which 370 completed, valid surveys were obtained, yielding a response rate of 60 percent. The remainder (149) either refused to participate, did not speak English or Spanish, could not be called back, or had not ever purchased a Passport.

The survey included questions on the following topics:

- Screening questions to verify Passport use,
- Card purchase, use and renewal,
- Transit use,
- Attitudes and perceptions of the Passport, and
- Demographic information.

A copy of the English version of the survey is located in Appendix 4D, and a list of variable frequencies is located in Appendix 4E.

4.5.2.2 Survey results

Our sample includes both current and previous Passport users: 53.8 percent report currently having a Passport, and 46.2 percent report having had a Passport at sometime in the past. There were more female respondents (54.1 percent) than male respondents (45.9 percent). Just 29 (7 percent) of the surveys were completed in Spanish. As with the previous survey, respondent characteristics indicate a transit dependent population: 17.6 percent are children, almost half are students, and more than half do not have a driver's license (Table 4-7). The median income interval is $15,000 - $19,999, even lower than that

Table 4-7 Characteristics of Respondents - July 1997 Survey

Variable	Percent	N
AGE		
15 or younger	17.6	
16 - 24	35.1	
25 - 64	40.6	
65 or older	6.7	370
OCCUPATION		
student	49.2	
full-time employed	22.4	
part-time employed	13.2	
Other	15.1	370
INCOME		
less than $9,000	32.9	
$9,000 - $14,999	16.7	
$15,000 - $19,999	9.3	
$20,000 - $29,999	11.1	
$30,000 - $39,999	6.5	
$40,000 or more	23.6	216
DRIVER'S LICENSE (age 16 or older only)		
yes	44.9	305
no	55.1	

of our onboard survey. We thought that a number of young people may have reported their own income rather than that of the household. However, most children (80 percent) did not answer this question. The majority of older persons reported incomes in the two lowest categories, and a substantial number (of those who responded) in all age categories also reported incomes in the two lowest categories.

As expected, current Passport users are regular transit riders (see Figure 4.6), and use transit mainly for non-discretionary travel: work or school accounts for 77.5 percent of all trips, with the remainder for other purposes (note that this question asked for the primary trip purpose when using the bus, so trips to home would not be included).

Current Passport holders were asked about the type of card they used; 53.5 percent had some type of pass, and the remainder had debit cards. Passport holders were asked how long ago they first bought the Passport and whether they were still using the card. The mean response regarding original purchase was 12 months, and the range was from two weeks to two years ago. Eighty percent of current holders state that they still use their Passport. Of those who have a Passport but are not using it, the most frequent reason given for not using the card is that it needs to be recharged. Reasons for not using the Passport are shown in Figure 4.7.

Current holders were asked where they first bought the Passport; results are shown in Figure 4.8. They were also asked about the transit service they use most frequently. The most frequently used service is VISTA (38.6 percent), followed by SCAT (18.5 percent). Simi Valley, Thousand Oaks, Fillmore, and Santa Paula each account for seven to eight percent, with Moorpark and Camarillo each at five percent. These results are consistent with the Passport card sales data (see Section 4.3).

We compared where Passport users purchased their card with the transit system they used most frequently. About 57 percent bought the card at the transit system they used most frequently. The notable exception is VISTA, where just 10 percent of those who use VISTA most frequently bought their Passport at VCTC. This is reasonable, given that VISTA is an intercity service, and for many passengers an outlet closer to home is more convenient than the VCTC offices in Ventura.

4.5.2.2.1 Comparisons of pass users and debit card users

Type of Passport (monthly pass or debit card) varies by the transit system the respondent uses most frequently. Those who use Simi Valley, SCAT, Fillmore or Santa Paula most frequently have monthly passes, whereas those who use Moorpark, Thousand Oaks or VISTA most frequently are more likely to use debit cards. Camarillo patrons have equal numbers of each type of Passport.[19] Some of these differences are consistent with agency fares, but others are not. For example, there is no other pass alternative for Fillmore and Santa Paula, and the Passport pass is cheaper than the Simi Valley pass. On the other hand, SCAT passes are cheaper than Passport passes. Nor is there any relationship between the transit service the respondent uses most frequently and frequency of transit use. That is, greater use of passes for Simi Valley, SCAT, Fillmore, and Santa Paula is not due to more frequent transit trips. Note that our survey information pertains only to those who are using Passports; we have no information on market share. We cannot draw any conclusions regarding why Passport users have chosen the Passport rather than other fare media.

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[19]Differences between groups significant at $p < .000$, using Kendall's Tau-b.

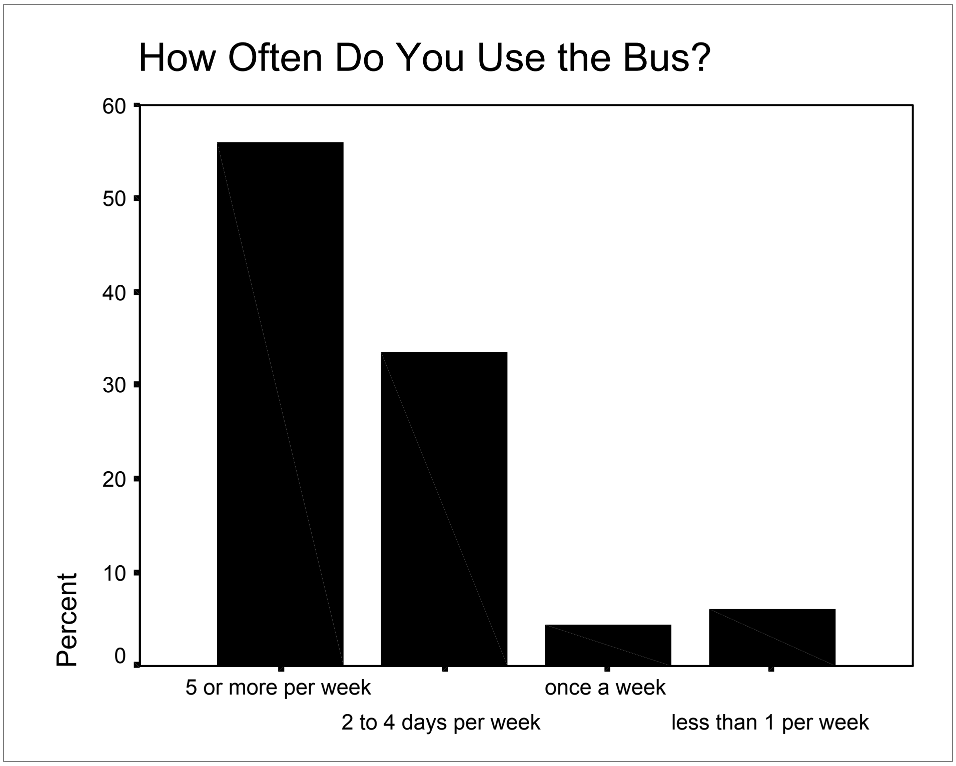

Figure 4.6 How Often Do You Use the Bus?

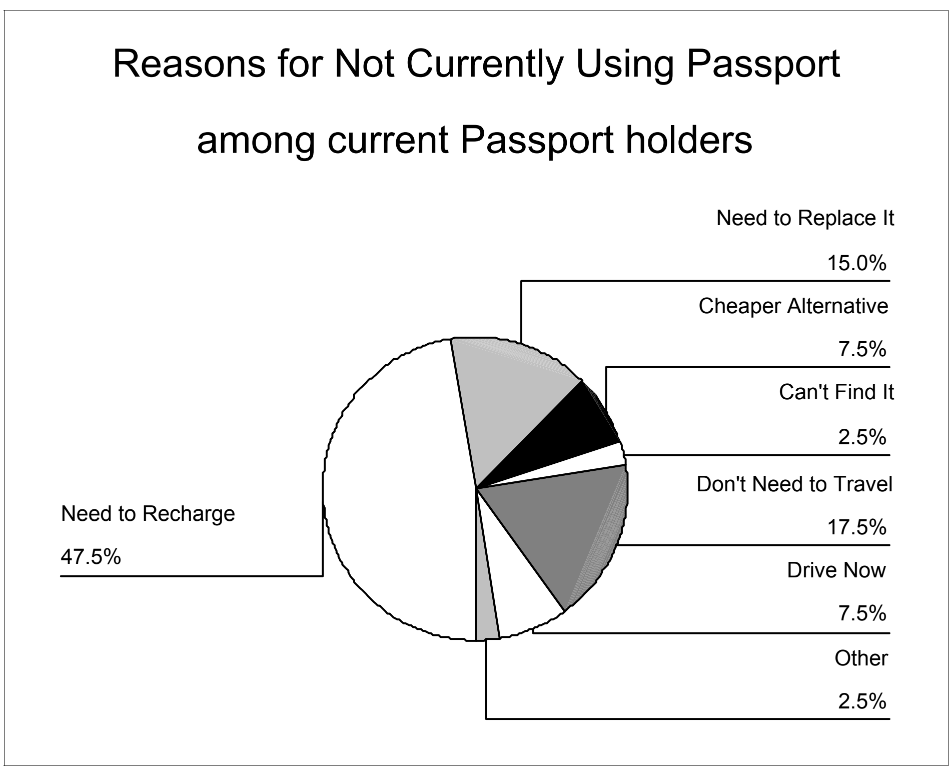

Figure 4.7 Reasons for Not Currently Using Passport among Current Passport Holders

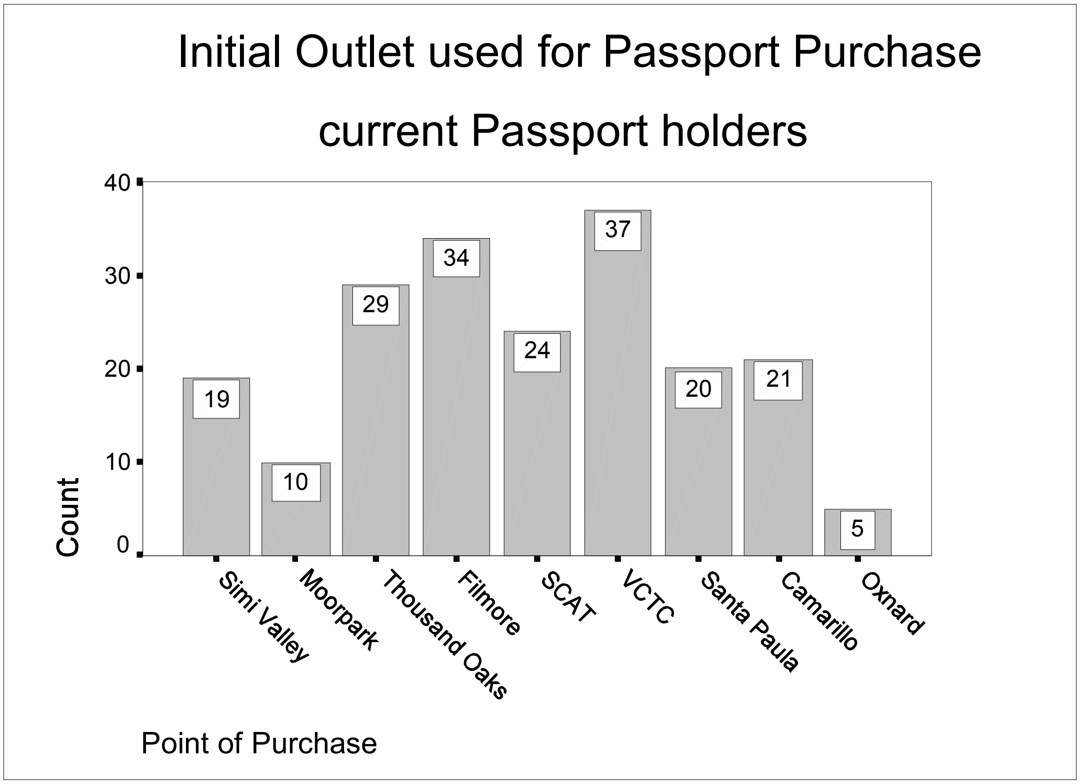

Figure 4.8 Initial Outlet Used for Passport Purchase

Although the debit card was a new addition to the Passport when it was converted to the Smart Passport, the mean time since original purchase for the cards is quite similar: 12.4 months for the pass and 11.4 months for the debit card. It is possible that this result is simply an artifact of the way our sample was drawn: the earlier the original purchase, the less likely the individual would be in the sample, given the possibility for changes in residence location, telephone numbers, etc. In addition, we surmise that Passport use has a turnover rate similar to that of transit use in general, so earlier purchasers would be less likely to be current users than later purchasers. Those who were no longer using a Passport were asked when they had purchased their Passport and when they had stopped using it. Unfortunately, virtually none of these respondents were able to answer these questions, so we have no means for testing this idea.

Both pass and debit card users are quite habitual in renewing their cards, with 83 percent and 72 percent, respectively, reporting that they always renew their Passport at the same place. However, there are differences in where the Passports are renewed, as shown in Table 4-8. Consistent with our onboard survey, Passport users rarely renew by

Table 4-8 Where Did You Last Renew Your Passport?

	Percent within group[a]	
	Monthly Pass	Debit
At an outlet location	80.4%	53.8%
On the bus	16.8%	26.9%
By telephone	9.0%	1.1%
I have not renewed	1.9%	18.3%
N	107	93

[a] Differences between groups significant at $p < .000$, based on Kendall's Tau-b

telephone.[20] Debit card users are more likely to renew on the bus. Since debit cards can be purchased for as little as $10, it is reasonable that more renewals would take place on the bus. It is unclear why such a large share of debit card users have not renewed their cards, given that the mean time since original purchase is close to one year. One possible explanation is that debit card holders are less frequent bus travelers. This proved to be the case. There are significant differences in reported frequency of bus usage: 66.4 percent of monthly pass users use the bus five or more days per week, compared to 44.1 percent of debit card users, and 24.3 percent of monthly pass users use the bus two to four days per week compared to 44.1 percent of debit card users.[21]

Passport users were also asked whether they had ever used the other type of card. That is, monthly pass users were asked whether they had used a debit card, and debit card users were asked if they had used a monthly pass. Just 7.5 percent of monthly pass users had previously used a debit card, but 40.4 percent of debit card users had previously used a monthly pass. This is also consistent with the more recent availability of the debit card, and with the observed flat total sales of Passports since early 1996. Those who had switched from monthly pass to debit card were asked an open-ended question regarding why they switched. We grouped responses into the following categories: ease of use (e.g., easier to

[20] The option of renewing by telephone was not available for the entire duration of the DOT.

[21] Differences between groups significant at $p < .003$, based on Kendall's Tau-b.

carry than cash, more convenient, don't have to have exact change; 41.7 percent), less frequent bus use (e.g., not using the bus as much, don't ride bus a lot, didn't use monthly pass enough; 30.6 percent), and the debit card is less costly (e.g., it was cheaper, monthly pass got expensive, cheaper for me; 25.0 percent).

Finally, Passport users were asked how they usually paid their fare before they used a Passport. The vast majority of both monthly pass users and debit card users used cash (84.1 percent and 74.2 percent, respectively). Consistent with the information on switching from one type of Passport to another, 9.7 percent of debit card users reported previously using a monthly pass for their fare.

We also examined whether the type of Passport used is related to individual characteristics. Results are given in Table 4-9. All of the individual characteristics are significantly related to the type of Passport owned. Females are more likely to use the pass, and males are more likely to use the debit card. Younger people (especially students) are more likely to use the debit card, while older people are somewhat more likely to use passes. Those who are either employed part-time or not employed ("other" includes retired) are also more likely to use passes. Similar results are obtained when comparing trip purpose and type of Passport; debit cards are more likely to be used for school trips, while passes are more likely to be used for work and other trips (not shown in Table 4.9). Among income categories, passes are more prevalent among those in the lowest and highest income categories. These results suggest that the two types of Passports appeal to quite different markets, and different travel preferences are reflected in basic demographic characteristics, assuming that all respondents are purchasing Passports themselves.[22]

4.5.2.2.2 Attitudes and experiences with the Passport

As in the previous surveys, Passport users are overwhelmingly satisfied, with 83 percent reporting being "very satisfied" with the Smart Passport card. We compared level of satisfaction across the two types of cards. Just five (of 93) debit card users stated they were "somewhat dissatisfied", while none of the monthly pass users were somewhat dissatisfied

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[22] Some Passports were purchased by public agencies for third parties, as in the example of the Camarillo Hospital debit cards. Every effort was made to remove such cards from the survey file, but given the condition of the data base, it is possible that some such card users were included in the survey.

Table 4-9 Passport Type and Respondent Characteristics

	Percent within Group		
	Monthly Pass	Debit	Sig.[a]
GENDER			
Male	33.6	52.7	
Female	66.4	47.3	.006
AGE			
15 or under	15.0	16.1	
16 - 24	27.1	39.8	
25 - 34	14.0	10.8	
35 - 49	22.4	16.1	
50- 64	10.3	12.9	
65 or older	11.2	4.3	.100
OCCUPATION			
Student	36.4	57.0	
Full-time employed	23.4	24.7	
Part-time employed	21.5	7.5	
Other	18.7	10.7	.001
INCOME			
Less than $9,000	44.4	24.6	
$9,000 - $14,999	14.3	14.8	
$15,000 - $19,999	9.5	9.8	
$20,000 - $29,999	11.1	4.9	
$30,000 - $39,999	4.8	6.6	
$40,000 or more	15.9	39.3	.002

[a] Based on Kendall's Tau-b

(no one was "very dissatisfied'). A somewhat higher percentage of pass users were "very satisfied" (87 percent vs 79 percent), but these differences are not statistically significant.[23]

Respondents were asked their opinion of the Passport on five items; these are the same items shown in Table 4.6 from the onboard survey. Recall that the onboard survey asked, "why do you use a Passport," and the respondent could mark all that apply, so the questions are not exactly comparable. Results are given in Table 4-10. There were no significant differences across card types. Once again, we observe a very high level of satisfaction with the Passport. Note that fewer respondents agree that it is useful because it

[23] Kendall's Tau-b significance level: p<.122.

Table 4-10 Opinion of the Smart Passport

	Percent answering yes
Good value	97.5%
Easy to use	98.0%
Don't have to carry money	96.0%
Can use on any bus in County	83.0%
Easy to buy and renew	90.5%

can be used on any bus in the County. As noted earlier, this likely reflects the limited opportunities for using multiple services in the County.

Problems with the cards are common; 73 percent of pass users and 82 percent of debit card users reported that they have had a problem with the card reader reading their card. This is of course a very large percentage, but it is consistent with the extent of equipment problems documented in Chapter Three.[24] The driver's most common response was to allow the person to ride free (76 percent of all responses). In only four cases was the person required to pay for the trip. There was no difference in responses to problems across card types. It appears that problems with the cards have few adverse consequences for users, hence it is reasonable that Passport users are very satisfied with the cards despite the high rate of problems.

A major question is whether the greater convenience of an integrated and automated fare medium promotes transit ridership. We had no direct way of testing whether use of the Passport results in more transit use, save our comparison of card sales before and after introduction of the Smart Passport. We therefore simply asked Passport users a series of three questions: 1) do you travel by bus more frequently; 2) do you travel by bus to new places; and 3) do you use bus routes that you did not use before as a result of having a Smart Passport? Responses are of course very subjective. Results are given in Table 4-11. The majority of Passport users state that they make more frequent bus trips

[24] In the Phase II FOT, about 40 percent of respondents reported a problem with reading their card. One could argue that since the cards were circulating for a longer period of time in Phase III, the problem rate may not have been very different between the two phases.

than before. As would be expected, the percentage is higher among pass users. There is a significant

Table 4-11 Impact of Passport on Transit Use

	Percent answering "true"		
Now that I have a Smart Passport...	Pass	Debit	Sig.[a]
I make more frequent bus trips than before	65.4%	52.7%	.120
I make trips to new places by bus	55.1%	35.5%	.007
I use bus routes that I did not use before	49.5%	47.3%	N/S

[a] Based on Kendall's Tau-b

difference between pass users and debit card users on making trips to new places. The incremental cost of additional trips is zero for pass users. Recalling that passes are used more by older people, women, and those who are part-time or not employed, using passes for "new trips" is consistent with more discretionary trip making. Finally, slightly under half of the respondents report that they use bus routes that they have not used before.

Can we conclude that the Smart Passport has resulted in more transit ridership? First, a monthly pass, smart or not, promotes additional trips, so to the extent that transit riders buy more passes, they will make more trips. Second, we do not know the prior circumstances of the respondent. He or she may have bought the Passport because of a new job, or going to a new school. In this case, the Passport did not stimulate more transit use, but rather is the result of engaging in a new activity. The only way to determine whether the Passport stimulated transit use would be to evaluate ridership data over time. If total ridership increases, and this increase is explained by Passport trips, we could conclude that the Passport contributed significantly to transit use. As noted earlier, however, reliable data on Passport trip-making are not available.

4.5.2.2.3 Former Passport users

Of the 370 valid responses, 170 (42 percent) reported that they no longer had a Smart Passport. We asked why they discontinued using the Passport; reasons are listed in Table 4-12. The most frequent answer was, "stopped using the bus," followed by changes in occupation status, car access, and the price of buying the card. These results are quite consistent with our interpretation of the survey results above. There is a lot of turnover of transit users; just as some people likely bought Passports as a result of new jobs, other

Table 4-12 Why Did You Discontinue Using Your Passport

Reason	Percent
Stopped using the bus	31.4
Left school or lost job	17.7
Changed mode (car, carpooling)	13.2
Too much money to spend at one time	10.9
Card lost or stolen	9.7
Moved	8.0
Didn't or couldn't renew card	3.5
Other	5.4

stopped buying Passports as they finished school, bought cars, etc. Note that there were no instances of people discontinuing card use because of problems with the card, or dissatisfaction (this was an open-ended question).

We tested whether discontinuing the card is related to individual characteristics. There is no relationship with gender, occupation, status, household income, or having a driver's license. There is a relationship with age: children 15 or younger are more likely to be former Passport users, while adults of all age groups older than 35 or more likely to be current Passport users.[25] This result may simply reflect a higher turnover rate of card use among young people. We also estimated a simple logistic regression with Passport user status as the dependent variable, and measures of age, occupation, and income as independent variables. Variables were only marginally significant, and the results are not shown here.

4.5.2.2.4 Spanish respondents

It was noted earlier that just 29 of the 371 valid surveys were completed in Spanish. The low share of Spanish responses is in part a function of the lower likelihood of Spanish speakers to use the Passport. From the first survey, nine (14.3 percent) of the 63 respondents who had ever used a Passport were Spanish. In this survey 25 (6.7 percent) of those who had ever used a Passport were Spanish. The lack of Spanish respondents also reflects bias in the telephone survey: Spanish speakers may be less inclined to be

[25] Based on Kendall's Tau-b, significant at $p < .024$.

interviewed over the phone, less likely to have a telephone or to provide a valid telephone number.

Spanish respondents are different in many ways from English respondents. First, they are more likely to be employed full or part-time, to be between the ages of 16 and 49 (prime working years for those with limited skills and education), and to be frequent bus users. We have no information on household income, because less than half of these respondents answered the question. Second, they are even less likely to have a driver's license, credit card, or ATM card, as shown in Table 4-13. We have included both numbers and percentages in the Table, and they are based on respondents 16 years or older. All differences are significant ($p < .005$), despite the small numbers of Spanish respondents. Clearly the Spanish respondents are far less inclined to use card media of any kind.

Of the 29 Spanish respondents, 15 reported having a valid Passport, and of these, 11 were still using the Passport. Fourteen of the 15 have monthly passes. We were unable to explore why Spanish respondents stopped using their Passport, what impact the Passport had on bus travel, or their perceptions about the Passport, because of the small number of responses and missing information. Many questions were not answered, or were given a response of "don't know".

4.5.2.3 Summary of the survey results

Survey 2 results were quite consistent with those of Survey 1. Ventura County's transit users are mainly transit dependents: students, persons from very low income households, and many who do not have a driver's license. They are also regular users, with most respondents using the bus three or more times per week. Use of the Smart Passport is higher for English speakers, and for those with relatively higher incomes. Passport use is quite uncommon among Spanish speakers. Spanish speakers are more likely not to know about the Passport. It is also possible that using a Passport is simply not consistent with cash-oriented consumption habits (as indicated by the absence of ATM cards and credit cards among Spanish speaking respondents).

As expected, those who use the monthly pass make more trips than those who use the debit card. Passport users tend to buy and renew their cards in the same place; debit card users are more likely to take advantage of recharging on the bus. Use of telephone and the Internet for purchases and renewals is almost non-existent. Passport users report taking more trips as a result of purchasing the card, but this may be due to any number of factors, e.g., getting a job, going to school, etc.

Table 4-13 Driver's License, ATM and Credit Cards

	Percent yes		Numbers	
Do you have a...	English	Spanish	English	Spanish
Driver's license?	47.7%	12.5%	134	3
ATM card?	56.2%	25.0%	158	6
Credit card?	33.8%	4.2%	95	1
	Total Responses		281	24

Passport users are very satisfied with the card; they find them easy and convenient to use, and problems with the cards have not been a deterrent to their use. Since drivers usually allow passengers to ride free when there is a problem with the card (participating operators had agreed to this policy), users have not had to bear any consequences of card failures. We conclude that for the small number of transit users who use it, the Passport is an attractive fare alternative.

4.5.3 Conclusions on User Response

We began our analysis in this chapter with cards sales and a discussion of sales trends. We find no evidence that introduction of the Smart Passport resulted in higher Passport sales, or in greater use of transit in Ventura County. This is an expected result for the following reasons:

- The Passport and new VISTA service was introduced long before the Smart Passport. Additional services – availability of a debit card, and more options for buying and renewing cards – did not materially affect the quality or availability of transit.
- Ventura County is not easily served by transit due to its low density and dispersed development pattern. Hence, transit is not an attractive substitute for the private vehicle, and the transit market is limited primarily to the transportation disadvantaged. A more convenient fare medium is not sufficient to attract discretionary riders under these circumstances.
- Transit services in Ventura County are not well integrated. There are few opportunities for transfers between services, and the County's geography limits demand for inter-service trips.

- Competing fares on the part of some operators made the Passport less attractive.
- Transit riders did not take advantage of the flexibility the Passport offers. Although the Passport provides significant flexibility in where one can buy and renew, most Passport users buy and renew them in the same place. Debit card users take advantage of the option of renewing on the bus, and this convenience (plus the ability to purchase in increments of as little as $10), may explain why so many pass users were drawn to the debit card.

It is therefore not surprising that such a small number of Passports – 400 or so – are in circulation today, and that the market share represented by the Passport is likely in the range of five percent.

As in Phase II, Passport users were most satisfied with the card, despite the large percentage of users who encountered problems with the card. Since most problems were solved by allowing the passenger to ride free, there is no reason why users should find card malfunctions to be a problem. Indeed, for debit card users, riding free is especially advantageous. We note that had larger numbers of cards been in circulation, the transit operators probably would not have been able to sustain such a policy, as the revenue loss would have been prohibitive.

Our surveys demonstrated the extent to which transit serves a highly disadvantaged population in Ventura County. While conducting the onboard surveys, the research team encountered many riders who were unable to read or write in English or in Spanish, as well as many riders who were mentally disabled. The County median annual household income (1990) is over $45,000; the median reported income interval is $20,000 - $29,999 for the first survey and $15,000 - $19,999 for the second (in 1996 and 1997 dollars respectively). For the population, about 70.5 percent of adults have a driver's license, while the survey shares were 55 and 45 percent respectively.

The Spanish speaking transit patron is especially disadvantaged. Of the 24 Spanish speaking respondents who answered the question in Survey 1, 11 reported household incomes of under $9,000. Spanish speakers are even less likely than English speakers to have a driver's license, yet they are more likely to be part-time or full-time workers. Possession of an ATM card – a basic necessity of modern banking – is uncommon, and possession of a credit card is rare among Spanish speaking respondents. It is not surprising, then, that Spanish speakers are less likely to use Passports. Extremely low incomes suggest that people simply cannot put together the sum necessary to purchase a multi-trip pass. In addition, many Spanish speakers are recent immigrants; they likely have not been exposed to transaction cards of any type, and may not want to provide information of any sort to public agencies.

Given the circumstances of a mostly dependent transit market, is the Smart Passport an appropriate technology? Virtually no one purchased or renewed their cards via the Internet; less than 10 percent of respondents used the telephone. Monthly passes are easily accommodated without a “smart” fare system, and the very poor are not inclined to make block purchases in any case. The intent of providing “seamless transit” is constrained by the services themselves, which in this case are not closely integrated. The Smart Card system may be more appropriate where transit serves higher income, discretionary riders, and where actual service integration exists. In an area like Ventura County, investment in an advanced fare payment system would have to be justified for reasons other than ridership benefits.

CHAPTER FIVE
INSTITUTIONAL RESPONSE

5.1 INTRODUCTION

This demonstration and implementation of technology in transit operations in Ventura County required interaction between project sponsors; a private sector system developer; and originally seven transit operations, later increased to nine, with the addition of two Dial-A-Ride operations. The institutional analysis was focussed on understanding and explaining the roles and responsibilities of the many project participants with the intent of answering the following questions:

- What role did commitment to the goals and objectives of the project play in its ultimate success or failure?
- Are there lessons to be learned for the future organization and administration of complex multi-party FOT projects?
- What were the anticipated operator benefits?
- What were the institutional issues arising from the project?
- What were the views of the project partners at the conclusion of the evaluation?
- Are there particular lessons learned with regard to fostering public/private partnerships?

5.2 THE ROLE OF PROJECT EVALUATORS

In almost any project the effective cooperation of the institutional players is important in insuring success or failure of the final outcome. Previous experience with the evaluation of transportation projects and in particular Field Operational Tests involving new technology, has indicated that institutional responses to projects are critical and frequently in need of guidance and improvement.

The role of evaluation study teams can vary from one project to another. In all cases it is essential that they adhere to standards of neutrality and objectivity with the intent of performing a fair and impartial evaluation. In the course of a lengthy study, considerable amounts of data and knowledge are frequently assembled which can be useful in helping to inform some decision-making processes. The sharing of such data can sometimes help direct project deployment in a positive manner. In other cases the sharing of interim data can be considered likely to bias decisions and outcomes and in such cases is not usually shared with project participants.

The object of the institutional analysis process in this study was to follow the actions of the multiple partners in the project and to poll their views and responses at appropriate times. In addition, their views were to be sought with regard to satisfaction with the project and support for maintaining or expanding the various project elements.

The study team attended the monthly project meetings which were organized by the project manager and attended by transit operators, VCTC, Caltrans and Echelon Industries, Inc., the technical developer. They documented the planning and implementation process through attendance at these meetings. They shared with the group their early findings from a survey of bus users and drew attention to a lack of awareness of the transit service and the Passport Program. Apart from this, the evaluation team contributed little, if any, data or information to the progress of the study. As part of the evaluation process they interviewed those involved at both a fairly early stage in the implementation process and again in later phases. Within the constraints of the timing and budget for the project every attempt was made to wait until the system was fully operational before undertaking final summary analysis. The evaluation, however, had to be concluded before all of the project objectives had been achieved.

5.3 THE PROJECT PARTNERS

The partners involved in the project implementation are a good example of the type of institutional complexity that can be found in the deployment of technology in the transit sector across a whole region, in this case Ventura County in the State of California. In Chapter One, Figure 1.2 illustrates the numbers of project partners and the complexity of the relationships between them. They were: a commercial technology developer and vendor; the Volpe National Transportation Systems Center of the Research and Special Programs Administration of the U.S. Department of Transportation, the State Department of Transportation; the County Transportation Commission with responsibility for both regional transit service and resource allocation; the largest public transit operator by county standards (circa 35 buses) but still a small operator by national standards; five small city transit services, two operating their own vehicles, the other three contracting the service out; and two contract operated Dial-A-Ride services. They are described in more detail as follows:

5.3.1 Echelon Industries, Inc. - The Technology Developer

Echelon was the instigator of the project and received Small Business Administration start up funds to aid the development of the concept. The project director is an entrepreneurial developer of leading edge technology applications in transit. The company develops software applications for initial testing at small transit properties. Echelon uses off-the-shelf hardware components and designs software to create potential commercial packages for a wider market. This approach was used in the successful Smart Card II project reported in Giuliano and Moore, 1996. This then led to the opportunity to perform the much more technically demanding multi-element Smart Card III Study.

The Project Chronology in section 2.2 of Chapter Two demonstrates how Echelon led all of the early start up activities for the project. Following agreement to participate from VCTC in June 1994, Echelon wrote a proposal in August 1994 with the expectation that the FOT start date would be November 1994. However, funding for the project was not final until April 1995 when Echelon commenced work. The VCTC project manager was retained in June 1995, but the first project team meeting did not take place until August 1995. In the interim, it appears that Echelon was responsible for all of the project development including the goals and objectives of the project.

5.3.2 California Department of Transportation (Caltrans) Office of Advanced Systems Integration and Implementation

Caltrans was the contracting agency for the study. Changes in personnel between the two Smart Card studies created continuity problems for the agency. Their role in the project emerged as the monitoring of progress rather than active participation or leadership.

5.3.3 Ventura County Transportation Commission (VCTC)

This is a young, small agency run by an experienced and energetic administrator. They take pride in their emphasis on technological innovation in their programs and are staunch believers in the benefits of technology, e.g., their VCTC Home Page www.goventura.org. They have many responsibilities including contracting for the VISTA countywide bus routes and the two Dial-A-Ride services. When the opportunity to host the project arose it was promoted with enthusiasm. The expectation was that in particular the data-gathering potential of the project could provide cost-effective data for Section 15 reporting. However, with a staff of only eleven working on multiple projects there was no time for project oversight or management. Also at the inception of the project they had yet to hire an accountant to work on such issues as the most effective means to gather data and divide revenues between the participating agencies. A project manager was hired to help guide the progress of the study.

5.3.4 South Coast Area Transit (SCAT)

This is the largest transit operator in Ventura County with services extending from Port Hueneme, through Oxnard, Ventura, and out to Ojai. The services are well run, operated, and promoted. Like VCTC, when seeking board approval for the project they stressed the value of the data to be collected and potential cost savings associated with this. Fare policy at SCAT is, however, revealing of the competitive nature of their services. Their monthly pass prices are lower than the Passport and their multi-ride tickets are also competitively priced and very popular. The relationship between VCTC and SCAT is competitive. The then Director of Marketing for SCAT was supportive of the project; however, other parts of the operation were not.

5.3.5 Simi Valley Transit

This is a small (nine buses), city-owned and operated transit company. Services are run with very limited resources and they were reluctant to be included in the project. Political pressure brought about their involvement. They are concerned about the pricing of the Passport as this undercuts their own fares leading to potential revenue losses. Improved data was expected to be one of the chief benefits of the project.

5.3.6 Thousand Oaks Transit

This is also a city service that owns its vehicles. They contract for the operation of the services with Dave Systems. They consider themselves to be progressive and innovative and were supportive of the countywide Passport as well as the data collection and technology features of the project. Thousand Oaks has a population of 110,000 and demand for service is growing. They were working on route re-structuring plans throughout the project.

5.3.7 Camarillo Area Transit

Camarillo is a city of 50,000 and the users of the local service, which was a fixed route with hail and stop facilities, were 70 percent seniors and disabled. The service is a contract operation with three vehicles. A transit study was underway during the project and it was anticipated that it would convert to a Dial-A-Ride service. The project was expected to have very little impact or value. A VISTA route links the city to Ventura and Passport sales were expected to be mainly to students.

5.3.8 Moorpark City Bus

This city-owned, one-bus operation, is operated by a contractor. They did not anticipate much benefit from the project but participated to be supportive. Their greater concern was the prospect of losing the under-performing VISTA service. City staff involved in the project had many other responsibilities within their job description.

5.3.9 Ojai Trolley Service

This is a fixed-route city-owned and operated service. Ojai is an isolated scenic town which is a local tourist attraction and hosts a number of special events. The trolleys are two customized vehicles made to look like vintage vehicles to blend with the old-town feel. They provide both local service and a tourist attraction. The services do not connect in schedule with the SCAT service from Ventura. The project was supported for political reasons but seemed largely irrelevant to the nature of their operations.

5.3.10 Fillmore Paratransit Service

This is operated by the Fillmore Area Transit Corporation (FATCO) under contract to VCTC. The services were included in the demonstration because they were funded by VCTC. The operator is interested in the innovative technology and supportive of the Passport concept. The availability of a high powered computer at the FATCO offices made on-site sales of Passports possible.

5.3.11 Santa Paula Dial-A-Ride

This is operated by Santa Barbara Transportation, Inc. and is also under contract to VCTC and participated in the project for the same reason. The company also operates the East and Central VISTA services and Route 126 from Ventura to Santa Paula and Fillmore. Sales of Passports from this office were by fax and mail-back because they lacked computing staff or equipment.

5.3.12 Project Manager, A Consultant

The consultant was employed directly by VCTC as the project manager. This was her first assignment to an ITS demonstration project. The consultant has a strong political background and knowledge of institutional consensus building, but lacked technical knowledge. Her contractual responsibilities involved writing a final report and project coordination. The contract did not specify her relationship to the technical developer, the other transit operators or those responsible for the marketing effort (who would not take direction from her). Within VCTC the leadership gave only intermittent consideration to the project. The position of project manager was therefore weak making it difficult to assume a strong leadership role.

5.4 THE GOALS OF THE STUDY

The only formal written goals for the study are in a work program document written by Echelon (Echelon, 1994). They are as follows:

- "To create and implement a fare transaction system which will address the integrated inter and intra agency fare transaction needs of a multi-agency operation. The first goal relates to using the advanced fare payment system to encourage, accommodate, manage and monitor the movement of passengers between transit systems".
- "The second goal is to produce ridership statistics to address Section 15 reporting needs".

The brevity of the goals and the lack of any other form of written technical objectives for the project are noteworthy. The interests of the many parties involved and the roles and responsibilities of the many players were not addressed in formal documentation.

5.5 FORMAL RELATIONS BETWEEN THE PARTIES

There was a minimal level of written formality between the parties. The following are important points.

5.5.1 Project Objectives

There is no written record of formal preliminary discussion of the objectives of the project by the project partners. This would have entailed creating a description of the roles and responsibilities of all parties to insure the success of the project. The first Echelon Progress Report (Echelon, 1995a) which documents the Needs Review makes no reference to the roles of the partners. It is purely concerned with technical issues, not institutional aspects of the project.

5.5.2 Operator Investment

- The transit agencies had no cost involvement in the project other than staff time. Included in their agreements was the provision of hardware, software, and maintenance.
- At the end of the project demonstration period those that wanted the equipment left on the vehicles could keep it or ask for it to be removed at no cost.

5.5.3 Operator Responsibilities

- There were no written agreements about making vehicles available for work by the technical developer, reporting faults in a timely manner or supplying essential information in advance of the project with regard to vehicle types and garage location or fare structure. One of the first tasks undertaken by Echelon was a "Needs Assessment" that involved the collection of base information. It was reported at the time that the maintenance staff seemed generally very cooperative. All agreements about the supply of information by the operators appear to have been oral and informal.
- There appears to have been no written agreements with regard to the delivery of software documentation, data, reports or statistics by the technical developer.
- There were no agreements to unify the fare policies, or payment policies regarding cash, checks, or negative balances on debit cards. There was also no agreement to keep the fare policies fixed for the period of the demonstration.

5.6 ANTICIPATED OPERATOR BENEFITS

The evaluation team interviewed all of the operators for the first time in February 1996. At that time the project was in the early implementation phase with Passports being sold but vehicles and outlets only partially equipped. All those interviewed were asked why they were participating and what the anticipated benefits were for their agency. The primary general benefit was seen as the ability to generate data for the following purposes:

5.6.1 Section 15 Reporting

In the case of the larger operators it was anticipated that the use of the passenger counters to generate accurate passenger counts would make it possible to substitute such data for annual surveys.

5.6.2 Service and Route Planning

Obtaining information by stop location was seen as important by many of the operators. Two operators (Thousand Oaks and Camarillo) were undertaking route re-structuring throughout the course of the project and welcomed the additional data source.

5.6.3 Schedule Adherence

Monitoring on-time performance of service was mentioned by both Thousand Oaks and Simi Valley. The ability to check on both early and late departures from stops using the GPS capabilities was expected to be valuable.

5.6.4 Understanding the Market

SCAT, the largest operator, anticipated that the data should lead to greater understanding about the users of their services and knowledge about the characteristics of both Monthly and Debit Passport users. It would also allow them to understand the extent to which SCAT services were used by passengers who started their trips with other operators.

5.6.5 Other Benefits

The Fillmore Dial-A-Ride service indicated that the fare registration capabilities would cut down on the manual paper work undertaken by their drivers to register their passengers. Another operator mentioned the manner in which the project was taking a first step towards cashless transactions which they hoped would be the trend for the future. It should be noted that the Ojai Trolley service anticipated no benefits to its services from the demonstration project.

5.6.6 Passenger Benefits

Convenience was one of the passenger benefits mentioned. It was anticipated that parents of school children using the buses would appreciate the Passport. However, several of the operators commented that they felt the cost savings to be gained by using the Passport were unlikely to be experienced by really low-income riders. They have found that this group is resistant to paying in advance even if they will save money. Budgeting difficulties, lack of financial resources, and cultural factors (in the case of Hispanic riders) were cited as explanations by FATCO, Santa Barbara Transportation Inc., and the City of Ojai.

5.6.7 Benefits Not Raised or Discussed

The introduction of Smart Card technology especially when adopted by multiple operators is often cited as having the benefit of integration of transit service. The term “seamless integration” is frequently used in this context. The Ventura County transit operators had little, if any, expectation in this regard perhaps because the countywide Passport (which existed before the introduction of the smart technology) already offered an integrated fare. There was no expectation that Smart Cards would generate new ridership.

5.7 MAJOR ISSUES

5.7.1 Operator Information about the Project

The operators seemed to have been given minimal information about the project. They knew that a chip-embedded Smart Card would replace the previous Passport and would be sold on the buses and at initializing outlets. The implications for driver training, retrofitting of the bus fleet, computer equipment, and staff computing skills needed do not seem to have been discussed in advance. With regard to maintenance of the equipment, problems were not anticipated. One spokesperson commented about the equipment: “It is supposedly self-diagnostic, the parts are easy to purchase and install, and Echelon will be there as backup”. There was no advance agreement about the reporting of equipment failures to Echelon or the project manager. From the comments made during the first round of interviews it was clear that the operators had little understanding of the technical sophistication of the equipment or its components in terms of hardware or software and what it would take to operate, utilize, and maintain. With hindsight it can be seen that there was no prior examination of the part to be played by the operators in contributing to the success or failure of the demonstration.

The overall impression of the operators was that they were involved in a demonstration project for which the components were basically tested and fully operational. The project manager was also under the impression that the successful results of the Smart Card II project were merely being applied to a wider market. The demonstration was viewed as an implementation program rather than (as became the case) an on-going research and development program with the Ventura county transit operators as test subjects.

5.7.2 Fare Policy

As indicated in Chapter One, prior to the introduction of the Smart Card there was the countywide Passport program. This was a monthly flat fare pass for use on all services. Monthly renewals involved placing new stickers on the passes. There was therefore a monthly fare medium that was good for all operators. The original intention had been to introduce the Passport as a Smart Card. However, when the full project was delayed the Passport was started anyway. The only real difference introduced by the smart technology was the debit card and the ability to re-charge the passes on the buses. There were, however, a number of operator disagreements that had been papered over by the Passport program. The reimbursement program through VCTC was not universally accepted as being fair. Simi Valley in particular felt that they were losing revenues by potential purchasers of their own tickets turning to the Passport. To avoid losing revenues the largest operator SCAT had an aggressive pricing policy for multi-ride tickets and for their own monthly passes. This policy was almost certainly competing with the Passport and likely to continue to undermine its attractions. There had been no attempt to harmonize classifications for seniors, students, etc., among the city operators or unify approaches to fare and service changes. There was a noticeable unwillingness among the operators to agree on common policies. One example of this was the question of how to deal with negative card balances for the debit cards. SCAT would not accept negative card balances; other operators did.

Services within the county were also not fully integrated in terms of timetables. (VCTC later took steps towards improvements). A prevailing opinion seemed to be that there was little transfer between operators. Another opinion prevalent among the operators was that the existing Passport and the Smart Card version would remain unattractive to the poor who paid in cash and lacked the ability to pay in advance. All of these factors meant that there was no strong unified support for the sale and promotion of the Smart Card-based Passport. There was more interest in whether or not data generated by the system would lead to a more equitable distribution of revenues associated with their sales. However, the issue is significant only to the extent that Smart Cards are bought and used.

The matrix of fares for all of the operators was a key element in the FareTrans software. Multiple requests were made to the operators by the technology developer for this information. Likewise the evaluation team experienced difficulty in procuring this quite fundamental information. In August 1997 (i.e., at the conclusion of the evaluation period), in the case of the Fillmore Dial-A-Ride it was noted that still not all of the details were correctly coded into the system. It should also be noted that there were no agreements on keeping fare policies fixed during the demonstration period. Responsibility for these problems seems to lie with both sides of the partnership. Lack of concern for and oversight of such technical details indicates the weakness of the partnership and lack of commitment to it.

5.7.3 Marketing

The advertising campaign began at the end of December 1995 when the first Smart Card Passport sales began. A glossy brochure was distributed and in January a press release was distributed to the media. Public service announcements were also prepared. Unfortunately the timing of the advertising campaign was in advance of the full implementation of the project. When pre-testing the first round of passenger surveys for the evaluation it was noted that not only was there a lack of awareness of the Passport but also knowledge of the transit system. The VISTA services were poorly advertised and information was hard to obtain, e.g., the Santa Paula Dial-A-Ride had no listing in the telephone book and an information center at the major regional shopping mall which VISTA routes served, had neither timetables nor information to offer about the services. Also VISTA bus stops were poorly marked. Meanwhile the major commercial operator SCAT had an aggressive program to market its own services and ticket types.

The issue of marketing and appropriate materials was discussed once in the project partners group meeting. One of the Dial-A-Ride operators requested a simple flyer for distribution at marketing outreach meetings at which she made presentations to, e.g., the Soroptimists and residents of a mobile home park. VCTC countered the suggestion with a formal overhead presentation with the intent of insuring continuity of presentation of material about the project. The presentation package proved to be too technical for the types of audience served and lacked basic marketing information, e.g., there was nothing that gave fare information or explained the savings to be made by card use or any information about the debit card.

5.7.4 Equipment Installation

As indicated in Chapter Three, the installation of equipment in the buses, at the garages, and at the card issuing outlets did not proceed smoothly. The experience indicates the level of detail required in the planning and budgeting of such project elements. Echelon argued that the problems were the result of the undue haste with which the project was implemented, changes in the configurations of systems caused by the additions of the two Dial-A-Ride systems, late delivery from vendors, and other difficulties such as the need to customize equipment to meet the needs of fifteen different vehicle types as well as the preferences of eight different operators. Echelon also experienced difficulties with the availability of vehicles and uncooperative maintenance departments and staff. The operators for their part were often unhappy about the demands placed upon their staff, garages, and vehicles; missed appointments; and a general lack of comprehension of the extent of the installation requirements. The frustrations were compounded by the various rounds of software upgrades and equipment replacement that took place over the course of the project.

Card sales and initialization were another aspect of the equipment installation that proved troublesome due to lack of appropriate computers, telephone lines, and staff with sufficiently high levels of computer comprehension and experience. A list of equipment required had been circulated in advance. The requirements were explained in both written and oral form in highly technical language. However, it seems that there was no follow through to see if those responsible understood the implications of the requirements, e.g., modem lines must be dedicated and cannot be connected into a city voice messaging system. The need for a Windows '95 version of the program had also not been foreseen. The lack of availability of manuals or any form of written documentation to guide low level staff through the FTS program was also indicated to be a problem. These problems had not emerged clearly at the time of the Needs Assessment. Echelon had accepted assurances that staff were computer literate at face value. The lack of understanding of the partners of the technical requirements of the project caused delays and added frustration.

5.7.5 Staff Training

Driver training took place twice. This became necessary as the systems were modified and improved. Several of the smaller operators in particular felt the need for this support because they said that they found they encountered the Smart Cards fairly infrequently and were uncertain as to whether they were following the correct procedures. Laminated crib sheets were developed by two of the operators to help drivers as reminders with the less intuitively obvious functions. From the point of view of the technical developer, the re-training was essential in order to improve driver cooperation and understanding. Echelon had misjudged the extent to which automated procedures would be necessary to avoid making demands on drivers. Frustration at driver inability to understand and fully cooperate with the use of the system was evident in relations with one of the contract operators. There seems to have been a fundamental problem with the task requirements of the use of the technology and the qualifications of the staff. A reality of life for contract transit operations is that many experience relatively high staff turnovers of employees paid low wages. Benefits are low and motivation is poor. Contract operators have no incentive to: (1) do more than their contract requires and (2) use technology that allows their services to be closely monitored.

Repeat training was also required for staff of the card issuing outlets. Low levels of computer skills and understanding were also found to be a problem in the use of the system. Poor data entry by uncommitted low level staff also appeared as a problem. The lack of written materials and guides only compounded the difficulties. There appears to have been a lack of sophistication in the programs that would have helped with some of these problems. More use of internal validity checks could have been incorporated.

The experiences with staff problems associated with the use of technically sophisticated systems point to a general problem encountered in many fields. Low pay, inadequate training, and backup support contribute to a poorly motivated workforce ill equipped for the introduction of new technology. Such problems need to be taken account of both in the design of systems and in the training programs to accompany their implementation.

It should also be noted that there was no training for maintenance personnel at the transit properties. One transit operator commented on this in the context of the future use of the system. He explained that his staff lacked understanding of the system. They did not know how to maintain or update the equipment; where to purchase the parts; or how much time or cost would be involved in doing so. This knowledge would be essential if they were seeking to make a long-term decision to continue with such system elements at their own expense. To this might be added that staff ignorance of the equipment and its requirements would also mean that they lacked understanding of how the equipment might be affected by other maintenance work they performed.

5.7.6 Project Coordination

The project partners met monthly at VCTC to discuss the project. Agendas were circulated in advance, but with rare exception, there were no formal written minutes with action items to be followed through on. At each meeting Echelon would report on progress. The operating representatives would raise questions about difficulties and problems and he would respond. This frequently consumed most of the meeting time. Reports were mainly verbal with illustrative data and partial reports being distributed from time to time. The meetings were not particularly interactive and frequently confusing to follow. A list of problems would be raised but there was seldom a clear decision on action to be taken. As an example a report based on partial GIS data would be presented along with the comment that there are lots of missing data problems associated with records of card holders which makes identifying where they live difficult. Such a statement would never be pursued in terms of why the problem existed and what could be done to resolve it. Responsibility was never allocated for the resolution of problems. Important policy issues such as what to do about negative balances on debit cards were briefly discussed with a decision to allow some agencies to go negative while SCAT's no negative policy was maintained. This dual policy was not discussed in the context of fare coordination.

The Technology Developer presentations proved to be difficult for most of the partners to understand or follow at a technical level. A lack of technical expertise within the group made it difficult to communicate concerns. Partial graphical information would be used to illustrate the often tantalizing potential of certain aspects of the technology, but data shortcomings and gaps were not adequately addressed.

Other forms of project coordination proceeded through faxed memos. Some were requests for important data and others associated with re-statements of instructions for the operation of the system.

The operator group meetings were not used for formal review of the project status against milestones, schedule or technical status. The technology developer appeared to be proceeding without formal oversight. The formal project status reports went to VOLPE who were not represented at the group meetings. Questions were raised about the start and end times for the project and whether it would be extended, but none of the partners could answer the question. The project manager attempted to initiate a discussion of the use of the reporting features and a group evaluation of the project, but neither of these discussions was taken to serious conclusions. New ideas for promotion of the Passport and consideration of a cheaper form of Smart Card were discussed, but also went no further.

5.7.7 Project Ownership

Chapter Three discusses the different views and experiences of the project partners with the maintenance of the systems. The lack of good cooperative relationships and understanding in some cases between Echelon and the maintenance departments undoubtedly contributed to undermining part of the value of the demonstration project. It became clear in the late stages of institutional interviewing that lack of information about, or knowledge of the systems on the vehicles was a widespread problem.

The maintenance experience points to a deeper problem associated with the project, i.e., lack of ownership of the project or commitment to the goals and objectives. The reasons for this appear to be:

- lack of formal agreements to promptly inform the technology developer of problems and make easy access to vehicles for repairs,
- lack of knowledge of the installed systems,
- lack of financial commitment of the operators to the project,
- low card use making the system almost irrelevant,
- allowing passengers to ride free when there were equipment problems, and
- inability to use or lack of interest in the reporting systems.

The situation would obviously have been very different if agencies had been challenged by potential revenue losses each time the equipment had malfunctioned. Also if the properties had committed to the purchase of the equipment, maintenance departments would have insisted on training to understand the equipment and help insure that it was well maintained and functioning correctly. In this sense the demonstration became divorced from a real operating environment.

Chapter 1 describes the complex funding and contracting arrangements for this demonstration project and this is illustrated in Figure 1.2. Those people responsible for the funding sources effectively had no responsible role to play in directing the project. Echelon, the recipient of the SBA funds, was therefore free to follow a commercial interpretation of the project and needed only to maintain the cooperation of at least the majority of the operators to support the test environment. The operators were confused about the project purpose, lacked knowledge and ownership, and had no yardstick or results against which to measure progress. Despite all the delays and frustration, they supported the principle of the application of the technology. They believed that if the problems could be resolved, then the results would make everything worthwhile.

5.8 THE PARTNERS' VIEWS OF THE PROJECT

The transit operators were interviewed for the second time in August 1996. At this point it was unknown whether or not the demonstration would be extended past October 1996. It subsequently was and will continue until the end of June 1998. The following is a summary of views of the project experience.

5.8.1 Operator Expectations

There appears to be consensus that the operators did not know what they were getting into.

- One individual claimed to be shocked by the recognition that the project was experimental rather than a demonstration implementation of technology, some of which had previously been tested in Torrance under the Smart Card II project.
- The operators had no understanding of the extent of the problems with the data. They expressed frustration at the lack of promised reports but anticipated that the problems would be resolved.

5.8.2 Concerns Specific to Smaller Operators

To some of the smaller services, malfunctioning equipment had become normal (comments from Santa Barbara Transportation Inc. and Camarillo).

- Concern was expressed for the inconvenience to passengers particularly when cards malfunctioned and had to be replaced. The policy of allowing free boarding whenever this occurred had helped to minimize passenger concerns. However, if revenue losses had actually occurred such a policy would not have been sustainable and the problem would have been a considerable public relations concern.
- Camarillo commented that given the low levels of transfers between services as well as the limited market for advance purchases they doubted the value of the effort for their market.
- The difficulties experienced by drivers for Santa Barbara Transportation, Inc. and Camarillo were cited as an example of the need for the technology to be intuitive and user friendly.
- Simi Valley commented that having both GFI systems for handling cash and the FareTrans demonstration system for Smart Cards highlighted a problem concerning the need to integrate the reporting from both systems. It was felt that having the two separate systems only adds to management burden for a small operation.

- The lack of information about what was working and what was not was a cause of concern, as was the lack of understanding of the maintenance requirements and associated costs. Simi Valley remarked that they would be fearful of investing in such systems out of concern for their rapid obsolescence. One view was that the systems being tested were unlikely to meet the needs of small operators but that some elements may yet prove useful.

5.8.3 Operator Interactions

Surprisingly, given the problems experienced, the majority of operators still support the program and wanted to continue with the demonstration. Fully operational and reporting passenger counters were cited as a priority item. They believed a fully operational period was also necessary in order to gather data on on-going maintenance costs. It was concluded that with hindsight it would be good to hear more from the other operators about their experiences and for there to be more group interaction in general. The subject of operational costs of the system was of interest but there was a lack of awareness that no agreements exist to provide such data to the partners.

5.8.4 VCTC's View

VCTC views the project in a positive light and remains optimistic that as the demonstration continues further technical problems will be resolved. They consider that the project was instrumental in helping the agencies reach agreements on the distribution of revenues and that this was a valuable hurdle to have overcome.

5.9 THE HOPE FOR OPERATOR BENEFITS

The primary agreed benefit for operators was the ability of the complete system to generate data for planning and auditing purposes. Chapter Three details the problems encountered with the passenger counters. The unreliability of the counts would suggest that this element is unready to replace the annual surveys required for Section 15 reporting. Also the very small numbers of card users meant that analyzing card user data for planning purposes would not be useful. There is no evidence of any operator having access to and being able to use GPS data to check schedule adherence. Unreliability of the FareTrans VMS element meant that Fillmore Dial-A-Ride was never able to cut down on manual registration of passengers. Simi Valley also reported additional management burden with the need to reconcile their automated GFI readouts by fare type and revenue with the pass data from a separate system. As noted in Chapter Two, the equitable division of card revenues, based on an accurate electronic database also never materialized throughout the period of the evaluation.

5.10 PUBLIC PRIVATE PARTNERSHIPS

Public private partnerships come in many forms and combinations. In the case of new technology development for transportation purposes they are commonly seen as a means of developing and bringing products, in support of public policy goals, to market quickly. In the case of this project, the public sector underwrote integrated software development for off the shelf products that required integration for multi-agency use. If successful the transit industry would benefit by having such systems commercially available. The commercial vendor, in exchange for his commitment and expertise, received a complex real-world test environment that would not normally have been available. In addition, the development costs and application in a wide-scale test environment were financially supported. (It is unknown how much Echelon contributed to the project.) If successful, the demonstration opportunity would have allowed Echelon to develop integrated market packages with commercial potential and bring them from experimental stage to market maturity. The transit operators stood to gain free hardware and software installed on their vehicles with new data gathering potential.

In retrospect it can be seen that this demonstration was a public-private partnership that failed to realize its full potential. The project was to a considerable extent undermined by a lack of leadership. A project director was needed whose central task was to insure that benefits would accrue to both sides of the partnership. The leadership role would have required an individual with a firm understanding of the complexity of the technological task, a real knowledge of transit operations and finally understanding and authority to deal with problems associated with political support for the project.

Such a project director would have been responsible for generating project goals and objectives and forging formal agreements with regard to the responsibilities of all of the partners. This would have clarified the vendor’s role and what he would and would not be required to deliver. It would also have defined the boundaries of commercial and proprietory information versus the public right to information that would help them determine the value of technology products. It would also have laid the ground rules for operator cooperation and support and have clarified what was essential to the conduct of the project.

5.11 SUMMARY OF INSTITUTIONAL LESSONS LEARNED

Based on our assessment, institutional lessons learned may be summarized as follows:

First, the lack of clear goals and objectives and formal agreements among the project partners undoubtedly contributed to the project's many problems. Despite everything, the project partners remain convinced of the potential benefits and committed in principal to support for the project. The evaluation team can only comment that this optimistic support was based on a lack of full understanding of the technical failures of the project. Second, it is essential to have such complex multi-party FOT projects led by those with sufficient technological understanding to be able to understand the issues, interpret them and design actions to resolve both technical and institutional problems.

Third, there are several institutional issues arising from this project:

- The operators lack of information about the status of the project. Operators understood the project to be an implementation program, while in reality it was a commercial research and development program using Ventura County transit operators as test subjects, from which they would gain little or anything.
- Lack of agreement on fare policy and reimbursement issues represented an immature climate for the wide promotion and use of Smart Cards.
- The market for pre-paid passes in such low-income transit user markets was insufficiently appreciated.
- The marketing of the Smart Card Passport was inappropriately timed and lacking in duration and effort.
- Vehicle equipment installation proved to be time consuming and frustrating for all parties involved. These project elements require very detailed planning, scheduling and budgeting. Office-based card sales and initialization equipment installation suffered from "technical need" communication problems and overly optimistic assumptions regarding staff computer skills.
- Training of both drivers and office staff suffered from overly optimistic assumptions about technology acceptance and understanding. Offering no training to maintenance staff did nothing toward helping stimulate responsible maintenance support for the project.
- Project coordination and leadership was weak allowing the technology vendor to proceed with minimal public oversight.
- The transit operators lacked ownership in the project, did not understand its components and were unconcerned when parts failed. The demonstration became divorced from a real operating environment.

What were the views of the project partners at the conclusion of the evaluation? Despite the projects' problems and a continuing lack of data and information, VCTC and the other operators remained optimistic that solutions would be found to the many problems.

Are there particular lessons learned with regard to fostering public/private partnerships? Complex technical projects involving many players require strong leadership and the ability to design and forge agreements that are in the interests of all parties. To direct competently requires knowledge and understanding of the principles of the technologies and of the environments in which they are to be used. Projects funded largely with public funds but in which the public sector has little ownership seem likely to be undermined by lack of sufficient interest and involvement in their success or failure.

CHAPTER SIX
CONCLUSIONS

This chapter provides a summary of the major findings of the evaluation, presents lessons learned and recommendations for future advanced technology FOTs, and discusses the implications of our findings for broader application of integrated systems such as the FareTrans VMS. The chapter concludes with an epilogue which addresses recent events in Ventura County.

6.1 SUMMARY OF MAJOR FINDINGS

This section summarizes findings on technical performance, user response, and institutional issues.

6.1.1 Technical Performance

Chapter Three described the technical performance evaluation in terms of field logistics, operational or component performance, and functional or system performance. Four major issues were identified.

6.1.1.1 Rushed deployment

The FOT got off to a slow start for the usual reasons – contract negotiations between Echelon, VOLPE, *and* Caltrans; delays in formulating the technical proposal, etc. Phase II took place in Los Angeles County, and the intent was originally to continue the project there. When participants could not be recruited in Los Angeles County, VCTC was approached and accepted the project. From VCTC's perspective, the project was a good fit with the new VISTA services that were about to be launched. However, VCTC initially expected that the Smart Card would be launched at the same time as the VISTA services. From the beginning, VCTC wanted the Smart Card available as soon as possible, and issued the plastic Passport as an interim measure.

At this point VCTC had little information on the project, and had little time to encourage the other transit operators to join the demonstration. We surmise that VCTC's insistence to proceed with deployment despite Echelon's lack of preparedness, and Echelon's willingness to do so was due to lack of information. VCTC did not know the potential consequences of deploying equipment that had not been adequately tested, *though the agency reports facing compelling political incentives to proceed*. Echelon did not know how complex and diverse the transit operators were, and therefore did not anticipate the time and effort it would take to get hardware and software designed, developed and installed.

Rushed deployment led to a cascade of problems. Selling Passports before the hardware and software were available to collect sales and initialization data made it necessary to perform all data collection and transmission by hand. Card data built up, but the software wasn't available to manage the data. As the bus equipment was deployed, test card data (necessary to test the system) was commingled with actual customer data; related data problems persisted through the duration of the FOT. Once the Passports were issued, pressure to get the system up and running increased. Delays in equipment procurement – routine occurrences in such projects – became critical problems. Equipment was installed incrementally, which added to the complexity of gaining access to vehicles and made necessary a lot of trouble-shooting on buses and in the garages. Software was written at the same time, and was also installed incrementally. As a result, the software had to be re-written repeatedly. Training suffered, because drivers had to be trained to use the equipment, but much of it didn't work until after the training was completed.

6.1.1.2 Training

The FareTrans VMS equipment proved to be more difficult for drivers to use than anticipated. Incorrect data input by drivers forced significant changes in system design. Lack of opportunity to respond to equipment failures, or incorrect interpretation of equipment failures led to various problems. The combination of limited training and infrequent Passport use on the buses seems to have contributed to these problems. In the outlet offices, staff responsible for card sales often did not have sufficient computer expertise to use the software correctly. The lack of technical expertise was not anticipated by Echelon. Echelon took at face value operator assertions of in-house computer literacy, *and made similar assumptions with respect to VCTC*. Training requirements turned out to be greater than anticipated for both drivers and outlet personnel.

Garage staff training requirements were largely unaddressed. The explanation is institutional: there was no formal arrangement to define responsibilities and reporting procedures for the FareTrans equipment. Echelon depended on transit management to develop procedures for handling equipment and reporting problems, rather than dealing directly with garage personnel. Garage personnel were unaware of what the FOT would involve, and Echelon was unaware of relevant aspects of maintenance operations. In some cases (particularly SCAT), the garage personnel gave little support to the FOT which in turn led to difficulties in identifying and solving equipment problems, with negative effects on technical performance.

6.1.1.3 Complexity of bus operations

We identify the complexity of bus operations as the reason why fully automating the centralized data collection scheme proved not to be possible. As noted in Chapter One, an integrated fare system requires exchange and updating of information across all operators and outlets in near real-time. This implies a very complex (yet robust) set of data communications links between vehicles and garages, garages and central data bank, and between outlets and the central data bank. Problems at any point may corrupt data or interfere with data transmission. Problems occurred with all of these links. Vehicle units sometimes failed to upload data to garage computers, or sometimes were not working. Garage computers were inadvertently disconnected, suffered from voltage fluctuations, and failed to perform for many reasons. The central computer proved to be very sensitive to anomalies in transaction records. Given the way that data files are uploaded, the probability of anomalies is high, hence the probability of data loss remained high throughout the test. The problem between outlets and the central data bank were due to human error: outlet personnel made errors in inputting card information; some card information continued to be transmitted by hand to VCTC and then input into the file, again allowing for errors in the data. Because of the potential for errors and lost data, such a system must be monitored daily. A fully automated FareTrans VMS does not appear to be technically feasible. An operator must be kept in the loop.

In all of these cases, Echelon Industries responded to address problems. Some solutions took considerable time to implement. The largest operator in this FOT is very small by industry standards. If such a system were deployed among two or more operators of even moderate size (say 200 buses) making substantial use of Smart Cards, these linkage problems would quickly increase to levels that might render such a deployment infeasible.

6.1.1.4 Automated passenger counting function

The automated passenger counting function did not work reliably during the FOT. Although the APC equipment appeared to be working, Echelon could not provide the corresponding passenger count data, nor could the research team make use of the data in the transaction data file. In the two cases for which Echelon provided the automatic passenger counts, there was considerable variance between the field counts and the APC estimates.

The APCs are the key to collecting Section 15 data and to collecting data on ridership patterns. Without the ability to use the automated data for passenger counts, transit agencies must resort to manual counts. None of the transit agencies received passenger count data during the FOT that was sufficient for Section 15 reporting purposes.[1] As noted in Chapter One, Echelon provided some example data of boardings and alightings by stop for Camarillo (1 route) and Simi Valley (4 routes). Data for operations as small and as lightly utilized as these provides only limited evidence of the potential of the system. The real test for APCs is how they operate on heavily patronized routes, where many people are boarding and alighting at the same time. This case was a much smaller exercise, and there were problems both with lost data and with the accuracy of the counts.

6.1.2 User Response

There are three basic questions with respect to user response. First is the market test of customer satisfaction. Are Passport users satisfied with the card as a fare medium? The second question is more fundamental: does the Passport increase the attractiveness of using public transit? In theory, an integrated fare should make public transit more attractive for some trips, as transferring between operators is easier and less costly. We were not able to explore this issue, because the integrated fare was established with the precursor Passport and the new VISTA service, not the new fare technology. However, the smart Passport included the new feature of a debit card, and the availability of such a card has the potential to make transit more attractive. There is a third question of serving the market. Given the characteristics of transit demand, does the Passport improve transit in ways that are important to the market which it serves?

6.1.2.1 Passport users response

Passport users were very satisfied with the Passport, consistent with the results from the Phase II evaluation. A large proportion of Passport users reported having problems with the cards, but since most problems were solved by allowing the passenger to ride free, it is not surprising that experiencing these problems did not lead to lower levels of satisfaction. Passport users considered the card to be a good value, easy to use, and valued the fact that one could ride the bus and not have to have the correct change for paying the fare.

There were few differences between pass users and debit card users. All Passport users tend to buy and renew their cards in the same place, but debit card users are more likely to recharge their cards on the bus. Use of telephone and the Internet for card purchase or renewals is almost non-existent. There were no clear patterns in the type of Passport used in relation to the transit service most frequently used. That is, differences across transit agencies were not consistent with fare structures.

[1] *VCTC reports SCAT used ridership data collected with the test APC equipment as the basis for a Section 15 report in fiscal year 1997.*

There appears to be a substantial amount of turnover among Passport users. When asked whether the Passport resulted in more transit use, the majority of Passport users stated that they made more frequent bus trips and traveled to new places by bus as a result of buying a Passport. On the other hand, when former Passport users were asked why they stopped buying the Passport, the most frequent responses were that the respondent stopped using the bus, changed employment status, or changed mode of travel.

Transit use in Ventura County is limited primarily to the transit-dependent population – those who are too young, too old, or too poor to drive. Passport users are more likely to be English speakers and have higher household incomes than other transit users. Passport use is uncommon among Spanish speakers, who are also less likely to know about the Passport. In addition, using the Passport may simply be inconsistent with cultural values and traditions. The Spanish speaking respondents were far less likely to have any type of financial transaction card than English speaking respondents, including instruments such as automatic teller cards. Spanish speaking respondents also had lower incomes and were less likely to have a driver's license than English speaking respondents.

6.1.2.2 Impact on transit use

Chapter Four noted that an automated fare system represents a significant capital investment for transit operators. The fare system cannot replace cash, and therefore must be operated and maintained in addition to the traditional farebox. The fare system also requires extensive monitoring, maintenance, and repair. In light of these additional costs, it is important to consider its benefits carefully. What does the transit agency get in return for incurring this additional expense? An obvious possible benefit is increased ridership, as a result of providing a more convenient fare medium. Because the new integrated service (VISTA) and the Passport were launched 1-_ years before the smart Passport, we were not able to examine the impact of the integrated service. The only additional element provided by the smart Passport was the debit card option.

We were unable to conduct any analysis of changes in overall transit use in Ventura County as a result of the Passport. We did track Passport sales before and after introduction of the smart Passport. The sales data does not suggest increased card sales as a result of the smart Passport. The Passport market share is estimated at about five percent of the total transit market. Even if Passport sales had doubled, this would have had little effect on total transit use.

6.1.2.3 Does Passport serve the transit market?

Ventura County transit patrons are overwhelmingly transit dependent. Reported household incomes are well below the County median, and the rate of driver's license possession is extremely low. It is likely that our survey data understates the degree of transit dependence, because the most dependent population is less likely to have a telephone, to be willing to respond to requests for information, or to be literate enough to respond.

Our results show that Passport users represent a small portion of Ventura County transit users, and that the Passport has apparently not resulted in a significant increase in transit patronage. Numerous studies have shown that for those who have a choice, choosing transit depends upon cost and convenience, with cost including travel time. We described the geography of Ventura County in Chapter Two, noting its low density and dispersed development pattern. Transit service in such areas cannot compete with the private vehicle – the travel time disadvantage of transit is too great. The smart Passport does not materially affect the transit disadvantage, and consequently we should not expect any response in terms of drawing discretionary riders to transit.

What about the transit dependent? Our surveys showed that the price of a Passport is prohibitive for many passengers. Informal interviews with bus drivers indicated that many passengers could barely manage the cash fare for one trip. Prior studies show that transit users have clear preferences regarding how transit might be improved; they want better service and lower fares. The Passport does not measurably improve service, because opportunities for functional integration across the transit operators involved in the test is limited. It does not provide a lower fare alternative for those who cannot accumulate enough cash to make a block purchase. *We* must therefore ask whether, in an environment like Ventura County, the resources invested in an automated system such as FareTrans VMS might be better spent on service improvements*?*

6.1.3 Institutional Issues

This FOT was conducted within a complex set of institutional relationships. Echelon is a private, for-profit enterprise that secured public financing to develop a commercial product. Since the objective was commercial product development, much of Echelon's activities were proprietary. Financing came from the federal government (FTA and SBA), project oversight came from Caltrans, VCTC was the local sponsor, and an independent consultant was hired to manage the project. Seven participating transit operators implied a much greater degree of coordination and cooperation than usual. Relationships were further complicated by the number of contractors involved in transit service provision.

6.1.3.1 Institutional background

Some unique aspects of this FOT are important to understanding the institutional outcomes observed. First, as with other FOTs, this field operational test was overlaid on a pre-existing set of institutional relationships in Ventura County. VCTC is both a service operator and the local transit funding agency; thus the other transit operators are dependent upon VCTC for allocation of subsidies. Second, VCTC is a small organization, with just 11 employed staff. Similarly, all transit operators except SCAT are one-, two-, or three-person operations. Thus, personal relationships between the various participants were established and extensive. Third, the placement of Phase III in Ventura County meant that it was located far from the Caltrans District 7 office, which housed the local sponsor, and even farther from Echelon's offices.

6.1.3.2 Goals, objectives and contractual arrangements

It is telling that the only written goals and objectives for this FOT were located in a work program document written by Echelon, and that these goals were very general. As far as the evaluation team knows, there was never a discussion of goals and objectives among the project participants. Rather, participants were presented with a task description and schedule developed by Echelon. This document was highly technical, and focused only on the technical tasks that would lead to deployment of the system. There was no discussion of information requirements, equipment access, agency responsibilities, etc. Participants had no information regarding their role in the FOT.

This lack of information continued throughout the project. The only regular reporting of project activities was performed by Echelon in the form of monthly progress reports submitted to the DOT's Volpe National Transportation Systems Center, and copied to VCTC. In the early months of the project participant meetings, the project manager issued meeting summaries, but this practice was abandoned early in the project.

There were no formal agreements regarding a decision-making process, or regarding the roles and responsibilities of project participants. Consequently, as delays and problems were encountered, there was no formal structure in which to assign responsibility, decide on a course of action, and monitor progress. For example, a complete inventory of fares was required for programming the FareTrans VMS software. It took several months for Echelon to acquire this basic information, and several more months to verify its accuracy. The project manager could ask participants to provide the data, but *seemed to lack* the authority to insist, or to collect it herself.

The absence of clear and formal contractual arrangements affected both Echelon and the participating operators as well as project outcomes. VCTC was able to take actions such as *trying to hold Echelon Industries to stated delivery dates by* marketing the smart

Passport before the system was ready for installation. There was no agreement regarding equipment readiness as a condition for selling Passports, no formal process for re-assessing the project schedule, and no source of authority for addressing logistical problems such as access to vehicles. Echelon was able to use the FOT to test additional equipment, as there was nothing in the contract arrangements that prevented this. Further, there was no requirement to inform project participants of this action.

6.1.3.3 Understanding of the FOT and lack of information

With the exception of Echelon Industries, the participants' understanding of the project was vague. They thought that a fully operational system was being deployed. They did not understand that the focus of the effort was testing new technology, not deployment of an off-the-shelf system. They did not understand the complexity of the system, the demands that would be placed on them for vehicle and garage access, the technical sophistication that would be required to use the equipment, or the possibilities for equipment failures. This created problems for both Echelon and the operators. Participants experienced an increasing and unanticipated burden of providing vehicle access, responding to requests for information, and providing access to garages and offices. As problems and delays continued, maintaining support and cooperation within the operators' organizations, e.g., with contractors and garage personnel, became increasingly difficult. By not providing clear requirements for both technical equipment and human expertise, Echelon encountered numerous implementation problems, such as for example in the case of computers, modems, and technicians at sales outlets.

On the other hand, participants' lack of understanding no doubt explains some decisions and requirements that greatly complicated the FOT, and that Echelon felt constrained to accept. We noted earlier that the rush to deployment is likely explained by a lack of understanding on the part of both Echelon and VCTC. Additional examples include the insistence of some operators for highly customized equipment installations (e.g., stanchions that were made of the same metal as other equipment on the bus; placement of PTUs); differences in Passport fare policies across operators (e.g., negative balances on debit cards), and inclusion of DAR services after the FOT was already underway.

The operators desire to avoid new maintenance responsibilities contributed to a lack of information *that* affected technical performance. Without formal training and procedures for monitoring the equipment, maintenance staff did not know how to monitor the equipment or what to do when it failed. Without formal procedures for checking on-board equipment, there was no way to quickly respond to equipment problems. Without documentation for the software, administrative staff had no way of solving even the simplest data input problem.

A final aspect of this lack of information is revealed by the technical mismatch between Echelon and the participating operators. This mismatch was most obvious at the monthly meetings. Echelon would provide a detailed and complex verbal report on project progress, much of which was incomprehensible to the operators. There was no printed summary of task progress, or issues to be resolved. The technical mismatch made it difficult for Echelon to communicate information and equipment needs. For example, when computer requirements were discussed, Echelon gave a verbal description of RAM, ROM, baud rate, etc. Echelon did not learn that this description was not understood until they were in the field trying to install software and found that many of the computers were not sufficiently powerful to support their products.

6.1.3.4 Ventura as an equipment testing ground

We noted in Chapters Three and Five that Echelon used the FOT for further testing of equipment and software. Project participants were unaware of this until the end of the FOT. The additional testing added to the burden of the participating operators and prevented the system from achieving a stable operating state. This would likely not have been the case if the project had strong leadership and management, or if the operators had a significant financial stake in the project. Because 1) Echelon was not subject to any reporting requirements that made it necessary to reveal this decision, 2) the operators didn't pay for the equipment, and 3) Passport use represented a very small portion of transit revenues (except in the case of VISTA), the operators had little incentive to pay much attention to what was happening with the equipment.

6.1.3.5 Participant satisfaction

It is important to note that the majority of the operators remained supportive of the project, and that the FareTrans VMS has since become permanent in Ventura County (See section 6.4). Operators continued to expect that sooner or later they would gain access to the data they needed for operations planning and Section 15. By the end of the FOT, many felt that the worst was behind them, and, having gone through the trouble of deploying the system, it was prudent now to take advantage of it.

6.1.4 Summary

Chapter One described the FOT objectives as stated in the Echelon documents. The major goal was to develop and implement a fare transactions and vehicle management system that would 1) accommodate integrated fare transactions among the participating operators; 2) generate data and reports necessary for multi-agency operation; and 3) produce ridership statistics suitable for Section 15 reporting requirements. These objectives were not fully accomplished. Integrated fare transactions were accomplished via the deployment of on-board equipment, sales and use of the smart Passport; and communications between agencies, outlets, garages and the central data files. Data and reports were generated, but their reliability was never established. Statistics suitable for Section 15 reporting requirements were produced only in example form for one small operator. Our evaluation shows that the limited success of this FOT in reaching its stated objectives resulted from a combination of technical and institutional problems.

It is important to place these findings in context. This FOT demonstrated that an integrated fare and vehicle management system is technically feasible. The test provides an important proof of concept. Fare transaction equipment was designed, developed and installed on a wide variety of transit vehicles. Smart Passports were sold at different outlets, and transit passengers successfully used the Passports on all the participating transit services. Transit passengers who purchased the Passport were overwhelmingly positive in their assessment of the card. From the passenger's perspective, system problems were invisible. Data management and communication were accomplished by Echelon retaining the central data bank function and resorting to hand transmission of data as necessary. Echelon adapted to implementation deadlines, operators' changing requirements, and a variety of unanticipated technical problems.

Ventura County's Phase III demonstration was far more complicated than the Phase II exercise in Los Angeles. Moving from using the FareTrans VMS in single operations to using it in an integrated way across several operators is a significant technological and institutional challenge. An integrated system requires a complex data communications and management system that was completely absent from the previous phase. An integrated system also requires cooperation among the participating operators with respect to fares, service decisions, card policies, and revenue allocation. This aspect was also absent in the previous phase. Deployment was made more complex by the operators' inability to agree to consistent policies. *Different rules for as handling overdrawn debit cards or establishing card lockout periods demonstrated the system's flexibility, but taxed Echelon's ability to respond in the field*. Phase III was further complicated by adding the passenger counting element which greatly increased data processing and communications requirements. Thus the deployment and relatively successful operation of most of the system is clearly a major accomplishment.

6.2 LESSONS LEARNED AND RECOMMENDATIONS

The same evaluation team has evaluated both Phase II and Phase III. Lessons learned are the result of both phases of this FOT.

6.2.1 Incremental Tests

New technology tests are complex, and should be approached incrementally. The differences in outcomes between Phase II and Phase III are striking. The goal of Phase II was straightforward: to demonstrate the operational feasibility of on-board equipment, and to compare the technical performance of two types of Smart Card technologies. At the time, there was some disappointment among project leaders that the Phase II test would be so limited. In retrospect, this is a major factor in its success. All parties were satisfied with the FOT, and at least one operator contracted directly with Echelon for additional services as a result of the FOT.

In contrast, Phase III attempted to deploy many different elements (card transaction equipment, APCs, printers, voice messaging), while also testing integration for the first time, and in two dimensions at once. The problems associated with automating data flows and integrating across multiple operators proved to be enough of a challenge. The project would likely have gone more smoothly had the APCs been delayed to a later phase.

6.2.2 Unavoidable Delays

Delays are unavoidable, and should be built into FOT schedules. The evaluation team has collectively been involved in seven different FOTs. Delays have been a significant problem in all of them. Inevitably, procurement takes longer than anticipated, vendor contracts have unforeseen problems, and funding approvals are delayed. Technical problems also arise; solving these problems generally involves some degree of system re-design. Phase III is the first case in which the deployment schedule was forced, and this led to many subsequent problems. Strategies to minimize delay problems include building in some flexible time in the project schedule, close management (including clearly defined project authority), and pro-active problem solving.

6.2.3 Strong Management.

FOTs require strong and consistent management. The Phase III FOT suffered as a result of weak and inconsistent management. There was a sense that no-one was in charge. The Volpe Center was Echelon’s contractor, but had almost no involvement in the FOT. Local sponsors included Caltrans and VCTC. The Caltrans-Headquarters project manager was replaced in the middle of the FOT, and the Caltrans-District 7 project manager attended only one monthly meeting during the entire project. Whether Caltrans had any authority over Echelon was unclear. VCTC clearly was the lead agency in Ventura, but the burdens imposed on an overextended staff seemed to preclude any consistent monitoring. Hiring an outside project manager did not solve the problem, because she had no real authority to take actions or enforce decisions. Instead, problems gradually built up until VCTC leadership took action, sometimes at Echelon's prompting.

Strong and consistent management is required to keep the FOT on course, broker disagreements among project participants, facilitate problem solving, and enforce contractual obligations. *This points to the importance of a project manager with both real and apparent authority.*

6.2.4 Formal Arrangements

Contractual arrangements should be formal and clear to all parties. Phase III was remarkable (but by no means unique) in its absence of documentation and lack of formal roles and responsibilities among project participants. We surmise that this was partially due to the local environment, where there was a high level of personal familiarity among participants. Project participants were also uninformed. They had never been involved in an FOT, and they received little information about what the project would entail. The absence of formal arrangements allowed Echelon to act independently and be selective about providing project information. The same flexibility allowed VCTC to make reactive decisions and change the rules as the FOT progressed.

Many of the problems encountered could have been avoided had roles and responsibilities been clear. It would not have taken months to obtain information as basic as fare structures.

6.2.5 Participant Buy-In

Buy-in is required of all participants. An FOT involves all levels of the participating organizations, from management to the lowest clerks. In this case, drivers, garage personnel, administrative staff, as well as management were effectively part of the FOT, whether they knew it or not. However, only management was involved in the decision-making, even when drivers or others were involved. In the transit agencies, Echelon relied on management to gain the cooperation of drivers, garage staff, and contract service providers. Echelon relied on management to provide necessary information, and to communicate project requirements to their staff. This did not work. Communications between Echelon and the transit agencies regarding technical matters was problematic. Lack of support on the part of some contractors and SCAT maintenance staff reduced technical performance.

To gain the support of all participants, adequate information on the FOT must be provided. Information must be communicated in terms that are comprehensible to people with limited technical knowledge. Participants must be convinced that the FOT is important, and that their cooperation is critical to the project's success.

6.2.6 Test Sites

Choice of the test site should be appropriate to the goals and objectives of the FOT. The goal of this FOT was to demonstrate an integrated fare and vehicle management system. Using seven small operators for such a test had both advantages and disadvantages. Using small operators implies fewer buses and less complicated route systems. Small operators typically are less bureaucratic and therefore are more capable of making decisions and working cooperatively. On the other hand, small municipal operations are unsophisticated and often are run as part of other public works activities. In this case, most of the small operations were contract operations, and the contractors had no incentive to participate in the project beyond what was necessary to keep the contract. Implementing a highly sophisticated technical system in such an environment implies a very big change in operations.

Further, the nature of the services these operators provided made the prospect of a seamless, multi-agency fare system irrelevant. The operators served mostly distinct, widely separated locations. There were no operational adjustments made to promote or even enable multi-agency trips. At the few locations that could accommodate interagency transfers, no new user information was made available to travelers, nor is it clear that these new options would have been useful for the market being served.

6.2.7 Technical Knowledge

Basic technical knowledge and expertise of project participants cannot be assumed. Public agencies do not necessarily have the latest computer equipment. The best equipment available also tends to be the most secure: Modem access to computers connected to government networks is unlikely. Public agency staff are not necessarily familiar with basic computing technology. Transit drivers are employed to drive buses, collect fares, and provide courteous service to transit patrons. Technical skill requirements are limited. Maintenance staff are highly trained in bus maintenance and repair, but do not necessarily have the skills to deal with new technical equipment, or with computing and data transmission equipment. Small private contractors tend to pay lower wages and use older equipment, and are even less technically sophisticated.

The mismatch between Echelon's expectations and the reality of the transit operators contributed to many problems. Inadequate computer equipment was a problem until early 1997, when VCTC took the necessary step of purchasing new computers for some of the outlets and garages. Driver's inability to input correct information caused much redesign of the system software. Communications between Echelon and the operators was a constant problem. Managers of FOTs should begin with the assumption that participants do not have technical knowledge, and should assure effective communications between the technology developers and project participants. This process is abstract and consumes project resources, but it is a necessary cost of doing business in the field.

6.2.8 Financial Stake

When participants do not have a financial stake in the FOT, there is less incentive for taking ownership and responsibility. The participating agencies had no financial interest in the FOT, with the exception of VCTC's purchase of computers near the end of the FOT. Lack of financial involvement creates problems, as it in effect removes the FOT from the real world of scarce resources. Had the transit operators paid some portion of the capital costs, or had they been responsible for maintaining the equipment, there would have been a clear incentive to keep the equipment operating. Echelon would have been held to a much higher standard of performance, and it is likely that data and other problems would have been discovered and resolved more rapidly.

Financial interest would also have generated an assessment of whether the system was a worthy investment. Decisions now being made in Ventura are based on sunk costs: the system has been installed, and a great deal of effort was devoted to getting it to perform at an acceptable level. The question for Ventura is how to best manage the system it has in place. For other transit agencies, the question is whether such an investment should be made.

Of course FOTs are experimental, and it is unlikely that transit agencies would agree to participate if a financial commitment were involved. This is a problem for all FOTs and is not easily resolved. At a minimum, comprehensive analysis of costs should be a part of FOT evaluation.

6.2.9 Public/Private Partnerships

Public/private partnerships require that the interests of both sectors be served. Like many other FOTs, this one involved a private technology developer and several public agencies. Echelon's main objective was to develop a commercially successful product that would lead to future profits. That effort was subsidized with public funds. In theory, subsidies are justified because the public interest is served by bringing useful products (e.g., products which improve productivity of public services) to market more rapidly. In addition to the direct subsidies, Echelon received indirect subsidies in the form of time and effort provided by all the project participants, access to equipment, and a test bed for further experimentation. In contrast, project participants did not receive the deliverables they were promised. It appears that in this case, the public sector was not adequately compensated for its efforts.

Public/private partnerships require clear agreements regarding expectations, responsibilities and contributions for all parties. As noted in point 4 above, formal contractual arrangements are critical to establishing effective FOTs.

6.3 SHOULD INTEGRATED FARE MANAGEMENT SYSTEMS BE WIDELY ADOPTED?

An important purpose of an evaluation such as this is to consider wider application of the technology. The key questions here are: 1) is the Smart Card an appropriate fare media for public transit? 2) is there a market for integrated fares? 3) is a bundled system which includes Smart Card, GPS, and APCs appropriate for public transit?

6.3.1 Is the Smart Card an Appropriate Fare Media?

Passengers who used the Passport were overwhelmingly positive. However, we estimate that the Passport is used only by about five percent of Ventura County transit riders. Even among VISTA passengers, for which the Passport is the regular multiple-ride fare medium, the Passport is used by about 20 percent of passengers. Limited use of the Passport has a number of explanations: participating operators offered their own multiple-ride options which in some cases were cheaper than the Passport; buying a pass of any sort requires some degree of inconvenience (extra trip to an outlet); buying multiple rides is not financially feasible for very low-income transit users; the common fare was not a sufficient inducement in a transit environment where transfers between operators were rare and inconvenient.

The most recent NPTS data show that the market for public transit is increasingly one of the transit-dependent population (Pucher, 1998). In large metropolitan areas, the market for public transit is also increasingly diverse, with recent immigrants making up a growing proportion of ridership. Evaluations of Phase II and Phase III of this FOT both show that those with very low incomes and those who do not speak English are least likely to use the Passport. It would appear that media such as the Passport appeal to a declining share of transit patrons.

Although transit operators and drivers find cash fares to be inconvenient, it is difficult to envision elimination of cash fares. Therefore Smart Cards must be evaluated as an additional fare medium. The onboard cash box cannot be eliminated, nor can all the functions associated with collecting cash fares. In an area like Ventura, the costs of purchasing, installing, operating, and maintaining the system would far exceed the benefits of offering this fare alternative for a small minority of passengers.

Our evaluation of Phase II indicated that the market for the Smart Card is among more affluent, discretionary riders, such as long distance commuters to downtown jobs. These commuters have chosen transit for its relative convenience and lower price. A fare medium that could be renewed onboard the bus and provides significant discounts would be attractive. However, a careful assessment of costs and benefits would be required to determine whether a Smart Card system would be cost-effective even for commuter-oriented transit services.

6.3.2 Is There a Market for Integrated Fares?

We were unable to determine whether the availability of an integrated fare leads to increased ridership, because the new VISTA service and the Passport were introduced before the smart Passport. Chapter One stated that true service integration requires more than a common fare medium. It requires integration of the service itself – convenient transfers, coordinated schedules, etc. These conditions were not met in Ventura County. With the exception of VISTA, the other transit operations served highly localized markets. The geography of the County precluded integrated services, and in the few locations where transfers between services were possible, services were not coordinated.

Chapter One also noted that conditions for service integration typically occur in dense urban settings, where different modes intersect, or where different operators offer service in the same area. Such markets exist. The WMATA demonstration linked bus, rail, and parking fees. Various arrangements have been established to accommodate bus and rail transfers for downtown commuters. However, barriers to service integration have been institutional, not technical. *The seven small operators involved in the Ventura County demonstration showed how difficult it can be to overcome institutional barriers*. The VISTA service was set up in such a way that even at some designated transfer locations, bus stops were physically separate.

If opportunities for service integration are more likely in dense urban settings, it follows that the integrated fare medium must be able to perform adequately in an urban context. Urban transit systems are large and receive a larger proportion of revenue from the fare box than is the case for Ventura County. Data collection, transmission, and management requirements would therefore be far more demanding. Revenue allocation would be a critical issue. The level of technical performance of an integrated fare system would therefore have to be much better than what was observed during the Phase III demonstration for such a system to be feasible.

6.3.3 The Integrated System

The FareTrans VMS combined three technologies: Smart Card, GPS, and APCs. We found that the APCs did not work, and that the desired data from the APCs and GPS was not provided to the transit operators during the FOT. Given the experiences of this FOT, it is also worthwhile to consider the potential benefits of each of these elements. GPS is a more widely used technology. Commercial freight operators make extensive use of GPS for vehicle tracking, schedule monitoring, and assigning pick-ups and deliveries. GPS in public transit offers the possibility of vehicle tracking and monitoring schedule adherence. For large urban transit systems, schedule adherence is frequently a problem. GPS can be used to monitor routes, identify problems and generate strategies for improving schedule adherence. GPS also allows quicker responses to bus emergencies. It is therefore not surprising that GPS is being used or tested by a variety of transit operators (Casey, et al., 1998).

When linked with APCs, GPS provides the opportunity to track ridership in time and space. It is possible to count boardings and alightings by stop, and therefore to obtain detailed information on transit demand patterns and vehicle load factors. Working APCs would indeed make it possible to conduct ridership counts required for Section 15 reporting. Whether investment in such a system is warranted depends on its costs relative to the cost of collecting the data in some other way. Large transit systems would likely benefit more than small systems. First, the cost of Section 15 data collection is higher for large systems. And second, ridership patterns are more transparent in small systems. Long-term managers or drivers have considerable informal knowledge of ridership patterns, and therefore more extensive data collection may have limited use. In contrast, large systems may benefit greatly from the opportunity to gather ridership data in a systematic way. The APCs provide the possibility of regular random sampling.

The Smart Card is required if individual trips are of interest. Because the propensity to use Smart Cards is related to characteristics of the riders, however, Smart Card trip data will not be representative of the general ridership. Therefore Smart Cards cannot be justified on grounds of data collection or operations planning.

We conclude that Smart Cards may have limited utility for public transit, at least for the foreseeable future. As Smart Cards become common for other types of financial transactions, it is possible that they will be more attractive to transit riders. For example, a more effective strategy for public transit may be to wait and use media that are adopted in other sectors, for example ATM/debit cards. Magnetic stripe cards do not have sufficient reliability for wide-spread transit use (Moore and Giuliano, 1998), but if electronic purses enter use in other markets, their use could be extended to include transit transactions. Smart Cards are not necessary for passenger data collection, nor could they be relied upon to provide unbiased data on ridership patterns. An additional fare collection system adds to operating costs. GPS has potential for a variety of applications in public transit. APCs remain attractive in concept, but their technical performance remains to be demonstrated.

6.4 EPILOGUE

Echelon Industries reports that one of the reasons for their aggressive component testing program was their perception that permanent adoption in Ventura County was unlikely. Echelon felt the firm had made its best effort, and had continued to have considerable faith in their FareTrans VMS design. But the deployment had been difficult for all the reasons described here and in preceding chapters, and Echelon assumed that the operators would decline continued use of the system. From a commercial perspective, the value of the FOT to Echelon then became a function of what Echelon could learn, and this depended on how much testing could be done.

The Ventura County Transportation Commission viewed the FOT outcomes differently than Echelon Industries anticipated. VCTC seemed to understand the magnitude of the barriers that had been overcome during the test; and developed a genuine appreciation for the system's potential. Supporting operators' Section 15 reporting requirements remains an important priority for VCTC and those operators subject to these requirements. VCTC's administration ultimately did elect to retain the FareTrans VMS on its VISTA routes (Gherardi, 1998), and also in cooperation with other operators. VCTC has entered into a maintenance and reporting contract with Echelon Industries. VCTC has also expanded the original deployment to include all SCAT, Simi Valley, and Moorpark buses. The service contracts VCTC provides to Santa Barbara and Antelope Valley Bus Companies and FATCO for provision of VISTA services have been modified to specify FareTrans VMS problem reporting requirements, and to ensure timely vehicle availability when FareTrans VMS repairs must be made. VCTC is investigating other extensions of the technology, including use of a commuter rail pass.

These decisions reflect considerable optimism. As we have described, project outcomes were difficult to measure because the project continued to generate changes and refinements throughout the FOT and following the conclusion of the formal test period. Even in the closing months of the test, the system was not yet performing in a stable, reliable way. Learning was still occurring on the parts of both Echelon and the operators, and problems were still being identified and addressed. This process continued unabated long after the evaluation team stopped collecting field data. For example, it was not until April 1998 that Echelon identified the circumstances under which some of transaction data being uploaded from the garage computers to the central data bank were inadvertently being deleted. This problem was identified because VCTC compared boardings and alightings reported by Echelon to field counts of their own. The evaluation team had the same experience and reported this to VCTC. Perhaps this is why VCTC conducted additional counts after the evaluation had ended. We like to think so.

Had the test continued into a period in which the system's stable operation was clearly observable, had Echelon not be forced into the field prematurely, or had more cooperation been forthcoming from the garages, a clearer accounting of the system's performance would likely be possible. The evaluation is constrained to the data collected in the field and provided by Echelon, and this data does not describe a system that is functioning reliably.

Is it now? Throughout both Phases of the FOT, Echelon Industries has behaved in a predictable, rationale way – identifying opportunities, taking calculated risks, and responding to the sorts of economic incentives important to commercial firms. VCTC's decision to retain and maintain the FareTrans VMS equipment gives Echelon Industries new incentives to make sure the system performs reliably. It is reasonable to expect Echelon has responded to these new incentives. It is in Echelon's interests to improve the system's performance. VCTC is clearly encouraged and remains enthusiastic about the product. The current system may be performing better than the system measured by the evaluation team, but we have no objective way to verify this.

Is VCTC being too optimistic? Public agencies are historically conservative, particularly with respect to technology procurement, and the Commission has little incentive to take unwarranted risks. But in retrospect, it is clear that VCTC wanted to retain the system even under circumstances in which Echelon and the evaluation team both would have predicted otherwise. One interpretation is that the Commission is showing vision, and has a deep enough understanding of the constraints Echelon has had to work through over the past four years to know what must be done to put the FareTrans VMS equipment to productive use. We do not discount this view, but our perceptions are tempered by VCTC's decision to force the deployment schedule at the beginning of the test. *While this certainly demonstrates a willingness to perform the critical role of project champion, this* also suggests a capacity for over optimism.

There is more to be considered. There are differences in perceived and measured system availability and performance across operators. These differences are reported here, and by VCTC (Gherardi, 1998). These differences lead us to conclude that active cooperation in the SCAT garage would make considerable difference in the performance of Echelon's system on South Coast Area Transit agency buses. This is important because SCAT is large relative to the other County operators. This is a qualitative conclusion, but an informed one.

We remain unconvinced that automatic passenger counters work in Ventura County or anywhere else. We are not convinced that they never will work, but we cannot verify that they do. Our evaluation activities have brought us no information from the field at large, anecdotal or otherwise, indicating that this is a mature technology. We can verify that the APC sensor equipment operates reliably. The system was in service less frequently than we expected, but some of our observations were certainly affected by the difficulty Echelon had in making repairs at SCAT. More importantly, it is unclear that the means exists for converting Echelon's raw APC data to reliable measures of boardings and alightings. Echelon provided the evaluation team with access to its APC records, but not the algorithm Echelon uses to convert this raw data to report values. Even when this raw APC data was available, Echelon was usually unable to provide automatic passenger counts to compare against our field observations. Without knowledge of Echelon's algorithm, the evaluation team has no way to convert raw APC data into additional count estimates, nor any way to replicate the few estimates Echelon was able to provide. Consequently there is little we can say about the quality of future automatic passenger counts in Ventura County, other than that there is enormous room for improvement relative to our measurements. Nor is this not a trivial problem. If Echelon is able to make these improvements, we think they will be the first in the field to do so.

Still, our overall assessment of APC technology is that it will work. Combining APC and GPS data with changes in bus practices and advanced pattern recognition programs are likely to eventually provide the cross referencing and inference opportunities needed to construct high quality APC estimates. A more sophisticated system may be more expensive, but if the objective is to support Section 15 data collection requirements, every bus need not be equipped with working APCs. Regular random sampling can be accomplished even if relatively small portion of the fleet is APC-equipped and these buses are rotated systematically across routes. These sorts of changes in bus practices were not part of the FOT, but achieving them is likely to be a necessary step for successful commercial deployment.[2]

[2] VCTC reports this approach was implemented following the demonstration.

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APPENDIX 1A
LITERATURE REVIEW

Many transit agencies are examining ways to improve their operations. Transit operators want to increase efficiency, attract more riders, and conform to government regulations and reporting requirements. They are increasingly testing and using advanced fare media as one way to improve their services. Potential benefits of advanced fare media include simplifying the fare collection process, enabling integration with other transit operators and modes, including rail systems and parking; reducing operating costs, increasing the convenience and attractiveness of transit, and providing information about passengers and transit operations.

Until recently, the most commonly used advanced fare media was magnetic stripe cards. As a result of recent technological improvements in microprocessors and reductions in technology cost, Smart Cards have begun to replace magnetic stripe cards. Transit agencies all around the world are testing or implementing Smart Card systems. But because the technology is relatively new, the literature on Smart Cards in transit consists mostly of test reports, conference proceedings, and articles from the media. This review provides a reference for transit agencies interested in adapting Smart Card technology.

This literature review consists of three parts. Part One is a summary of the evolution of Smart Card technology. Part Two is an investigation of the potential impacts of Smart Cards in achieving transit operators' goals, and of what transit requires from this technology. Part Three is a summary of results from previous studies of Smart Card applications in transit.

1A.1 EVOLUTION OF FARE CARD TECHNOLOGY

1A.1.1 Magnetic Stripe Cards

Magnetic stripe cards appeared in the banking industry in the late 1970's. Once international standards were developed, magnetic stripe cards became an effective way of providing convenient customer service. The use of ATMs allowed banks to offer new services, and to accommodate more customers without increasing staff levels or building expensive facilities (Casey, et al., 1996). A magnetic stripe consists of magnetic material combined with paint or binder that is subjected to a magnetic field before drying. Today, these cards are widely used for banking, retail, telephone systems, access control, airline ticketing, and transit fare collection. Magnetic stripe cards are inexpensive, but they have several shortcomings. They have a limited capacity to store information, although data can be read both to and from the card. In addition, they are relatively easy to duplicate, and subject to fraudulent use.

1A.1.2 Integrated Circuit (IC) Memory Cards

IC memory cards rely on electronically programmable read only memory (EPROM), and lack a microprocessor, although they are sometimes referred to as “Smart Cards.” These cards have a circuit capable of executing some preprogrammed instructions. The circuit cannot be reprogrammed, since instructions are built into the circuit itself. Such wired logic cards are used chiefly as prepaid cards for public phones. IC memory cards are also referred to as “first generation Smart Cards” (Bright, 1988).

1A.1.3 IC Smart Cards

As the data storage capacity of cards has increased, the benefits and incentives associated with coupling data storage with processing capacity have also increased. Like first generation cards, second generation cards are portable data storage devices. However, second generation cards also include microprocessors, and thus combine a degree of intelligence with provisions for identity and security (Bright, 1988). These cards include a microprocessor, arithmetic processing registers, random access memory (RAM) used during program execution, read-only memory (ROM) to house the operating system, electronically erasable read-only memory (EEPROM) for data storage, input/output, and an integrated operating system embedded in a credit card-sized plastic (Giuliano and Moore, 1996).

Smart Cards were invented in 1974 by a French company, Innovatron. Smart Cards were first developed in Europe because high telecommunications costs provided special motivation for offline capabilities in cards (Fancher, 1996). In the US, where telephone calls are cheap and it is a simple matter to attach a magnetic-stripe reader to a phone line, the fraud-reduction capabilities of Smart Cards are not necessarily worth the extra expense. Instead, merchants can dial up a central database to make sure a card is valid before completing a transaction. In Europe, where calls are generally more expensive and connecting modem-equipped devices to phone lines is more difficult, security was a significant driving force behind Smart Card introduction. By the early 1980s pilot projects were underway in France to use Smart Cards for such applications as postal money orders and prepaid tokens for public pay phones. In 1982, a banking test began that involved residents, merchants, and banks in French cities of Blois, Caen, and Lyons (Geehan, 1989, p. 38).

1A.1.4 Contact vs. Contactless Cards

Smart Cards can be classified as contact and contactless cards, depending on how data is transmitted between the card and the card reader. Electronic information is communicated between contact cards and external devices through physical contact. In contrast, contactless cards need merely be brought into proximity with the target reader. The user does not have to remove such a proximity card from his/her wallet or purse for electronic read/write/verify sequence to occur and transactions to be allowed. Contactless cards use either a capacitive/inductive or a radio frequency technique to interchange data between the card and the reader (Joshi, 1994). Radio frequency cards achieve data interchange via an antenna embedded within the card (Giuliano and Moore, 1996)

1A.1.5 Super cards

Third-generation Smart Cards are called “super” or “active” cards. These cards include a display and keypad, eliminate the need for installing card readers, and provide a user-friendly dialogue and corresponding ease of use (Bright, 1988). Bright describes the “ULTICARD” developed by the Smart Card International, Inc., as a model for these third-generation cards. The ULTICARD has been used in Houston’s Methodist Hospital and Baylor College of Medicine to prompt and record patient food and drug intakes, and to record patients’ body weights and exercise routines. The card was also used by Thomas Cook travel agency to record travel status, trip itinerary, frequent traveler information, travel expenses, and other user information.

1A.2 FARE COLLECTION IN TRANSIT

In traditional fare collection practice, the driver oversees the deposit of fares into a simple drop box with a slot. Traditional fare payment methods prohibit differentiated fare structures, and make it difficult to remove fare collection from the domain of the vehicle. Further, fare boxes lengthen transaction times, and require substantial maintenance. They offer no opportunities for automatic statistical data collection, and are subject to evasion (Koo, 1993; Geehan, 1989).

1A.2.1 Automated Fare Payment Media in Transit

Advanced fare payment in transit uses advanced technology to collect fare payments electronically. The simplest means of advanced fare payment is a time-based, read-only magnetic ticket. The more enhanced magnetic stripe card has read and write capabilities, which enable value to be stored and subsequently deducted from the card. A Smart Card has more data processing and security features, enabling complicated fare programs and transfer schemes among modes (Dinning and Collura, 1996).

Automated fare media makes differentiated fare pricing systems much easier to implement. Instead of being charged flat fares, users can be charged fares based on distance, time of day, their income, and their age. Advanced fare media are also convenient for the users because they eliminate the need to carry exact change and to remember the exact fare.

Handling tokens, paper transfers, and tickets may be very labor-intensive and expensive for agencies. Adoption of automated fare media may decrease these costs because transactions are automatic, and reductions can be made in the ranks of fare collection staff and revenue processing personnel (Fleichman, 1996). Interest on the cash collected and the percentage of stored value that is never used can be a source of revenue for the operators (Dinning and Collura, 1996).

Many transit officials claim that they forego millions of dollars each year because of fare evasions, theft, and other types of fare abuse associated with fare boxes. The use of automated fare media can result in a more controlled fare collection process and eliminates the need for drivers to check the correctness of fare payments while they are driving buses. According to New York officials, implementation of magnetic stripe cards together with new turnstile designs and increased police presence have reduced fare evasion by 50 percent (Dinning and Collura, 1996).

Advanced fare media can support intermodal transportation. A common fare media makes transferring between systems easier, and removes the need to purchase media from each operator. Patrons who possess a fare card that can be used on other transit systems may be more likely to explore what another system has to offer (WMATA, 1996, p. 26). An advanced common fare media allows flexible pricing and records data to support revenue distribution between agencies.

1A.2.2 Use of Magnetic Stripe Cards in Transit

The first use of magnetic stripe fare cards in North America was on the Long Island Railroad in 1964 (Casey, et al., 1996, p.100). Data corruption in magnetically encoded tickets becomes problematic in the transit environment due to effects from stray magnetic fields in the passenger environment (Geehan, 1989, p. 99). Despite their various technical limitations, magnetic stripe cards are inexpensive and fairly standardized in transit applications relative to Smart Cards. Magnetic stripe cards remain the most widely used advanced fare medium.

1A.2.3 Use of Smart Cards in Transit

Smart Cards have the potential to improve transit operations in several ways. The independent intelligence of Smart Card allows the read/write units to operate in a secure manner without connecting to another, larger computer system. Further, "a programmable microprocessor's flexibility and capacity for complex operations is ideal for transit use because fare collection requires storage of information that is frequently updated" (Roberts and Wong, 1988, p. 3). Smart Cards also can store a greater amount of information than magnetic stripe cards. When coupled with a programmable microprocessor, this capability allows more sophisticated fare pricing systems as required from the transit systems.

Smart Card systems can automatically collect data on transit operation, revenue, and patronage. Thus, data that the transit agency would otherwise have to collect through fare boxes and supplemental surveys (or ride checking) can be collected more cheaply and reliably. Data collected from transaction summaries can be used to obtain more information about transit markets, and this information can be used to increase ridership.

Smart Cards, especially contactless Smart Cards, may increase efficiency of transit operations by increasing passenger throughput. Chavala and Coifman (1996) found that the average boarding time for Smart Card users was about 0.40 to 0.64 the time required by cash and token users. However, they also found that the use of Smart Cards by up to 50 percent of riders did not result in a statistically significant reduction in average vehicle dwell time at bus stops.

Smart Cards are also easier for the elderly and the handicapped to use. In the case of contactless cards, the user does not have to remove the contactless card from their wallet or purse for the electronic read/write/verify sequence to occur and passage to be allowed. In the case of contact cards, the card is merely touched to the reader. Magnetic stripe cards need to be swiped, which may be difficult for the elderly and the handicapped.

The push for improved transit access by clean air requirements encourages integrated fares across transportation modes and transit agencies (Fleichman, 1996, p. 5). Similar requirements exist in the Transportation Equity Act for the 21st Century (TEA-21). Smart Card technology is the "ultimate form of fare integration" (Papageorgis, 1990, p. 49). Integrated fare payment systems are made possible by Smart Card technology through advances in electronic data processing, data storage, and data communication. By automatically recording trips, revenues can be split between different transit operators (Casey, et al., 1996, p. 98).

Because Smart Cards operate without mechanical parts and data moves electronically between the card and the terminal, problems associated with paper fare card dispensers and magnetic-stripe transport devices are eliminated (WMATA, 1996, p. 9).

Since they do not get in direct contact with the card reader, it is reasonable to assume that the contactless Smart Card technology avoids wear on mechanical parts, and guarantees long life even if cards are used very frequently (Koo, 1993). By decreasing fare box maintenance and prolonging equipment life, Smart Cards can reduce cost of transit operations.

Integration of fare collection and control equipment with other electronic equipment onboard the vehicle can help to avoid duplication and excessive costs" (Geehan, 1989, p. 103). Numerous benefits are possible. For example (Giuliano and Moore, 1996), a fare transaction unit linked with a vehicle locator system permits distance-based or "needs-based" fares to be charged, and schedule adherence to be monitored. A passenger boarding/alighting counting system linked with a fare transaction system can provide a detailed database of ridership characteristics. This meets the requirements of Section 15 of the federal transit regulations, decreasing the expenses associated with meeting federal requirements for collection of ridership data. In this type of integration, sensors are mounted on the vehicle to permit the driver and central operations to determine vehicle loads, and readers are located either in the infrastructure or onboard the transit vehicle to allow fare payment. A transfer and receipt printing system helps improve data keeping and reduce transfer costs. A bus stop announcement system addresses ADA requirements.

1A.3 RESULTS FROM PREVIOUS STUDIES OF ADVANCED FARE MEDIA APPLICATIONS IN TRANSIT

There are many ongoing or planned tests of various technologies around the world. Several tests are underway or in development in the US (Fleichman, 1996). See Table A1-1 for a list of some of the worldwide applications.

1A.3.1 Ann Arbor, Michigan

The Ann Arbor Transportation Authority (AATA) Smart Bus project provides a multimodal system that supports both bus and parking applications. Proximity cards were used onboard the bus system and in designated parking lots (Bolton, 1993).

1A.3.2 Manchester, England

The Greater Manchester Passenger Transport Executive (GMPTE) automatic ticketing system was upgraded from magnetic strip to a contactless RFID Smart Card system. This benefits both the transit system and its users by improving system speed, convenience, and reliability. The initial purchase involved 500,000 cards used on Greater

Table A1-1 Summary of Fare Applications

Location	Transit Agency	Project Name	Type
Bus Systems			
Ajax, Ontario	Ajax Transit Authority	Ridekey	RF Coupling
Burlington, Ontario	Burlington Transport	Pilot Bus Card System	RF Coupling
Dublin, Ireland	Dublin Bus	DASH (GAUDI field trial)	IC Contact
Helsinki, Finland	Helsinki Metropolitan Area Council	Helsinki Travel Card Trial (Bus 91)	IC Contact
Helsinki, Finland	Helsinki City Transport	Helsinki Travel Card Trial (Bus 91)	RF Coupling
London, England	London Transport	Contactless Card Trial	RF Coupling
Los Angeles, CA	Culver City Municipal Bus	Metrocard	Mag Stripe
Oslo, Norway	AS Oslo Sporveiver	Common Electronic Ticketing	RF Coupling
Phoenix, AZ	Phoenix Transit System	Bus Card Plus	Mag Stripe
Closed Rail Systems			
Chicago, IL	Chicago Transit Authority	Automated Fare Collection System	Mag Stripe
London, England	London Underground Ltd.	Touch and Pass (Go-card)	RF Coupling
Washington, D.C.	Washington Metro Area Transit Auth.	Uniform Fare Technology Demo	RF Coupling
Washington, D.C.	Washington Metro Area Transit Auth.	Metrochek	Mag Stripe
Paratransit Systems			
Chicago, IL.	NE Illinois Regional Trans. Auth. (RTA)	Payment and Control Info System	IC Contact
Helsinki, Finland	Handicab (Espoo)	Helsinki Travel Card Trial	IC Contact
Oakland, CA	Bay Area Rapid Transit	RFID System	RFID (1)
Multimodal Fare Systems			
Ann Arbor, MI	Ann Arbor Transportation Authority	Ann Arbor Smart Bus	RFID
Berlin, Germany	Berlin Public Transport Company	Bus/Rail/Taxi/Retail Stores	
Biel, Switzerland	Post, Telephone & Telegraph (PTT)	POSTCARD	RF/Mag Strp.
Central Point, OR	Rogue Valley Counc. Of Governments	Rogue Valley Mobility Manager	Mag Stripe
Hong Kong, HK	Mass Transit Railway Corp. (MTRC)	Common Stored Value Ticket	RF Coupling
Manchester, England	Greater Manchester PTE	GMPTE Contactless Smart Card	RF Coupling
New York, NY	Metropolitan Transportation Authority	Metro Card (Rail, Bus)	Mag Stripe
Oakland, CA	Metropolitan Transpt. Commsn (MTC)	Translink (BART, CCCTA)	Mag Stripe

Notes: RF Coupling Cards require shorter read range. An RFID card has a smart transponder that permits longer range

Source: National Technical Information Service (1995) Smart Cards for Transit: Multi-Use Remotely Integrated Stored-Data Cards for Fare and Toll Payment

Manchester's 2,700 buses, and for Metroline and rail applications. This was the largest contactless application in the world, and the first full-scale use in a ticketing application.

1A.3.3 Washington, DC

The Washington Metropolitan Area Transportation Authority (WMATA) equipped 19 rapid transit stations, 21 buses, and a number of its parking lots with proximity Smart Card read-write turnstiles and fare boxes. The GO CARD system used battery-powered, contactless Smart Card prototypes, thus eliminating the requirement of power conditioning circuitry on the cards. User satisfaction and acceptance of the program was high (WMATA, 1996, p. 4).

1A.3.4 Phoenix, Arizona

In 1991, the Phoenix Transit System was the first in the nation to install magnetic card readers on the electronic fare boxes on their buses. In May 1995, Phoenix was again the first to introduce a commercial credit card bus fare payment program making use of the magnetic card readers. Phoenix bus users can use their bank-issued credit cards to pay bus fares. Phoenix Transit relies on the banks to issue cards, keep track of accounts, and bill customers, all for the usual fees charged merchants by credit card companies. Since the electronic fare box is not connected to an interactive network, it is not possible to check the validity of the credit cards in real time. An updated list of invalid card numbers is loaded into the fare boxes daily. This limits fare evasion. Phoenix transit estimates the rate of invalid credit card use at around two percent (Casey, et al., 1996, p. 101).

1A.3.5 London, England

In 1992, London Transport completed their "212 Demonstration Project" to assess the suitability of Smart Cards (Joshi, 1994). The Harrow Trial in London ran for over 18 months and involved 180 buses. The test, which included 20,000 cards and more than 4 million transactions, showed that public acceptability of the card was very high. Further, the operators found the system very useful on reducing boarding times. Equipment and card reliability were high, and the degree of management information available was much improved over that obtained by surveys (Higgs, 1996).

1A.3.6 Chicago, Illinois

The Chicago Transit Authority (CTA) is in the process of introducing a new automated fare collection system that uses read-write magnetic stripe stored value cards. The agency equipped rapid transit stations with turnstiles that will take these cards, and its bus fare boxes with read-write units. Cards could also be used for small purchases from cooperating Chicago merchants (Casey, et al., 1996, p. 103). Chicago's Regional Transit Authority (RTA) has plans for a Smart Card project that includes 17,000 limited mobility riders of paratransit services and 260 vehicles.

1A.3.7 Other Tests

Other tests are located in:

- Ajax, Ontario, which began in 1991, and is one of the first demonstrations of contactless fare media (WMATA, 1996, p. B-10);
- Blois, France, where it was found that use of an integrated circuit card as a credit card for post payment of urban transit fares has a number of disadvantages (Geehan, 1989, p. 35);
- Wilmington, Delaware, where a contact Smart Card was used as a multi-use electronic purse;
- Dublin, Ireland, where cards were tested for bus, phone, parking, and toll applications (Joshi, 1994); and
- the Greater Seattle-Puget Sound region, where interagency fare applications were tested.

1A.3.8 Extensions of Smart Card Applications

> "*Although the development of Smart Cards in the banking and telecom-munications industries is significant, it is still at its infancy in terms of transit applications. Performance requirements are not well established in Smart Cards applications in mass transit"* (Attoh-Okine and Shen, 1995).

Future advances in the use of the Smart Cards depend on several factors. These factors include the rate of growth of Smart Card applications, the rate at which human beings grow comfortable with these applications, the rate of technological change, and the costs of these applications.

Transit fare payment developments will increasingly intersect with developments in the banking industry, including increasing use of electronic funds transfer methods for purchase of fare media, and use of credit cards for direct payment of fares (Fleichman, 1996). The "electronic purse" or multiple-use media concept, i.e., prepaid cards that can be used to conduct transactions related to several different functions, will be tested in a wider scope. Some transit officials suggest that transit properties should speed developments by attempting to work with private industry, such as banks and retail chains, where joint cooperation would result in economies of operation and customer convenience (Geehan, 1989, p.101).

APPENDIX 2A
EQUIPMENT DEPLOYMENT

"All of the subcomponents were off-the-shelf so we were not involved with the re-design or modification of components. However, we did conduct extensive tests of alternative, more cost effective and/or state-of-the-art products" (Rebeiro, Echelon Industries, 1997).

Table 2A-1 Hardware Deployment Checklist

	Deployed?	**Modified?**	**Redesigned?**	**Multiple Products Tested?**
Displays	Yes	Not Applicable	Not Applicable	No
Fare Cards	Yes	Not Applicable	Not Applicable	No
Fare Card Reader/Writers	Yes	Not Applicable	Not Applicable	No
Processor Boards	Yes	Not Applicable	Not Applicable	Yes
Serial I/O Cards	Yes	Not Applicable	Not Applicable	Yes
Digital I/O Cards	Yes	Not Applicable	Not Applicable	Yes
APC Sensors	Yes	Not Applicable	Not Applicable	Yes
GPS Receivers	Yes	Not Applicable	Not Applicable	Yes
Power Supplies	Yes	Not Applicable	Not Applicable	Yes
Key Pads	Yes	Not Applicable	Not Applicable	No
Stanchions	Yes	Not Applicable	Not Applicable	No
Printers	Test Only	Not Applicable	Not Applicable	Yes
PTU (DU/PU/CU)	Yes	Not Applicable	Not Applicable	Not Applicable
PTU Storage	Yes	Not Applicable	Not Applicable	Yes
Odometers	Yes	Not Applicable	Not Applicable	No
Speakers	Yes	Not Applicable	Not Applicable	No
Sound Card	Yes	Not Applicable	Not Applicable	Yes
Garage Computer / Display / Printer	Yes	Not Applicable	Not Applicable	Not Applicable
Local Area Radios	Yes	Not Applicable	Not Applicable	Yes
Outlet Computer / Display / Printer	Yes	Not Applicable	Not Applicable	Not Applicable

Antennae (GPS and Spread Spectrum)	Yes	Not Applicable	Not Applicable	Yes
PTU and APC Enclosures	Yes	Not Applicable	Not Applicable	No Response
Other Hardware Elements	None			

"The process of software development was interactive and iterative. As the system operated it provided information to the operators and Echelon as to what changes were necessary or desirable. Agencies are currently reviewing the data and requesting additional features in order to track certain types of transactions and better accommodate accounting" (Rebeiro, 1997).

Table 2A-2 Software Deployment Checklist

	Deployed?	**Modified?**
Card Registration Program: • Card Initialization • Card Recharging • Card Inquiry • Card Reporting	 Yes Yes Yes Yes	 Yes Yes Yes Yes
Control Software	Yes	Yes
Application Software	Yes	Yes
Network Program	Yes	Yes
Other Software Elements	None	

APPENDIX 3A
EQUIPMENT PROBLEMS AND RESPONSES

Table 3A-1 Problems and Responses

Problem:	
Initial deployment was rushed. The equipment installed in the buses was assembled, connected, turned on, and installed. It was not burned in. Some hardware components were missing because they had not been delivered, yet software for the passenger, driver, and central logic elements of the system was necessarily written simultaneously.	
Nature: Institutional.	Scope: Systemic.
Resolution:	
Software had to be written to operate the system without the missing elements, and subsequently revised. Components failing in the field had to be replaced as failures were identified.	
Problem:	
Incorporation of subsequent hardware deliveries required computer code update, which created multiple versions of the system software. Some of these were incompatible. For example, cards initialized with one version of the software could not be read or otherwise modified with reader/writers using another version of the software. At one point, about one half of the field equipment was not working due to incompatibilities across different versions of the system software.	
Nature: Technical/Operational/Institutional.	Scope: Systemic.
Resolution:	
Software versions installed on computers at sales outlets, onboard buses, and in garages had to be updated incrementally.	
Problem:	
Accessing the buses to complete equipment installation, update software, or make repairs was difficult. SCAT buses were available to Echelon on weekends only. Some VISTA buses are park outs that go to drivers' homes rather than to garages. It sometimes took weeks for Echelon to access such park out vehicles.	
Nature: Institutional.	Scope: Site specific.
Resolution:	
This problem was unresolved.	

Problem:	
Cable connectors were not clamped correctly when FareTrans VMS hardware was installed on the buses.	
Nature: Technical.	Scope: Systemic.
Resolution:	
Cable connections were reworked on all buses.	

Problem:	
Jumpers are used to complete circuits in buses not equipped with automatic passenger counters. This informs the FareTrans VMS control unit that no sensor is available. Many of the buses supposed to have jumpers did not.	
Nature: Technical.	Scope: Multiple sites.
Resolution:	
Jumpers were acquired and installed.	

Problem:	
There are two to three incidents per week of blinking or blank displays.	
Nature: Technical.	Scope: Systemic.
Resolution:	
Unknown.	

Problem:	
Approximately 80 % of the transaction failures at the beginning of the test were due to bad data resident on fare cards. There are problems with the initializations done for the first cards sold. This amounts to about 5 % of the cards initialized in the first month of sales.	
Nature: Man/Machine Interface.	Scope: Systemic.
Resolution:	
As the personnel at outlets gained experience, problems with card initialization became much less frequent.	

Problem:	
Bad cards and test cards remained in circulation. How to get them back was unclear.	
Nature: Institutional.	Scope: Systemic.
Resolution:	
This problem was unresolved.	

Problem:	
Buses start up with a 6 to12-volt fluctuation that causes the FareTrans VMS to lock up. Some vans have only 6-volt electrical systems.	
Nature: Technical.	Scope: Multiple Sites.
Resolution:	
New power supplies were installed to accommodate the dip in voltage. A delay was built into the FareTrans VMS to allow the bus power to stabilize before starting up.	
Problem:	
AM/FM radios onboard the buses interfere with the card reader/writer.	
Nature: Technical.	Scope: Site Specific.
Resolution:	
Unknown.	
Problem:	
Garage computers freeze, preventing transaction data uploads and downloads.	
Nature: Technical.	Scope: Multiple Sites.
Resolution:	
Watchdog timers were attached to computers to periodically reboot the systems. Uniform power supplies were attached to computers to protect the systems form voltage fluctuations.	
Problem:	
AM/FM radios onboard the buses interfere with the card reader/writer.	
Nature: Technical.	Scope: Multiple Sites.
Resolution:	
Unknown.	
Problem:	
Automatic modem connections between the central and garage computers are often unsuccessful.	
Nature: Technical.	Scope: Multiple Sites.
Resolution:	
Keep an operator in the loop to reinforce automatic procedures and investigate missing transactions data. Train garage personnel not to answer dedicated phone lines.	

Problem:	
Transaction files uploaded from buses can be lost if communication with the garage computer fails. Data loss occurs because the FareTrans VMS assumes the transfer has occurred, and erases the data stored on the bus.	
Nature: Technical.	Scope: Systemic.
Resolution:	
Keep an operator in the loop to reinforce automatic procedures and investigate missing transactions data.	
Problem:	
There were problems writing to cards. Users disappeared from the database 5-10% of the time. Values being written to the card did not match values written to the database. In late May 1996, functionality was added to the fare cards and the manufacturer's write algorithm was put into use. More problems began occurring.	
Nature: Technical.	Scope: Systemic.
Resolution:	
The problem with the manufacturer's write algorithm was identified and solved.	
Problem: Spread spectrum radio antennas were not functioning as advertised.	
Nature: Technical.	Scope: Systemic.
Resolution:	
The antennas were replaced.	
Problem:	
Some buses do not appear to be available to upload and download data. Bus practices are more complex than anticipated.	
Nature: Operational.	Scope: Multiple Sites.
Resolution:	
Keep an operator in the loop to reinforce automatic procedures and investigate missing transactions data.	
Problem:	
APC lenses or reflectors were covered or otherwise obscured, preventing operation.	
Nature: Technical/Operational.	Scope: Systemic.
Resolution:	
Transit properties relying on automatic passenger counters must define routine maintenance checks to ensure that line of sight communication between sensors is unimpeded.	

Problem	
Buses are rotated across routes. Drivers sometimes input the wrong bus number, property number, driver ID number, and/or route number into the FareTrans VMS.	
Nature: Man/Machine Interface.	Scope: Systemic.
Resolution:	
Each FareTrans VMS unit has an internal signature associated with the bus number so that each vehicle can ultimately be identified. The options for drivers to input data were reduced to the driver ID and route numbers only, which remain incorrect about 15% of time.	
Problem:	
Drivers were confused by the FareTrans VMS audio feedback during communication with the garage computer. Beeps indicating the beginning of an upload were mistaken for verification of an upload, and drivers did not reduce speed sufficiently to permit the upload to be completed.	
Nature: Man/Machine Interface.	Scope: Site Specific.
Resolution:	
Unknown.	
Problem:	
Uploaded data relating to fare card recharges were lost.	
Nature: Technical.	Scope: Systemic.
Resolution:	
Data describing dates and dollars was inadvertently stored in a vector identified as dollars only. Non-conforming data was deleted. Since no data redundancy exists in the FareTrans VMS, this information could not be recovered.	
Problem:	
The original training strategy was unsuccessful. Supervisors trained by Echelon Industries generally were not able or willing to train drivers and additional outlet personnel.	
Nature: Institutional/Man-Machine Interface.	Scope: Systemic.
Resolution:	
Echelon Industries undertook additional training and retraining responsibilities.	

Problem:	
The nature of FareTrans VMS failures is difficult for drivers to identify. Echelon Industries reports that approximately 2/3 of driver failure reports cannot be interpreted.	
Nature: Man/Machine Interface.	Scope: Systemic.
Resolution:	
Several ad hoc attempts were made to improve trouble reporting. SCAT was particularly systematic. These attempts were largely unsuccessful.	
Problem:	
The card initialization software sometime produces duplicate transactions.	
Nature: Technical.	Scope: Systemic.
Resolution:	
The initialization software was debugged incrementally as problems arose.	
Problem:	
Outlet personnel decided the card initialization software should include a "cancel" button.	
Nature: Man/Machine Interface.	Scope: Systemic.
Resolution:	
Unknown.	
Problem:	
Test card use cannot be separated from use of test cards returned to circulation.	
Nature: Institutional.	Scope: Systemic.
Resolution:	
The agencies were counseled to restrict issuance of test cards to Echelon, who would code them as such. Agencies building their own test cards should not re-circulate them.	
Problem:	
Bus engines must be running for automatic passenger counters to work. Otherwise, boarding passengers are not counted.	
Nature: Technical.	Scope: Systemic.
Resolution:	
Leave bus engines on when the drivers are out of the vehicle. This precludes installation of APCs in Compressed Natural Gas (CNG) buses, which have shorter range than conventional coaches and are turned off when idle to conserve fuel.	

Problem:	
Bus drivers are counted as boardings and alightings when they enter and exit the bus.	
Nature: Technical/Operational.	Scope: Systemic.
Resolution:	
Echelon Industries procedure for converting raw APC counts to ridership estimates accounts for routine driver behavior.	
Problem:	
Echelon Industries required that buses equipped with APCs be assigned to specific routes, but standard bus practices made this difficult.	
Nature: Operational.	Scope: .Multiple sites.
Resolution:	
This problem was unresolved, greatly complicating the process needed to convert raw APC counts to ridership estimates.	
Problem:	
Smaller buses (vans) could not be equipped with APCs.	
Nature: Technical.	Scope: Multiple sites.
Resolution:	
This problem was unresolved. Operators with small vehicles often have small fleets, hence equipping even a single van provides substantial information about the operation.	
Problem:	
Federal standard SAEJ1708 defines how bus companies should interface computers on buses. Unfortunately, the standards for communications speeds (9600 baud) and priorities are inconsistent with the needs of the field operational test. The automatic passenger counter and fare card transactions are measured in milliseconds, and cannot be written to the control unit continuously. Writing continuously interferes with fare transactions.	
Nature: Technical/Institutional.	Scope: Systemic.
Resolution:	
Store passenger count data in a buffer so that the passenger transaction unit and the APC do not write to the control unit simultaneously. The automatic passenger counters monitor passenger counts continuously, but the APC computer writes counts to the main computer only every 10 to 15 seconds.	

Problem:	
It is difficult to correctly apportion alightings to boardings and produce ridership counts without knowing the route number. Attempts to minimize driver responsibilities, the existence of unpublished route variations, and informal stops, combined with gaps in agency equipment records make it difficult to obtain the correct route number before or after the fact.	
Nature: Operational/Man-machine interface.	Scope: Systemic.
Resolution:	
The onboard software is being modified to require a route entry from the driver. Echelon industries is attempting to modify the FareTrans VMS so that route information is taken from the bus blind setting.	
Problem:	
Buses are rotated across routes. It is difficult for transit operators to rotate buses equipped with APCs across routes systematically for sampling purposes.	
Nature: Operational.	Scope: Systemic.
Resolution:	
This problem is unresolved.	
Problem:	
Unanticipated delays in transaction file uploads from buses to garages created large files and data storage problems onboard the bus.	
Nature: Technical.	Scope: Systemic.
Resolution:	
Onboard software was rewritten to compress files and reduce storage requirements.	
Problem:	
Bus power system voltage drops when wheel chair lifts are operated can lock up the FareTrans VMS control unit.	
Nature: Technical/Operational.	Scope: Systemic.
Resolution:	
Wheel chair lifts are tested prior to starting up the FareTrans VMS. Power to the FareTrans VMS is cycled after wheel chair lifts are used in the field.	

Problem:

Approximately 20 FareTrans VMS BIOS (basic instruction operating set) batteries blew up in Spring of 1997.

Nature: Technical.	Scope: Systemic.

Resolution:

The FareTrans VMS equipment was placed onboard the buses where the agencies dictated. This created heat problems, which caused the batteries to explode. Echelon Industries modified casings and installed fans for cooling and a positive pressure system to control dust.

Problem:

Some of the data provided by drivers appears to be deliberately wrong.

Nature: Institutional	Scope: Multiple Sites.

Resolution:

This problem was unresolved, though cooperation from drivers improved over time. Different operators face very different incentives to participate in the field operational test; and the FareTrans VMS test received very different levels of attention and support from the properties involved.

Problem:

There is evidence of tampering with some onboard equipment.

Nature: Institutional.	Scope: Multiple Sites.

Resolution:

This problem was unresolved, though cooperation from drivers and garage personnel improved over time. Different operators face very different incentives, and the FareTrans VMS test received very different levels of attention and support.

Problem:

During the early stages of the test, the onboard system polled itself on a fixed schedule. This provides an internal test entry similar to a transaction record.

Nature: Technical.	Scope: Systemic.

Resolution:

This polling ceased when Echelon considered the system to be operating correctly.

Problem:	
Driver states of information about the system remained low. In Simi Valley, most drivers did not know that the system could accommodate transfer charge, in part because very few debit cards were in use. Drivers did not know about the different kinds of monthly passes.	
Nature: Institutional.	Scope: Systemic.
Resolution:	
Echelon Industries abandoned efforts to train supervisors to train drivers, and invested additional effort in training drivers directly.	
Problem:	
Computer literacy in the agencies is lower than Echelon Industries anticipated. For example, personnel had difficulty copying and compressing files, making data management and training more difficult than anticipated.	
Nature: Institutional.	Scope: Systemic.
Resolution:	
Echelon Industries retained control of the central data function and continued polling garage computers.	
Problem:	
Many of the PTU time clocks were inaccurate, and the drivers were not able to set the clock. There was also a problem adjusting the system to daylight savings time.	
Nature: Technical/Institutional.	Scope: Systemic.
Resolution:	
Echelon Industries abandoned efforts to train supervisors to train drivers, and invested additional effort in training drivers directly.	
Problem:	
Several incidences of vandalism occurred. GPS antenna on two buses were ripped apart. Cables were disconnected or connections were changed. Bus numbers and agency settings were changed on at least six vehicles. Control units were opened by unauthorized personnel in at least four vehicles.	
Nature: Institutional.	Scope: Multiple sites.
Resolution:	
In most cases, these acts appear to have been acts of drivers or other operator personnel. Consequently, Echelon Industries tended to ignore these outcomes, and tried instead to cultivate the interests of the project partners.	

Problem:	
While fare cards rarely failed electronically, they did fail mechanically. Approximately 3% of cards failed due to delamination.	
Nature: Technical.	Scope: Systemic.
Resolution:	
Unknown.	

APPENDIX 3B

FIELD SURVEY SCHEDULE

Monday, May 15, 1997

Team 1 Ana Diaz, Genevieve Giuliano

Morning: Boarding, alighting, and ridership counts onVISTA Route 126, beginning at 06:00.

Fillmore	San Buenaventura	San Buenaventura	Fillmore
06:00	07:00	07:00	08:00
08:00	09:00		

Afternoon: Boarding, alighting, and ridership counts on SCAT Route 6 (School Peak), beginning at 14:00.

Oxnard Transportation Center	Ventura and Dakota	Ventura and Dakota	Oxnard Transportation Center
14:00	15:19	15:25	16:50

Evening: Observe SCAT data uploads, SCAT garage, 301 E. 3rd Street, Oxnard.

Board buses at Oxnard Transportation Center and travel to to the SCAT garage, shuttle back to Oxnard Transportation Center, 18:00-20:00.

Team 2 Elif Karsi, Susan Rossbach

Morning: Boarding, alighting, and ridership counts on VISTA Route 126, beginning at 06:52.

Fillmore	San Buenaventura	San Buenaventura	Fillmore
06:52	07:56	08:00	09:00
09:00	10:00		

Afternoon: Boarding, alighting, and ridership counts on SCAT Route 6 (School Peak), beginning at 14:45.

Ventura and Dakota	Oxnard Transportation Center
14:45	16:10

Evening: Observe SCAT data uploads, SCAT garage, 301 E. 3rd Street, Oxnard.

Board buses at Oxnard Transportation Center and travel to to the SCAT garage, shuttle back to Oxnard Transportation Center, 18:00-20:00.

Team 3 Jim Moore

Observe data downloads at SBT garage, VISTA Route 126, Santa Paula.

Evening: Observe SCAT data uploads, SCAT garage, 301 E. 3rd Street, Oxnard.

Board buses at Oxnard Transportation Center and travel to to the SCAT garage, shuttle back to Oxnard Transportation Center, 18:00-20:00.

Tuesday, May 16, 1997

Team 1 Ana Diaz, Genevieve Giuliano

Morning: Boarding, alighting, and ridership counts on SCAT Route 2 and Route 6.

One observer departs the Oxnard Transportation Center at 07:40 on Route 2-2 and completes six round trips, returning to the Oxnard Transportation Center at 11:40.

One observer departs the Oxnard Transportation Center at 08:10 on Route 6-2 and completes six round trips, returning to the Oxnard Transportation Center at 11:10.

Afternoon: No observations.

Evening: Observe SCAT data uploads, SCAT garage, 301 E. 3rd Street, Oxnard.

Board buses at Oxnard Transportation Center and travel to to the SCAT garage, shuttle back to Oxnard Transportation Center, 18:00-20:00.

Team 2 Elif Karsi, Susan Rossbach

Morning: Boarding, alighting, and ridership counts on SCAT Route 1.

One observer departs the Oxnard Transportation Center at 07:45 on Route 1-2 and completes three round trips, returning to the Oxnard Transportation Center at 11:30.

One observer departs the Oxnard Transportation Center at 08:15 on Route 1-3 and completes three round trips, returning to the Oxnard Transportation Center at 11:55.

Afternoon: Boarding, alighting, and ridership counts on VISTA Route 101.

One observer departs the San Buenaventura Mall at 16:05 on Route 101, remains on the bus until service ends at 19:15, and travels with the bus back to the Antelope Valley Bus Lines garage in Oxnard to observe data uploads.

Second observer's activities cancelled: A spare Antelope Valley bus without FareTrans VMS equipment was in use.

Evening: Observe SCAT data uploads, SCAT garage, 301 E. 3rd Street, Oxnard.

Board buses at Oxnard Transportation Center and travel to to the SCAT garage, shuttle back to Oxnard Transportation Center, 18:00-20:00.

Team 3 Jim Moore

Check status of FareTrans VMS equipment on buses arriving at San Buenaventure Mall and the Oxnard Transportation Center.

Evening: Observe SCAT data uploads, SCAT garage, 301 E. 3rd Street, Oxnard.

Board buses at Oxnard Transportation Center and travel to to the SCAT garage, shuttle back to Oxnard Transportation Center, 18:00-20:00.

Wednesday, May 17, 1997

Morning: Jim Moore and Genevieve Giuliano return to USC. Students rest. No observations

Afternoon: Observe all Thousand Oak Routes (1, 2, and 4) and evening data uploads.

One observer departs the Oaks Mall at 14:00 on Route 1 and stays on the bus until the end of service at 18:42, and travels with the bus back to the Thousand Oaks garage to observe data uploads.

One observer departs the Oaks Mall at 14:00 on Route 2 and stays on the bus until the end of service at 18:36, and travels with the bus back to the Thousand Oaks garage to observe data uploads.

Third observer's activities cancelled. The FareTrans VMS on the thousand Oaks bus serving Route 4 was not operating.

APPENDIX 3C

FARETRANS VMS TRANSACTION RECORD FORMAT

TITLE	DATA TYPE	DESCRIPTION	COMMENTS	DEFAULT	CLARIFICATIONS
Date of Recording Data	date/time MM/DD/YY	Date of transaction, passenger count, or some other administrative function.	Total of 278,010 records. Of these 66,842 are fare card transactions. Data collection started 2/27/96 and ended 1/14/97.	All records have a date.	Early on, drivers could enter/change data such as the date, hence some “1980” transactions. The date is now automatic. As of 9/96, operators can only input Route # and Driver ID #.
Time of Recording Data	date/time HH:MM:SS A/PM	Time of count, transaction, etc.		All records have a time.	Automatic.
Driver ID Number	number 1 to 5 digits	Operator identification number	Entered by bus operator, hence not always accurate.	0	Assigned by the agency.
Bus Number	number 1 to 4 digits	Bus Number	Formerly entered by bus operator, hence not always accurate.	0	Assigned by the agency. Automatic.
Route Number	number 1 to 5 digits	Number of bus route	Entered by bus operator.	0	Assigned by the agency.
Latitude	number 7 digits	Bus location at time of count, transaction, etc.		0	Coordinates are correlated to bus stop locations using TIGER files.
Longitude	number 8 digits	Ditto		0	
Heading Degree	number 1 to 360 degrees.	Ditto		0	from GPS.
Number of Satellites Being Used	number 1 digit		usually 3 or 4	0	Used for location fix.
Cumulative Number of Boarding People	number	Cumulative number of	No passenger counts until mid	0	Passengers are counted whether

TITLE	DATA TYPE	DESCRIPTION	COMMENTS	DEFAULT	CLARIFICATIONS
		passengers boarding including current transaction	April. Sporadic operation until 9/96.		they use a fare card or not. Includes bus operator.
Cumulative Number of Alighting People	number	Cumulative number of passengers alighting including current transaction	Includes bus operator.	0	Every time the bus power is turned off, the cumulative counts reset at 0.
Fare Card ID Number Fard Card ID Number cont'd.	text 14 digits abcdefghijklmn	Identification number for fare card	ab- Outlet: 01=Camarillo 02=Moorpark 03=Ojai 04=SCAT 05=Simi Valley 06=Thousand Oaks 07=VISTA101 08=VISTA126 09=VISTACE 10=VISTAOP 11=VISTAFM 12=VISTAPU 13=VISTASP 14=VISTAAH 15=Lompoc 16=VISTAWL cdefgh- Card # ij- Agency: same codes as above k- Fare Type: 1=Adult 2=Senior 3=Disabled 4=Student 5=Child l- Card Type: 1=Debit Cash 3=Monthly Pass	00000000000000 .	The user purchases a card which is encoded with the Fare Card ID #. This # cannot be changed. Therefore, the data provided in the card # cannot be revised or updated. The outlet is the original point of sale. The six-digit card # is consecutively numbered for each outlet. Originally entered manually, it is now determined by computer. The agency is not a valid field. Ordinarily, it would be used to restrict card use to a certain operator but this was not desired for the study. The debit card can be used on any route - generally, the agency code is the same as

TITLE	DATA TYPE	DESCRIPTION	COMMENTS	DEFAULT	CLARIFICATIONS
			4=Dar Month Pass 5=DarPMonth Pass m- Trip Type: 1=Local 2=Commute n- Language: 1=English 2=Spanish etc.		the outlet code. Trip type was not used - irrelevant field. Occasionally, a "0" appears in a field and is not defined. This is an error which may have occured when agencies were manipulating data manually.
Trans Status Code Trans Status Code cont'd.	number 1 to 2 digits	Status of transaction in progress	Legend: 0- No transaction 1- Transaction OK 2- Transaction failure 3- Recharge debit cash card by operator 4- Recharge pass card by driver 5- Pass is expired 6- Pass is ineffective 7- Lost card 8- Stolen card 9- Negative balance 10- Over debt limit 11- Improper card process 12- Insufficient money 13- Recharge cash card via PTU.INI file 14- Recharge pass	None. A "successful" transaction occurs when codes 1, 3, 4, 13, 14 or 15 are listed. Equally valid are codes 5, 6, 7, 8, 9, 12 and 16 where the system is functioning correctly in not processing the fare. 0 and 17 are administrative codes, unrelated to a fare card transaction. A failure is indicated by codes 2 and 11, 2 being a system error and 11 being a user error. Code 10 is not used.	"0" indicates an activity that is not a fare care related transaction, such as a passenger count. "2" indicates something is wrong and the fare cannot be processed, such as a communication problem, defective equipment, damaged card, interference during data transfer. "6" A pass is "ineffective" when used prior to its start date. "9" indicates the card already has a negative balance. It is up to the driver's discretion whether the passenger my board. The negative balance continues to accrue until the card is recharged.

TITLE	DATA TYPE	DESCRIPTION	COMMENTS	DEFAULT	CLARIFICATIONS
			card via PTU.INI file 15- Transfer transaction 16- Reuse pass card within lock-out period 17- Bus power is now on		"11" indicates that the card was swiped too fast. "12" indicates that the card will go negative during this transaction. The lock out period for a pass is ~ 4 minutes; for a debit card ~ 6 seconds.
Number of Trips	number 1 to 3 digits	Cumulative # of trips for which the fare card has been used		0	
Debit Cash Amount	number decimal number	Account balance upon completion of current transaction	The value of the current transaction cannot be determined from the record itself. One must refer to the account balance from the previous transaction made with the fare card. Or, the fare can be deduced from the agency and the fare type.	0	All debit cards can go negative.
Pass Dates	text MM/YY	Pass is valid from the date of issue until the last day of this month.		None. However, a number of fields are 0/0.	
Recharge Amount	text 8 characters allowed	Being Tested. Is actually the fare amount.	generally 0 or a date.	none	
Debit Trip Account	number	Not Used.	occasional	0	Not Used.

TITLE	DATA TYPE	DESCRIPTION	COMMENTS	DEFAULT	CLARIFICATIONS
Boarding Adults	number	Cumulative number of boarding adults at the time of the current transaction	generally 0	0	Not Used.
Boarding Seniors	number	Similar to above	generally 0	0	Not Used.
Boarding Students	number	Similar to above	generally 0	0	Not Used.
Boarding E/H	number	Similar to above	generally 0	0	Not Used.
Total Users	number	Similar to above	generally 0	0	Not Used.
Boarding Others	number	Similar to above	generally 0	0	Not Used.
Condition Code	text 50 characters allowed	Not Used.	generally 0	none	Being Tested.
Bus Company Code	text 2 digits	ID number of operator		none	Same as agency codes.
Pass Fare Rate	number	Not Used.	generally blank or 0	0	Being Tested.

APPENDIX 3D

FARETRANS VMS AND BUS STATUS FOR SANTA BARBARA AND SOUTH COAST AREA TRANSIT

Table 3D-1 Status of FareTrans VMS Equipment on Santa Barbara Transit VISTA Buses and Routes, July 16 to August 12, 1997

Route	Bus	Date												
		7/16	7/17	7/18	7/19	7/20	7/21	7/22	7/23	7/24	7/25	7/26	7/27	7/28
VISTA DAR	W-39													
VISTA DAR	W-40													
VISTA DAR	W-45													
VISTA East	W-46		X	X			X							
VISTA East	W-47													
VISTA East	W-48													
VISTA East	W-49													
VISTA 126	T-3	X	X	X			X	X	X	X	X			X
VISTA 126	T-4													
VISTA 126	T-5													
VISTA 126	T-10													
Office Computer										X	X			X

Route	Bus	7/29	7/30	7/31	8/1	8/2	8/3	8/4	8/5	8/6	8/7	8/8	8/9	8/10	8/11	8/12
VISTA DAR	W-39															
VISTA DAR	W-40		X	X											X	
VISTA DAR	W-45															
VISTA East	W-46			X												
VISTA East	W-47															
VISTA East	W-48							X	X	X	X	X			X	X
VISTA East	W-49															
VISTA 126	T-3	X	X	X	X			X	X	X	X	X			X	X
VISTA 126	T-4															
VISTA 126	T-5															
VISTA 126	T-10															
Office Computer		X	X	X	X			X	X	X	X	X			X	

- (white box) Bus was not in service.
- X FareTrans VMS was reported not functioning, either in the case of a bus not in service, or the office computer.
- (grey box) Bus was in service, FareTrans VMS was functioning.
- (black box) Bus was in service, FareTrans VMS was not functioning

Table 3D-2 Status of FareTrans VMS Equipment on South Coast Area Transit Buses, May 1997

Bus	Date														
	5/01	5/02	5/03	5/04	5/05	5/06	5/07	5/08	5/09	5/10	5/11	5/12	5/13	5/14	5/15
3000															
3001															
3500															
3501															
3502															
3503															
3504															
3505															
3506															
3507															
3508															
3509															
3510															
3511															
3512															
3513															
3514															
3515															
3516															
3517															
4000															
4001															
4002															
4003															
4004															
4005															
4006															
4007															
4528															
4529															
4532															
4534															
4535															
4542															

Date															
5/16	5/17	5/18	5/19	5/20	5/21	5/22	5/23	5/24	5/25	5/26	5/27	5/28	5/29	5/30	5/31
	E														
			USC-OK	USC-OK											E
	E			USC-OK											E
	E			USC-OK											E
	E														
				USC-OK											
	E			USC-OK											
			USC-OK	USC-OK											E-OK
	E-OK			USC-OK											E
				USC-D											
	E		USC-OK												E
				USC-OK											
			USC-OK	USC-OK											E
			USC-OK	USC-D/W											
				USC-OK											
			USC-OK	USC-OK											
	E		USC-OK	USC-OK											E
			USC-OK	USC-OK											
				USC-OK											
	E-OK		USC-D	USC-OK											
			USC-D	USC-D											
				USC-OK											E
				USC-OK											E
	E			USC-OK											
				USC-OK											E
	E			USC-D											E
	E-OK														E
	E														E
	E														
	E														E
	E														E
	E														E

	No confirmations of bus going on service that day.
	Driver reported VMS defective (defect reports or tickets).
	Bus was confirmed to go on service due to either dispatch records or driver tickets.
	Drivers reported VMS both working and defective on the same day.
E	Echelon worked and did some repair on the bus.
E-OK	Echelon checked the system and it seemed OK, but it couldn't do further check due to either agency's request not to touch the bus or driver's need to go back on service.
USC-OK	USC reported VMS working.
USC-D	USC reported VMS defective.
USC-D/W	USC reported VMS both working and defective on the same day.

APPENDIX 4A
AUTOMATED DATA ISSUES

One of the demonstration's objectives was to collect detailed information on passenger travel patterns for service planning and fare policy decision-making. The types of data generated by the Faretrans system are described in Chapter Two. There are essentially two files; one is the "clearinghouse" file, referred to as the customer database, that manages the financial status of all cards; the other is the "transactions" file which includes all passenger and card transactions recorded on buses, as well as location data from the GPS system and various status information input by drivers.

4A.1 DATA ASSOCIATED WITH CARD PURCHASERS

Any purchase, renewal, or replacement of a lost, stolen or defective card must be recorded into the customer database file. Card purchases , renewals and replacements could take place at any authorized outlet (renewals could also take place on all buses except SCAT). This information then must be transmitted to the customer database file.

In order to obtain information on card purchasers, the Passport Form 1C included a series of questions to be asked of the customer during the initial Smart Passport purchase interview. The vendor created a system of screens and click-on menus which minimized the amount of data which needed to be typed and allowed data entry directly onto a computer at the sales outlet. This information was then sent to the customer database via modem. Customer data collected are shown in Table 4A-1.

There may not be a one-to-one correlation between options on the form and codes in the computer database. For instance, additional languages were available on the computerized form than listed on the paper form.

Some outlets did not have the required equipment and dedicated phone lines to send their customer data via modem. For these outlets, the resulting process was adopted: the sales outlet would fill out the Passport Form 1C and fax it to VCTC. VCTC would then build the card and then usually mail the card directly to the customer.

Some confusion resulted because of the introduction of manual processes into an automated system. When a card was built by VCTC, it would automatically be written with the VCTC's outlet code, NOT the original sales outlet's code. When the vendor generated status reports showing the number of cards issued by each agency, this incorrect attribution became

Table 4A-1 Card Customer Data

Title of Field in Access Customer Database	Title of Field on Passport Form 1C for Fare Card Initialization and Reporting on Lost, Stolen and Defective Cards	Description of Data and Method of Collection
Fare Card ID	not on form	automatic, composed of codes from next 5 items plus language; 14 digits
Agency	Fare Card Outlet	automatic, from computer; 2 digits
Fare Type	Fare or User Type	select from menu: adult, senior, disabled, student, child; 1 digit
Trip Type	not on form	select from menu; 1 digit
Card Type	Card Type	select from menu: debit cash, monthly pass, DAR, monthly pass w/DAR upgrade; 1 digit
User ID	not on form	sequential, automatic; 6 digits
Trip Balance	not on form	read from card
Card Status	Card Status	select from menu: initial purchase, card recharge, lost card, stolen card, defective card
CLName	Customer's Last Name	input data
CFName	Customer's First Name	input data
Cinitial	Customer's Middle Initial	input data
Caddress	Residence Address	input data
Unit	Apt. #	input data
Ccity	City	input data
Cstate	State	defaults to CA
Czip	Zip	input data
Hphone	Residence Tel. #	input data
FrequencyID	not on form	generally “0" or blank
PurposeID	not on form	generally “0" or blank
EthnicityID	not on form	generally “0" or blank
LanguageID	Language Preference	select from menu of four choices on form (English, Spanish, Vietnamese, Tagalog); others available upon request
GenderID	Gender	select from menu: male, female (optional data for planning purposes only)
AgeID	Age Group	select from menu: generally “0" or blank (optional data for planning purposes only)
IncomeID	Household Income	select from menu: generally “0" or blank (optional data for planning purposes only)
Payment Method	Payment Method	select from menu: cash, check, credit card

Title of Field in Access Customer Database	Title of Field on Passport Form 1C for Fare Card Initialization and Reporting on Lost, Stolen and Defective Cards	Description of Data and Method of Collection
CpaymentAmtInd	Monthly Pass Cost or Debit Cash or Lost/Stolen Card Charge	select from menus
Ename	Company Name and Dept.	input data
Eaddress	Employment Address Street	input data
Unit	Suite #	input data
Ecity	City	input data
Estate	State	defaults to CA
Wzip	Zip	input data
Wphone	Employment Tel. #	input data
Account Balance	not on form	read from card
Note	not on form	optional field
Date of Incident	Date for Lost, Stolen or Defective Card	input data
Weekly Date	not on form	generally not used
Monthly Date	not on form	date through which pass is effective
User Name	Approved By:	automatic: name of authorized individual doing data entry
Lupdate Time Stamp	not on form	automatic, date and time
Initial Time Stamp	not on form	automatic, date and time
AddRec	not on form	select on screen: yes, no

clear. Operators requested access to the customer database in order to correct this oversight. In the process, fare card ID numbers and customer information were altered and lost. The vendor has subsequently made software revisions which take this indirect data entry into account. He has created an additional field which records the activating outlet separate from the issuing outlet, as well as revised reports.

4A.2 CUSTOMER DATA BASE

The Customer table of the database consists of several types of transactions in one database: initial card purchases, recharges and replacement cards. There are a series of separate menu screens for entering data to initialize a card or to report lost, stolen or defective cards. These guide the operator through the process. Sometimes, however, the operator overlooked these menu options and used the initialization screen to record a replacement card. If done correctly, the replacement card should have a different fare card ID number than the original card issued, and the original card should be listed as stolen, lost or defective in the master database.

In general, data collection and compilation on customers proved troublesome. It was awkward for transit operators (who were given no incentive to pursue this line of questioning) to solicit personal information from customers during the initial card purchase interview. Fields, such as Customer's Age and Customer's Income, were left blank. In addition, operators were not necessarily trained to perform data entry. Input errors, particularly data in the wrong fields, resulted in a sloppy database.

Test cards were supposed to be initialized under the outlet designation "99" which would result in readily identifiable dummy transactions which could readily be removed from the databases. However, several agencies set up their own test cards with no distinguishing characteristics. These cards were generated for imaginary clients to test the system or train personnel and are virtually undetectable. This has made counting the number of card holders a difficult task.

A second obstacle to an accurate user count was multiple records of the same transaction in the customer database. These resulted from the outlets trying to initialize cards when the card reader/writer was not working. (This could be because the unit was disconnected). Originally, every time the operator selected "Write to Card" on the menu screen, the system would instantaneously send the information to the customer database, even if the card had not successfully been initialized. The operator may then press "Write to Card" several more times before realizing that the card reader/writer was not functioning. This would create the duplicate data entries. Initially, the vendor introduced a query in Access to delete duplicate records. Later, the vendor revised the initialization process so that the information did not write to the customer database until the operator confirmed that the card could be read on the card reader/writer. Only then is the initialization or recharge data sent to the customer database.

Another problem in automatically collecting customer data is that the card reader/writer is a radio device, which, if left too close to the computer monitor, the radiation emitted by the monitor could disrupt the radio transmission. Since different operators had different monitors, there were no standard guidelines as to where the card reader/writer should be in relation to the monitor. This proximity problem sometimes would cause the card to fail to write.

Finally, there is some customer data missing from the database. There are instances of "orphans," fare card ID's in the transaction database which do not correspond to customer information in the customer database. Two explanations we have uncovered are: 1) the card was later deleted from the customer database using the modify screen, or 2)the fare card ID number was changed when the outlet attempted to correct the customer database. Thus, there are “faceless” transactions for which we have no customer profile.

4A.3 COMPARISON OF CUSTOMER TABLE WITH VCTC DATA

The most recent version of the Customer table we received from the vendor is dated February 1998. It is reported to be a clean file, with duplicate entries and test cards filtered out of the file. It is also reported as missing some data, as the various transfers of data and cleaning efforts resulted in the loss of some entries. We have no information on how much data may have been lost. We compiled monthly totals for the period from January 1996 through June 1997; these totals include all card purchases, recharges and issuance of additional cards. We then compared these numbers to the actual card purchase records provided by VCTC. For the entire period, the Customer table gives 2952 card transactions, compared to VCTC’s 4686 transactions, a difference of 36 percent. We had anticipated that the difference would decrease with FOT duration, due to the delays in equipment installation and greater frequency of equipment problems in the early months of the FOT. This proved not to be the case, as illustrated in Figure 4A.1. For the first 6 months of 1997, the discrepancy ranges from 37 percent to 52 percent. We therefore elected not to use the Customer table data in our evaluation.

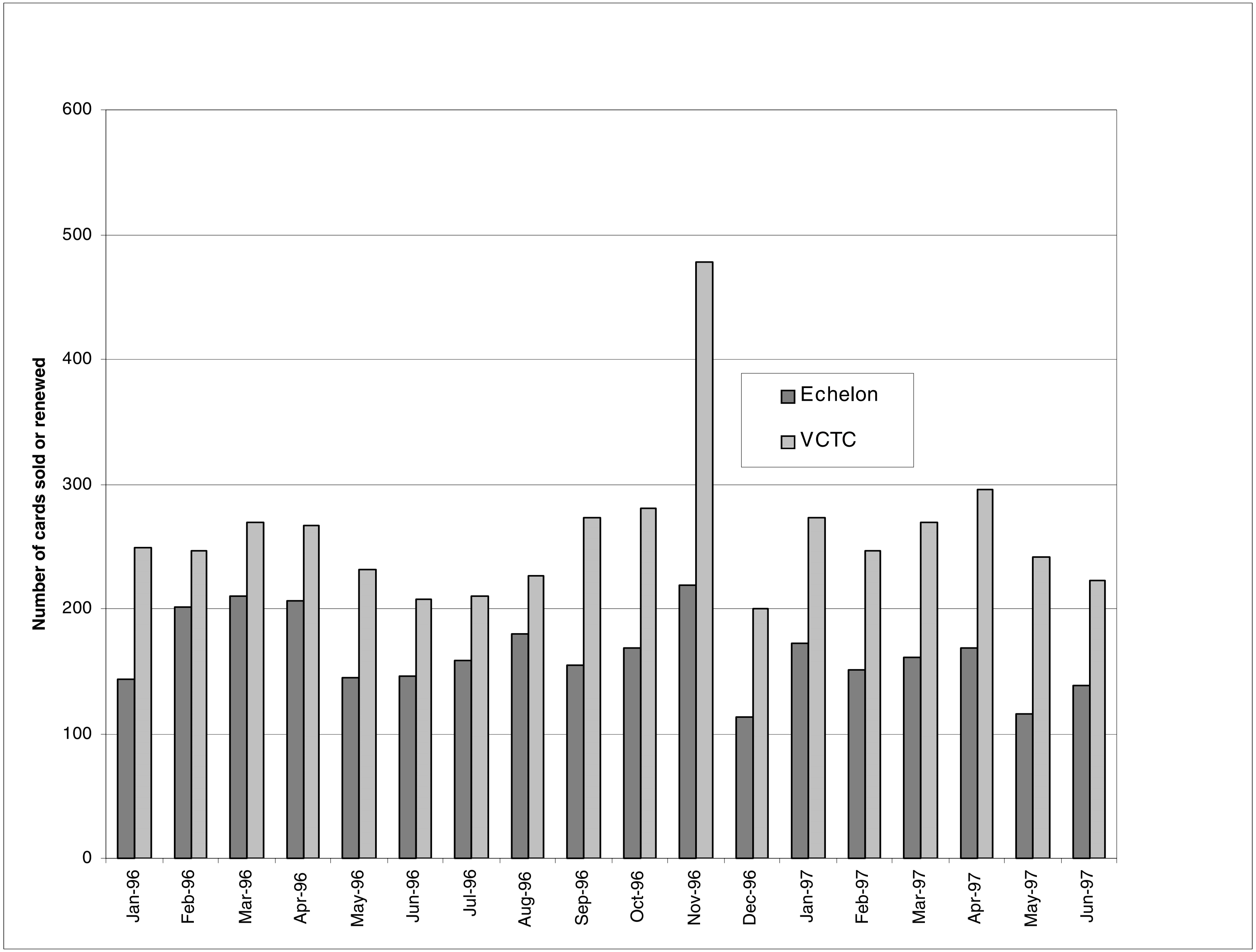

Figure 4A.1 Comparison of Card Sales Data

APPENDIX 4B

SURVEY INSTRUMENT -SURVEY I- MAY 1996

ID# 00275

DATE:
ROUTE:
TIME:
TEAM:

PLEASE RETURN TO SURVEY WORKER ON THIS BUS

POR FAVOR REGRESE ESTA ENCUESTA AL TRABAJADOR EN ESTE AUTOBUS

USC UNIVERSITY OF SOUTHERN CALIFORNIA

VISTA SERVICES SURVEY

Please take a moment to fill out this survey. Your answers will be used to help you and future transit riders receive better. service.

ENCUESTA DE SERVICIOS VISTA

Por favor tome un moment0 para llenar esta encuesta. Sus respuestes nos ayudaran a ofrecerle un mejor servicio de transit0 en el futuro.

Por favor conteste las siguientes preguntas sobre el viaje que esta por hacer.

1. ¿A donde va? (Marque una respuesta)

- ☐1 al trabajo
- ☐2 a la escuela
- ☐3 a la casa
- ☐4 otro lugar ____________

2. ¿Usualmente usa este autobus para este viaje?

- ☐1 SI
- ☐2 NO

3. ¿Con cuanta frecuencia viaja usted por autobus? (Marque una respuesta)

- ☐1 Menos de una ves por semana
- ☐2 Una o dos veces por semana
- ☐3 De 3 a 5 dias de la semana
- ☐4 Todos los dias

4. Este es un autobus VISTA. ¿A usado autobuses SCAT alguna vez?

- ☐1 SI
- ☐2 NO

5. ¿Que tipo de pago es usted?

- ☐1 Adulto
- ☐2 Estudiante
- ☐3 Mayor de edad/Encapacitado

12. Do you have any of the following:

(a)	A driver's license'?	☐1 YES	☐2 NO
(b)	A credit card?	☐1 YES	☐2 NO
(c)	A bank ATM card?	☐1 YES	☐2 NO

13. What is the total yearly income of all persons living in your household?

- ☐1 Under $9,000
- ☐2 $9,000 - $14,999
- ☐3 $15,000 - $19,999
- ☐4 $20,000 - $29,999
- ☐5 $30,000 - $39,999
- ☐6 $40,000 or more
- ☐7 Don't know

PLEASE RETURN TO SURVEY WORKER ON THIS BUS

THANK YOU

12. ¿Tiene alguna de las siguientes?

(a)	Licencia de manejar	☐1 SI	☐ 2NO
(b)	Targeta de credito	☐1 SI	☐ 2NO
(c)	Una targeta ATM del banco	☐1 SI	☐ 2NO

13. ¿Cual es el salario anual de todas las personas viviendo en el hogar?

☐1 Menos de $9,000
☐2 $9,000 - $14,999
☐3 $15,000 - $19,999
0 4 $20,000 - $29,999
0 5 $30,000 - $39,999
☐6 $40,000 0 mas
☐ 7 No se

POR FAVOR REGRESE ESTA ENCUESTA AL TRABAJADOR EN ESTE AUTOBUS

GRACIAS

Please answer the following questions about the trip you are making now.

1. Where are you going? (Check one)

☐1 to work
☐2 to school
☐3 to home
☐4 other____________

2. Do you usually use the bus for this trip?

☐1 YES
☐2 NO

3. How often do you travel by bus? (Check one)

01 Less then once a week
☐2 once or twice a week
0 3 3 to 5 days a week
☐ 4 every day

4. This is a VISTA bus. Do you ever use SCAT buses?

☐1 ✡☜💧
☐2 ☠🏳

5. What type of fare did you use on this trip?

☐1 Adult
☐2 Student
0 3 Senior/disabled

6. ¿Como pago la tarifa de este autobus?
(Marque una respuesta)

- ☐1 Dinero en efectivo ➔ VAYA A LA PREGUNTA 7
- 0 2 Pasaportede toda la zona ➔ VAYA A LA PREGUNTA 8

7. POR FAVOR CONTESTE ESTA PREGUNTA SI PAGO CON DINERO EN EFECTIVO

7(a) ¿A comprado alguna vez un Pasaporte que sirve en toda la zona?

- ☐1 SI **VAYA A LA PREGUNTA 8**
- ❑ 2 ☠⚐

⬇

7(b) ¿Si contesto no, porque? (Puede marcar mas de una opcion)

- ☐1 No se nada sobre el Pasaporte
- ☐2 No lo necesito/no uso el autobus con frecuencia
- ☐3 No es muy conveniente comprarlo
- ☐4 Es mucho dinero para pagarlo en un instante
- ☐5 No se donde comprar uno
- ☐6 No se cuanto cuesta
- ☐7 Otras razones

8(e) Have you experienced any problems when using your Passport?

- ☐1 YES
- ☐2 **NO**

ALL SURVEY RESPONDENTS. These questions are asked for statistical reasons only. All responses are kept in confidence.

9. Are you?

- ☐1 Male
- ☐2 Female

10. How old are you?

- ☐1 15 or under
- ☐2 16-24
- ☐3 25-34
- ☐4 **35-49**
- ☐5 50-64
- ☐6 65-74
- ☐7 75 or older

11. Are you? (Check one)

- ☐1 Student
- ☐2 Full-time employed
- ☐3 Part-time employed
- ☐4 Retired
- ☐5 Other

8(e) Ha experimentado algun problema cuando usa su Pasaporte?

☐1 SI
02 N O

PARA TODOS LOS **PARTICIPANTES** DE ESTA ENCUESTA. Estas preguntas las hacemos por razones estatisticas. Todas las respuestas se mantendran en confidencia.

9. ¿Es Usted?

01 Masculino ☐2 Femenina

10. ¿Que edad tiene?

01 15 años 0 menor
☐2 16-24
0 3 25-34
☐4 35-49
☐5 50-64
☐6 65-74
☐7 75 0 mayor

11. ¿Es usted? (Marque una respuesta)

☐1 Estudiante
☐2 Trabajador de tiempo completo
☐3 Trabajador de medio tiempo
☐4 Se ha usted retirado
☐5 Otro

6. How did you pay to use the bus? (Check one)

☐1 Cash ➜ GOT0 Q.7

0 2 Countywide Passport? ➜ GO TO Q.8

7. PLEASE ANSWER IF YOU PAID CASH

7(a) Have you ever bought a Countywide Passport?

☐1 YES GOTOQ.8 3 NEXT PAGE

02 N O
↓

7(b) If no, why not? (Check all that apply)

☐1 Don't know anything about them
☐2 Don't need them/don't use bus often
0 3 Its not convenient to buy them
☐4 Too much money to spend all at once
☐5 Don't know where to buy one
☐6 Don't know what they cost
☐7 Other reason

8. **POR FAVOR CONTESTE SI ALGUNA VEZ A COMPRADO UN PASAPORTE QUE SIRVE EN TODA LA ZONA**

8(a) ¿Que clase de Pasaporte tiene?

☐1 Mensual
☐2 Debit Card → ¿Que tipo de ticket o pasaporte a usado anteriormente? ______________

8(b) ¿Como ha renovado su pasaporte? (Puede marcar mas de una opcion)

☐1 En persona en una oficina
☐2 Por correo
☐3 Por telefono
☐4 Por e-mail (correo electronico)
☐5 En el autobus
☐6 No he renovado

8(c) ¿Porque usa usted el Pasaporte? (Puede marcar mas de una opcion)

☐1 Buen precio
☐2 Facil de usar
☐3 Facil de comprar y renovar
☐4 Lo puede usar en cualquier autobus de la zona
☐5 No tengo que cargar con el cambio adecuado

8(d) ¿Esta usted satisfecho con el Pasaporte? (Marque una respuesta)

☐1 Muy satisfecho
☐2 Satisfecho
☐3 No muy satisfecho
☐4 No estoy satisfecho

8. **PLEASE ANSWER IF YOU HAVE EVER BOUGHT A COUNTYWIDE PASSPORT**

8(a) What kind of Passport do (did) you have?

☐1 Monthly Pass
☐2 Debit Card → What type of ticket or pass did you use before? ______________

8(b) How have you renewed your Passport? (Check all that apply)

☐1 In person at office
☐2 By mail
☐3 By telephone
☐4 By e-mail
☐5 On the bus
☐6 Have not renewed

8(c) Why do you use a Passport? (Check all that apply)

☐1 Good value
☐2 Easy to use
☐3 Easy to buy and renew
☐4 Can use on any bus in County
☐5 Don't have to carry exact change

8(d) Are you satisfied with the Passport? (Check one)

☐1 very satisfied
☐2 satisfied
☐3 not satisfied
☐4 very unsatisfied

APPENDIX 4C

SURVEY 1 VARIABLE FREQUENCIES

User Survey 1 - May 1996

Frequency Tables

1. Trip Purpose

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	To work	45	26.0	27.1	27.1
	To School	35	20.2	21.1	48.2
	To Home	62	35.8	37.3	85.5
	Other	24	13.9	14.5	100.0
	Total	166	96.0	100.0	
Missing	System	7	4.0		
Total		173	100.0		

2. Do you usually use bus for this trip?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	149	86.1	90.9	90.9
	No	15	8.7	9.1	100.0
	Total	164	94.8	100.0	
Missing	System	9	5.2		
Total		173	100.0		

3. **How often do you use bus?**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Less than once a week	18	10.4	10.8	10.8
	1 - 2 times a week	20	11.6	12.0	22.9
	3 - 5 times a week	79	45.7	47.6	70.5
	Every day	49	28.3	29.5	100.0
	Total	166	96.0	100.0	
Missing	System	7	4.0		
Total		173	100.0		

4.Do you ever use SCAT buses?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	90	52.0	54.5	54.5
	No	74	42.8	44.8	99.4
	Total	165	95.4	100.0	
Missing	System	8	4.6		
Total		173	100.0		

5. What kind of fare did you pay?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Adult	82	47.4	49.7	49.7
	Student	53	30.6	32.1	81.8
	Senior/Disabled	29	16.8	17.6	99.4
	Total	165	95.4	100.0	
Missing	System	8	4.6		
Total		173	100.0		

6. How did you pay for this trip?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Cash	131	75.7	77.5	77.5
	Countywide Passport	38	22.0	22.5	100.0
	Total	169	97.7	100.0	
Missing	System	4	2.3		
Total		173	100.0		

7. Have you ever bought a passport?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	26	15.0	19.8	19.8
	No	105	60.7	80.2	100.0
	Total	131	75.7	100.0	
Missing	System	42	24.3		
Total		173	100.0		

Those who have not bought a passport:

8. a. Unaware of passport

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.00	53	50.5	51.5	51.5
	Selected	50	47.6	46.5	**100.0**
	Total	103	98.1	100.0	
Missing	System	2	1.9		
Total		105	100.0		

8. b. No need to buy passport

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.00	79	75.2	77.5	77.5
	Selected	23	21.9	22.5	100.0
	Total	102	97.1	100.0	
Missing	System	3	2.9		
Total		105	100.0		

8. c. Inconvenient to use passport

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.00	87	82.9	84.5	84.5
	Selected	16	15.2	15.5	100.0
	Total	103	98.1	100.0	
Missing	System	2	1.9		
Total		105	100.0		

8. d. Too much money needed to buy passport

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	91	86.7	88.3	88.3
	Selected	12	11.4	11.7	100.0
	Total	103	98.1	100.0	
Missing	System	2	1.9		
Total		105	100.0		

8. e. Don’t know where to buy passport

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	73	69.5	70.9	70.9
	1	30	28.6	29.1	100.0
	Total	103	98.1	100.0	
Missing	System	2	1.9		
Total		105	100.0		

8. f. Unknown cost of passport

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	81	77.1	78.6	78.6
	Selected	22	21 .0	21.4	100.0
	Total	103	98.1	100.0	
Missing	System	2	1.9		
Total		105	100.0		

8. g. Other reason of not buying passport

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.oo	93	88.6	90.3	90.3
	Selected	10	9.5	9.7	100.0
	Total	103	98.1	100.0	
Missing	System	2	1.9		
Total		105	100.0		

Those who have bought a passport:

9. Are you satisfied with passport?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Very satisfied	5	19.2	31.3	31.3
	Satisfied	6	23.1	37.5	68.8
	Not satisfied	3	11.5	18.8	87.5
	Very unsatisfied	2	7.7	12.5	100.0
	Total	16	61.5	100.0	
Missing	System	10	38.5		
Total		26	100.0		

10. Type of passport used

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Monthly pass	17	65.4	85.0	85.0
	Debit Card	3	11.5	15.0	100.0
	Total	20	76.9	100.0	
Missing	System	6	23.1		
Total		26	100.0		

11. How did you renew passport?

11. a. Renewed passport in person at office

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Selected	8	30.8	100.0	100.0
Missing	System	18	69.2		
Total		26	100.0		

11. b. Renewed passport by mail

		Frequency	Percent
Missing	System	26	100.0

11. c. Renewed passport by Telephone

		Frequency	Percent
Missing	System	26	100.0

11. d. Renewed passport by e-mail

		Frequency	Percent
Missing	System	26	100.0

11. e. Renewed passport on bus

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Selected	1	3.8	100.0	100.0
Missing	System	25	96.2		
Total		26	100.0		

11. f. Not renewed passport

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Selected	11	42.3	100.0	100.0
Missing	System	15	57.7		
Total		26	100.0		

12. Reasons for using the passport:

12. a. Reason: Good value of passport for user

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Selected	10	38.5	100.0	100.0
Missing	System	16	61.5		
Total		26	100.0		

12. b. Reason: Passport easy to use

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Selected	9	34.6	100.0	100.0
Missing	System	17	65.4		
Total		26	100.0		

12. c. Reason: Easy to buy and renew passport

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Selected	3	11.5	100.0	100.0
Missing	System	23	88.5		
Total		26	100.0		

12. d. Reason: can use on any bus in county

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Selected	2	7.7	100.0	100.0
Missing	System	24	92.3		
Total		26	100.0		

12. e. Reason: NO NEED to carry exact change

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Selected	6	23.1	100.0	100.0
Missing	System	20	76.9		
Total		26	100.0		

All users:

13. Gender of surveyee

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	82	47.4	50.3	50.3
	Female	81	46.8	49.7	100.0
	Total	163	94.2	100.0	
Missing	System	10	5.8		
Total		173	100.0		

14. Age of surveyee

		Frequency	Percent	Valid PePercent	Cumulative
Valid	15 or under	23	13.3	14. 1	1
	16-24	49	28.3	30.1	44.2
	25-34	23	13.3	14.1	58.3
	35-49	40	23.1	24.5	82.8
	50-64	14	8.1	8.6	91.4
	65-74	9	5.2	5.5	96.9
	75 or older	5	2.9	3.1	100.0
	Total	163	94.2	100.0	
Missing	System	10	5.8		
Total		173	100.0		

15. Occupation of surveyee

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Student	66	38.2	41.0	41.0
	Full time employed	59	34.1	36.6	77.6
	Part time employed	18	10.4	11.2	88.8
	Retired	8	4.6	5.0	93.8
	Other	10	5.8	6.2	100.0
	Total	161	93.1	100.0	
Missing	System	12	6.9		
Total		173	100.0		

16. a. Do you have a driver license?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	62	35.8	47.3	47.3
	No	69	39.9	52.7	100.0
	Total	131	75.7	100.0	
Missing	System	42	24.3		
Total		173	100.0		

16. b. Do you have a credit card?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	37	21.4	33.6	33.6
	No	73	42.2	66.4	100.0
	Total	110	63.6	100.0	
Missing	System	63	36.4		
Total		173	100.0		

16. c. Do you have an ATM card?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	52	30.1	43.3	43.3
	No	68	39.3	56.7	100.0
	Total	120	69.4	100.0	
Missing	System	53	30.6		
Total		173	100.0		

17. Income level of surveyee

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Under $9,000	22	12.7	15.2	15.2
	$9,000 - $14,999	19	11.0	13.1	28.3
	$15,000 - $19,999	6	3.5	4.1	32.4
	$20,000 - $29,000	10	5.8	6.9	39.3
	$30,000 - $39,999	15	8.7	10.3	49.7
	$40,000 or more	29	16.8	20.0	69.7
	Don't know	44	25.4	30.3	100.0
	Total	145	83.8	100.0	
Missing	System	28	16.2		
Total		173	100.0		

Language used

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	English	130	75.1	75.6	75.6
	Spanish	42	24.3	24.4	100.0
	Total	172	99.4'	100.0	
Missing	System	1	.6		
Total		173	100.0		

APPENDIX 4D

SURVEY INSTRUMENT - SURVEY 2 - JULY 1997

QUESTIONNAIRE WITH LOGIC & SKIP PATTERNS

QUESTIONNAIRE = USC
VERSION : FINAL

```
****************************
*        CODE BOX :        *
*                          *
* LT = LESS THAN     ( < ) *
* GT = GREATER THAN  ( > ) *
* EQ = EQUALS        ( = ) *
* NE = NOT EQUAL TO  ( # ) *
****************************
```

HELLO, MY NAME IS ____________ AND I AM CALLING FROM THE UNIVERSITY OF SOUTHERN CALIFORNIA. WE ARE CONDUCTING A SURVEY ABOUT BUS USE IN VENTURA COUNTY AND YOUR OPINIONS ARE IMPORTANT TO US. CAN YOU HELP ME OUT ?

****

1. DO YOU EVER USE BUSES IN VENTURA COUNTY ?

    1. YES
    2. NO

    (READ PRE-CODED RESPONSES-EXCEPT FOR 'DON'T KNOW','REFUSED',ETC)

    SKIP AFTER Q1 IF Q<1> EQ "1" THEN GO 5

****

2. HAVE YOU PURCHASED A SMART PASSPORT CARD FOR BUS USE IN VENTURA COUNTY ?

    1. YES
    2. NO

    (READ PRE-CODED RESPONSES-EXCEPT FOR 'DON'T KNOW','REFUSED',ETC)

    SKIP AFTER Q2 IF Q<2> EQ "2" THEN GO END

****

3. CAN I HAVE THE NAME OF THE PERSON YOU PURCHASED THE SMART CARD FOR ?

****

4. CAN I HAVE THEIR TELEPHONE NUMBER PLEASE ?

    SKIP AFTER Q4 GO END

***********************************kk**********************************

5. COULD YOU PLEASE TELL ME WHAT TYPE OF BUS FARE YOU WOULD BE ?

    1. ADULT
    2. SENIOR
    3. DISABLED
    4. STUDENT
    5. CHILD
    6. NO ANSWER

    (READ PRE-CODED RESPONSES-EXCEPT FOR 'DON'T KNOW','REFUSED',ETC)

****

6. COULD YOU PLEASE TELL ME WHICH OF THE FOLLOWING IS TRUE FOR YOU:

1. I CURRENTLY HAVE A VENTURA COUNTYWIDE SMART PASSPORT CARD
2. I DID HAVE A VENTURA COUNTYWIDE SMART PASSPORT CARD BUT NO LONGER HAVE ONE
3. I HAVE NEVER HAD A COUNTYWIDE SMART PASSPORT CARD
4. NO ANSWER

(READ PRE-CODED RESPONSES-EXCEPT FOR 'DON'T KNOW','REFUSED',ETC)

SKIP AFTER Q6 IF Q<6> EQ "2" THEN GO 38
SKIP AFTER Q6 IF Q<6> GE "3" THEN GO END
****
7. WHERE DID YOU FIRST PURCHASE YOUR SMART PASSPORT CARD ?

1. CITY OF SIMI VALLEY
2. CITY OF MOORPARK
3. CITY OF THOUSAND OAKS
4. FILMORE AREA TRANSIT (FILMORE AT THE BUS COMPANY OFFICE)/FATCO
5. SCAT (BUS COMPANY OFFICES)
6. VCTC (COUNTY OFFICES)
7. SANTA PAULA (BY THE OIL MUSEUM)
8. OTHER (OTHER LINE = 80)

(READ PRE-CODED RESPONSES-EXCEPT FOR 'DON'T KNOW','REFUSED',ETC)
****
8. HOW LONG AGO WAS THAT ?
SURVEYOR NOTE: SPECIFY IF IT IS WEEKS, MONTHS, OR YEARS
****
9. ARE YOU STILL USING THE CARD ?

1. YES
2. NO

(READ PRE-CODED RESPONSES-EXCEPT FOR 'DON'T KNOW','REFUSED',ETC)

SKIP AFTER Q9 IF Q<9> EQ "1" THEN GO 11
****
10. IS IT...?

1. GOOD BUT NEEDS RE-CHARGING
2. DOES NOT WORK AND NEEDS REPLACING
3. OTHER (OTHER LINE = 81)

(READ PRE-CODED RESPONSES-EXCEPT FOR 'DON'T KNOW','REFUSED',ETC)
****
11. IS YOUR SMART PASSPORT CARD:

1. A DIAL-A-RIDE MONTH PASS PLUS UPGRADE STICKER FOR USE OF ALL TRANSIT
2. A DIAL-A-RIDE MONTH PASS
3. A MONTHLY PASS
4. A DEBIT CARD

(READ PRE-CODED RESPONSES-EXCEPT FOR 'DON'T KNOW','REFUSED',ETC)

SKIP AFTER Q11 IF Q<11> EQ "4" THEN GO 18
****
12. HAVE YOU EVER HAD A SMART PASSPORT DEBIT CARD ?

1. YES
2. NO

(READ PRE-CODED RESPONSES-EXCEPT FOR 'DON'T KNOW','REFUSED',ETC)

SKIP AFTER Q12 IF Q<12> EQ "2" THEN GO 14

****

13. WHY DID YOU CHANGE TO A MONTHLY PASS ?

****

14. WHERE DID YOU LAST RENEW/RE-PURCHASE/EXCHANGE YOUR MONTHLY PASS ?

1. CITY OF SIMI VALLEY
2. CITY OF MOORPARK
3. CITY OF THOUSAND OAKS
4. FILMORE AREA TRANSIT (FILMORE AT THE BUS COMPANY OFFICE)/FATCO
5. SCAT (BUS COMPANY OFFICES)
6. VCTC (COUNTY OFFICES)
7. SANTA PAULA (BY THE OIL MUSEUM)
8. ON BOARD A BUS
9. BY PHONE WITH CREDIT CARD
10. OTHER (OTHER LINE = 82)

(READ PRE-CODED RESPONSES-EXCEPT FOR 'DON'T KNOW','REFUSED',ETC)

****

15. HOW MUCH DID IT COST ?
SURVEYOR NOTE: USE THE FOLLOWING FORMAT: I.E. 5.00

****

16. DO YOU ALWAYS RENEW/RE-PURCHASE/EXCHANGE YOUR MONTHLY PASS AT THE SAME PLACE?

1. ALWAYS USE THE SAME PLACE
2. DON'T ALWAYS USE THE SAME PLACE
3. DON'T KNOW/NA

(READ PRE-CODED RESPONSES-EXCEPT FOR 'DON'T KNOW','REFUSED',ETC)

SKIP AFTER Q16 IF Q<16> NE "2" THEN GO 26

****

17. WHERE ELSE HAVE YOU RENEWED/RE-PURCHASED/EXCHANGED YOUR MONTHLY PASS ? 17.1

1. CITY OF SIMI VALLEY
2. CITY OF MOORPARK
3. CITY OF THOUSAND OAKS
4. FILMORE AREA TRANSIT (FILMORE AT THE BUS COMPANY OFFICE)/FATCO
5. SCAT (BUS COMPANY OFFICES)
6. VCTC (COUNTY OFFICES)
7. SANTA PAULA (BY THE OIL MUSEUM)
8. ON BOARD A BUS
9. BY PHONE WITH CREDIT CARD
10. OTHER

(OTHER LINE = 83)

(Multiple Response)

(READ PRE-CODED RESPONSES-EXCEPT FOR 'DON'T KNOW','REFUSED',ETC)

SKIP AFTER Q17 GO 26

****

18. HAVE YOU EVER HAD A MONTHLY SMART PASSPORT CARD ?

1. YES
2. NO

(READ PRE-CODED RESPONSES-EXCEPT FOR 'DON'T KNOW','REFUSED',ETC)

SKIP AFTER Q18 IF Q<18> EQ "2" THEN GO 20

****

19. WHY DID YOU CHANGE TO A DEBIT CARD ?

****

20. WHEN YOU FIRST PURCHASED YOUR DEBIT CARD HOW MUCH VALUE DID IT HAVE ON IT ?

****

21. HOW LONG AGO WAS THAT ?
SURVEYOR NOTE: SPECIFY IF IT IS WEEKS, MONTHS, OR YEARS

****

22. WHERE DID YOU LAST RE-CHARGE YOUR DEBIT CARD ?

1. CITY OF SIMI VALLEY
2. CITY OF MOORPARK
3. CITY OF THOUSAND OAKS
4. FILMORE AREA TRANSIT (FIIMORE AT THE BUS COMPANY OFFICE)/FATCO
5. SCAT (BUS COMPANY OFFICES)
6. VCTC (COUNTY OFFICES)
7. SANTA PAULA (BY THE OIL MUSEUM)
8. ON BOARD A BUS
9. BY PHONE WITH CREDIT CARD
10. OTHER (OTHER LINE = 84)

(READ PRE-CODED RESPONSES-EXCEPT FOR 'DON'T KNOW','REFUSED',ETC)

****

23. HOW MUCH VALUE DID YOU PUT ON YOUR DEBIT CARD ?
SURVEYOR NOTE: USE THE FOLLOWING FORMAT: I.E. 5.00

****

24. DO YOU ALWAYS RENEW/RE-PURCHASE/EXCHANGE YOUR MONTHLY PASS AT THE SAME PLACE?

1. ALWAYS USE THE SAME PLACE
2. DON'T ALWAYS USE THE SAME PLACE
3. DON'T KNOW/NA

(READ PRE-CODED RESPONSES-EXCEPT FOR 'DON'T KNOW','REFUSED',ETC)

****

25. WHERE ELSE HAVE YOU RENEWED/RE-PURCHASED/EXCHANGED YOUR MONTHLY PASS ?

1. CITY OF SIMI VALLEY
2. CITY OF MOORPARK
3. CITY OF THOUSAND OAKS
4. FILMORE AREA TRANSIT (FILMORE AT THE BUS COMPANY OFFICE)/FATCO
5. SCAT (BUS COMPANY OFFICES)
6. VCTC (COUNTY OFFICES)
7. SANTA PAULA (BY THE OIL MUSEUM)
8. ON BOARD A BUS
9. BY PHONE WITH CREDIT CARD
10. OTHER (OTHER LINE = 85)

(Multiple Response)

(READ PRE-CODED RESPONSES-EXCEPT FOR 'DON'T KNOW','REFUSED',ETC)

SKIP BEFORE Q25 IF Q<24> NE "2" THEN GO 26

****

26. WHICH TRANSIT SERVICE DO YOU USE MOST OFTEN ?

*** SURVEYOR NOTE: CHOOSE ONLY ONE ****

1. SIMI VALLEY TRANSIT
2. MOORPARK CITY TRANSIT
3. CAMARILLO AREA TRANSIT
4. THOUSAND OAKS TRANSIT
5. VISTA
6. SCAT
7. FILMORE DIAL-A-RIDE
8. SANTA PAULA DIAL-A-RIDE
9. OTHER (OTHER LINE = 89)

(READ PRE-CODED RESPONSES-EXCEPT FOR 'DON'T KNOW','REFUSED',ETC)

****

27. ON AVERAGE HOW MANY DAYS PER WEEK DC YOU USE THE BUS ?

1. 5 OR MORE
2 . 2 - 4
3. ONCE
4. LESS THAN ONCE A WEEK

(DON'T READ PRE-CODED RESPONSES)

****

28. WHAT IS YOUR PRIMARY TRIP PURPOSE WHEN USING THE BUS ?

1. SCHOOL/COLLEGE
2. WORK
3. ALL OTHER PURPOSES

(PROMPT ONLY IF NO ANSWER)

****

29. HOW SATISFIED ARE YOU WITH YOUR SMART PASSPORT CARD ?

1. VERY SATISFIED
2. SOMEWHAT SATISFIED
3. SOMEWHAT DISSATISFIED
4. VERY DISSATISFIED
5. DON'T KNOW/NA

(READ PRE-CODED RESPONSES-EXCEPT FOR 'DON'T KNOW','REFUSED',ETC)

SKIP AFTER Q29 IF Q<29> LE "2" THEN GO 31
SKIP AFTER Q29 IF Q<29> EQ "5" THEN GO 31

****

30. PLEASE EXPLAIN WHY YOU ARE DISSATISFIED ?

t

31. HAVE YOU EVER PLACED YOUR CARD ON THE READER, BUT IT DIDN'T WORK ?

1. YES
2. NO

(READ PRE-CODED RESPONSES-EXCEPT FOR 'DON'T KNOW','REFUSED',ETC)

SKIP AFTER Q31 IF Q<31> EQ "2" THEN GO 33

****

32. WHAT HAPPENED ?

1. DRIVER MADE ME PAY
2. DRIVER LET ME RIDE FOR FREE ANYWAY

3. DRIVER TOLD ME I HAD NO MONEY ON THE CARD
4. DRIVER TOLD ME MY CARD HAD EXPIRED
5. DRIVER TOLD ME THE MACHINE WAS BROKEN
6. DRIVER TOLD ME MY CARD WAS FAULTY
7. OTHER (OTHER LINE = 86)

(Multiple Response)

(READ PRE-CODED RESPONSES-EXCEPT FOR 'DON'T KNOW','REFUSED',ETC)
****
33. ARE THE FOLLOWING STATEMENTS TRUE OR FALSE FOR YOU ?

ENTER 'XX' TO CONTINUE.

****
QUESTIONS 34-36 ARE RANDOMLY ROTATED
****
34. NOW THAT I HAVE A SMART PASSPORT CARD I MAKE MORE FREQUENT BUS TRIPS THAN BEFORE.

1. TRUE
2. FALSE
3. DON'T KNOW

(READ PRE-CODED RESPONSES-EXCEPT FOR 'DON'T KNOW','REFUSED',ETC)
****
35. NOW THAT I HAVE A SMART PASSPORT CARD I MAKE TRIPS TO NEW PLACES WITH THE BUS.

1. TRUE
2. FALSE
3. DON'T KNOW

(READ PRE-CODED RESPONSES-EXCEPT FOR 'DON'T KNOW','REFUSED',ETC)
****
36. NOW THAT I HAVE A SMART PASSPORT CARD I USE BUS ROUTES THAT I DID NOT USE BEFORE.

1. TRUE
2. FALSE
3. DON'T KNOW

(READ PRE-CODED RESPONSES-EXCEPT FOR 'DON'T KNOW','REFUSED',ETC)
****
37. HOW DID YOU PAY FOR YOUR BUS FARE BEFORE YOU HAD A SMART PASSPORT CARD ?

1. CASH
2. MONTHLY PASS
3. DISCOUNTED TICKETS (PREPAID BOOKS OF 10/20, ETC.)
4. TOKENS
5. OTHER (OTHER LINE = 87)

(READ PRE-CODED RESPONSES-EXCEPT FOR 'DON'T KNOW','REFUSED',ETC)

SKIP AFTER Q37 GO 41
****
38. WHEN DID YOU FIRST PURCHASE YOUR SMART PASSPORT CARD ?

SURVEYOR NOTE: CAPTURE THE MONTH AND YEAR. I.E. JULY 1997
****

39. WHEN DID YOU STOP USING YOUR SMART PASSPORT CARD'?

SURVEYOR NOTE: CAPTURE THE MONTH AND YEAR. I.E. JULY 1997
****
40. WHY DO YOU NO LONGER HAVE A SMART PASSPORT CARD ?

1. STOPPED USING THE BUS
2. TOO MUCH MONEY TO SPEND AT ONCE EACH MONTH
3. LOST/STOLEN, NEVER REPLACED
4. MOVED HOME OR WORK
5. LEFT SCHOOL
6. OTHER (OTHER LINE = 88)

(Multiple Response)

(READ PRE-CODED RESPONSES-EXCEPT FOR 'DON'T KNOW','REFUSED',ETC)
****
41. WHAT IS YOUR OPINION OF THE SMART PASSPORT CARD, IS IT...?

ENTER 'XX' TO CONTINUE.

****
QUESTIONS 42-46 ARE RANDOMLY ROTATED
****
42. A GOOD VALUE ?

1. YES
2. NO
3. DON'T KNOW

(READ PRE-CODED RESPONSES-EXCEPT FOR 'DON'T KNOW','REFUSED',ETC)
****
43. EASY TO USE ?

1. YES
2. NO
3. DON'T KNOW

(READ PRE-CODED RESPONSES-EXCEPT FOR 'DON'T KNOW','REFUSED',ETC)
*t***
44. EASY TO BUY AND RENEW ?

1. YES
2. NO
3. DON'T KNOW

(READ PRE-CODED RESPONSES-EXCEPT FOR 'DON'T KNOW','REFUSED',ETC)
****
45. USEFUL, CAN USE ON ANY BUS IN THE COUNTY ?

1. YES
2. NO
3. DON'T KNOW

(READ PRE-CODED RESPONSES-EXCEPT FOR 'DON'T KNOW','REFUSED',ETC)
****
46. SAFE, DON'T HAVE TO CARRY MONEY ?

1. YES
2. NO

3. DON'T KNOW

(READ PRE-CODED RESPONSES-EXCEPT FOR 'DON'T KNOW','REFUSED',ETC)
****
47. GENDER **** SURVEYOR NOTE: DO NOT ASK, RECORD BY OBSERVATION ****

1. MALE
2. FEMALE

(READ PRE-CODED RESPONSES-EXCEPT FOR 'DON'T KNOW','REFUSED',ETC)
****
48. WOULD YOU STOP ME WHEN I REACH THE CATEGORY THAT DESCRIBES YOU ?

1. 15 OR UNDER
2. 16 - 24
3. 25 - 34
4. 35 - 49
5. 50 - 64
6. 65 - 74
7. 75 OR OLDER

(READ PRE-CODED RESPONSES-EXCEPT FOR 'DON'T KNOW','REFUSED',ETC)
****
49. WHICH OF THE FOLLOWING DESCRIBES YOU ?

1. STUDENT
2. FULL-TIME EMPLOYED
3. PART-TIME EMPLOYED
4. RETIRED
5. OTHER

(READ PRE-CODED RESPONSES-EXCEPT FOR 'DON'T KNOW','REFUSED',ETC)
****
50. PLEASE STOP ME WHEN I MENTION THE CATEGORY THAT CONTAINS YOUR HOUSEHOLD'S TOTAL INCOME FOR LAST YEAR BEFORE TAXES. WAS IT...

1. UNDER $9,000
2. $9,000 TO $14,999
3. $15,000 TO $19,999
4. $20,000 TO $29,999
5. $30,000 TO $39,999
6. $40,000 OR MORE
7. DON'T KNOW/REFUSED

(READ PRE-CODED RESPONSES-EXCEPT FOR 'DON'T KNOW','REFUSED',ETC)
****
DO YOU HAVE ANY OF THE FOLLOWING ?

51. A DRIVER'S LICENSE ?

1. YES
2. NO

(READ PRE-CODED RESPONSES-EXCEPT FOR 'DON'T KNOW','REFUSED',ETC)
****
52. A CREDIT CARD ?

1. YES
2. NO

(READ PRE-CODED RESPONSES-EXCEPT FOR 'DON'T KNOW','REFUSED',ETC)
****
53. A BANKATMCARD?

1. YES
2. NO

(READ PRE-CODED RESPONSES-EXCEPT FOR 'DON'T KNOW','REFUSED',ETC)
****
54. FOR VERIFICATION PURPOSES ONLY, CAN YOU PLEASE SPELL YOUR FIRST AND LAST NAME FOR ME ?
****

THANK YOU VERY MUCH FOR YOUR HELP, YOUR OPINIONS ARE IMPORTANT TO US.

APPENDIX 4E

SURVEY 2 VARIABLE FREQUENCIES

Survey 2: Frequencies for the 370 respondents who purchased a smart passport use in Ventura County

Question 5: Fare Type

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Adult	130	35.1	35.1	35.1
	Senior	32	8.6	8.6	43.8
	Disabled	51	13.8	13.8	57.6
	Student	148	40.0	40.0	97.6
	Child	8	2.2	2.2	99.7
	No Answer	1	.3	.3	100.0
	Total	370	100.0	100.0	
Total		370	100.0		

Question 6: Status

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Current User	199	53.8	53.8	53.8
	Former Passport User	171	46.2	46.2	100.0
	Total	370	100.0	100.0	
Total		370	100.0		

Question 7: Point of Purchase

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Simi valley	19	5.1	9 5	9.5
	Moorpark	10	2.7	5:o	14.5
	Thousand Oaks	29	7.8	14.5	29.0
	Filmore	34	9.2	17.0	46.0
	SCAT	25	6.8	12.5	58.5
	VCTC	37	10.0	18.5	77.0
	Santa Paula	20	5.4	10.0	87.0
	Camarillo	21	5.7	10.5	97.5
	Oxnard	5	1.4	2.5	100.0
	Total	200	54.1	100.0	
Missing	System Missing	170	45.9		
	Total	170	45.9		
Total		370	100.0		

Question 8: How long ago did you purchase your passport? (Months)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.25	1	- 3	.5	.5
	.50	1	.3	.5	1.0
	1 .00	6	1.6	3.0	4.0
	1.50	1	.3	.5	4.5
	2.00	5	1.4	2.5	7.0
	3.00	13	3.5	6.5	13.4
	4.00	10	2.7	5.0	18.4
	5.00	9	2.4	4.5	22.9
	6.00	19	5.1	9.5	32.3
	7.00	15	4.1	7.5	39.8
	8.00	3	.8	1.5	41.3
	9.00	3	.8	1.5	42.8
	10.00	9	2.4	4.5	47.3
	11.00	11	3.0	5.5	52.7
	12.00	47	12.7	23.4	76.1
	12.25	1	.3	.5	76.6
	13.00	4	1.1	2.0	78.6
	14.00	2	.5	1.0	79.6
	18.00	7	1.9	3.5	83.1
	19.00	2	.5	1.0	84.1
	20.00	1	.3	.5	84.6
	22.00	1	.3	.5	85.1
	23.00	1	.3	.5	85.6
	24.00	13	3.5	6.5	92.0
	27.00	1	.3	.5	92.5
	30.00	2	.5	1.0	93.5
	36.00	10	2.7	5.0	98.5
	42.00	1	.3	.5	99.0
	48.00	1	.3	.5	99.5
	60.00	1	.3	.5	100.0
	Total	201	54.3	100.0	
Missing	System Missing	169	45.7		
	Total	169	45.7		
Total		370	100.0		

Question 9 : Still Using the Card?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	160	43.2	800	80.0
	No	40	10.8	20:o	loo:o
	Total	200	54.1	100.0	
Missing	System Missing	170	45.9		
	Total	170	45.9		
Total		370	100.0		

Question 10: Reason for Not Using Passport

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Need to Recharge	19	5.1	47.5	47.5
	Need to Replace It	6	1.6	15.0	62.5
	Am Using a Cheaper Alternative	3	.8	7.5	70.0
	Can't Find It	1	.3	2.5	72.5
	Don't Need to Travel	7	1.9	17.5	90.0
	Drive Now	3	.8	7.5	97.5
	Other	1	.3	2.5	100.0
	Total	40	10.8	100.0	
Missing	System Missing	330	89.2		
	Total	330	89.2		
Total		370	100.0		

Question 11: Card Type

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	UAK w/Upgrade	6	1.6	3.0	3.0
	DAR Pass	12	3.2	6.0	9.0
	Monthly Pass	89	24.1	44.5	53.5
	Debit Card	93	25.1	46.5	100.0
	Total	200	54.1	100.0	
Missing	System Missing	170	45.9		
	Total	170	45.9		
Total		370	100.0		

Pass Users

Question 12: Former Debit Card Holders Among Pass Users

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	8	2.2	7.5	7.5
	No	98	26.5	92.5	100.0
	Total	106	28.6	100.0	
Missing	System Missing	264	71.4		
	Total	264	71.4		
Total		370	100.0		

Question 13: Reasons for Changing from Debit Card to Pass

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	It's Convenient	6	1.6	60.0	60.0
	It's Less Expensive	2	.5	20.0	80.0
	I Ride the Bus More	2	.5	20.0	100.0
	Total	IO	2.7	100.0	
Missing	System Missing	360	97.3		
	Total	360	97.3		
Total		370	100.0		

Question 14: Most Recent Purchase Location

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Simi valley	11	3.0	10.4	10.4
	Moorpark	1	.3	.9	11.3
	Thousand Oaks	3	.8	2.8	14.2
	Fillmore	21	5.7	19.8	34.0
	SCAT	17	4.6	16.0	50.0
	VCTC	16	4.3	15.1	65.1
	Santa Paula	11	3.0	10.4	75.5
	Camarillo	4	1.1	3.8	79.2
	Oxnard	1	.3	.9	80.2
	On Board a Bus	18	4.9	17.0	97.2
	By Phone	1	.3	.9	98.1
	Never Renewed	2	.5	1.9	100.0
	Total	106	28.6	100.0	
Missing	System Missing	264	71.4		
	Total	264	71.4		
Total		370	100.0		

Question 15: Amount of Last Purchase

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	It Wa Free	2	.5	40.0	40.0
	I Don't Know	3	.8	60.0	100.0
	Total	5	1.4	100.0	
Missing	System Missing	365	98.6		
	Total	365	98.6		
Total		370	100.0		

Question 16: Do you always renewlre-purchase/exchange your monthly pass at the same place?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Always use the same place	88	23.8	83.0	83.0
	Don't always use the same place	11	3.0	10.4	93.4
	Don't know/NA	7	1.9	6.6	100.0
	Total	106	28.6	100.0	
Missing	System Missing	264	71.4		
	Total	264	71.4		
Total		370	100.0		

Question 17: List Other Outlets Used

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Thousand Oaks	1	.3	9.1	9.1
	Filmore	1	.3	9.1	18.2
	SCAT	3	.8	27.3	45.5
	VCTC	1	.3	9.1	54.5
	On Board A Bus	4	1.1	36.4	90.9
	Camarillo	1	.3	9.1	100.0
	Total	11	3.0	100.0	
Missing	System Missing	[redacted]	97.0		
	Total	[redacted]	97.0		
Total		[redacted]	[redacted]		

Debit Card Users

Question 18: Have you ever used a pass?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	38	10.3	40.4	40.4
	No	56	15.1	59.6	100.0
	Total	94	25.4	100.0	
Missing	System Missing	276	74.6		
	Total	276	74.6		
Total		370	100.0		

Question 19: Reasons for Switching from Pass to Debit Card

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	It's tasy to Use	15	4.1	41.7	41.7
	It's Less Expensive	9	2.4	25.0	66.7
	I Ride the Bus Less	11	3.0	30.6	97.2
	Free Ride if VMS N/A	1	.3	2.8	100.0
	Total	36	9.7	100.0	
Missing	System Missing	334	90.3		
	Total	334	90.3		
Total		370	100.0		

Question 20: Initial Amount Placed on Debit Card

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	I Don't Know	1	.3	100.0	100.0
	Total	1	.3	100.0	
Missing	System Missing	369	99.7		
	Total	369	99.7		
Total		370	100.0		

Question 21: Time Elapsed Since Initial Purchase (Months)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.5	1	.3	7 . 1	1.1
	1.5	1	.3	1.1	2.1
	2.0	4	1.1	4.3	6.4
	3.0	6	1.6	6.4	12.8
	4.0	7	1.9	7.4	20.2
	5.0	5	1.4	5.3	25.5
	6.0	12	3.2	12.8	38.3
	7.0	6	1.6	6.4	44.7
	8.0	2	.5	2.1	46.8
	9.0	1	.3	1.1	47.9
	10.0	2	.5	2.1	50.0
	11.0	8	2.2	8.5	58.5
	12.0	22	5.9	23.4	81.9
	15.0	1	.3	1.1	83.0
	18.0	1	.3	1.1	84.0
	19.0	1	.3	1.1	85.1
	20.0	2	.5	2.1	87.2
	23.0	3	.8	3.2	90.4
	24.0	6	1.6	6.4	96.8
	36.0	2	.5	2.1	98.9
	48.0	1	.3	1.1	100.0
	Total	94	25.4	100.0	
Missing	System Missing	276	74.6		
	Total	276	74.6		
Total		370	100.0		

Question 22: Most Recent Outlet for Recharge

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Simi valley	2	.5	2.1	2.1
	Moorpark	8	2.2	8.5	10.6
	Thousand Oaks	14	3.8	14.9	25.5
	Filmore	5	1.4	5.3	30.9
	SCAT	6	1.6	6.4	37.2
	VCTC	8	2.2	8.5	45.7
	Santa Paula	3	.8	3.2	48.9
	Camarillo	5	1.4	5.3	54.3
	On Board a Bus	25	6.8	26.6	80.9
	By Phone	1	.3	1.1	81.9
	Never Recharged	17	4.8	18.1	100.0
	Total	94	25.4	100.0	
Missing	System Missing	276	74.6		
	Total	276	74.6		
Total		370	100.0		

Question 24: Do you always renew/re-purchase/exchange your monthly pass at the same place?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Always use the same place	68	18.4	72.3	72.3
	Don't always use the same place	11	3.0	11.7	84.0
	Don't know or N/A.	15	4.1	16.0	100.0
	Total	94	25.4	100.0	
Missing	System Missing	276	74.6		
	Total	276	74.6		
Total		370	100.0		

Former Passport Users

Question 25: Where else have you renewed?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Simi valley	3	.8	27.3	27.3
	Moorpark	1	.3	9.1	36.4
	Thousand Oaks	2	.5	18.2	54.5
	Fillmore	2	.5	18.2	72.7
	VCTC	1	.3	9.1	81.8
	On Board a Bus	1	.3	9.1	90.9
	Never Renewed	1	.3	9.1	100.0
	Total	11	3.0	100.0	
Missing	System Missing	359	97.0		
	Total	359	97.0		
Total		370	100.0		

Question 26: Most Frequently Used Transit Service

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Simi valley	If	4 . 6	8.5	8.5
	Moorpark	IO	2.7	5.0	13.5
	Camarillo	IO	2.7	5.0	18.5
	Thousand Oaks	17	4.6	8.5	27.0
	VISTA	77	20.8	38.5	65.5
	SCAT	37	10.0	18.5	84.0
	Filmore DAR	16	4.3	8.0	92.0
	Santa Paula DAR	14	3.8	7.0	99.0
	Other	2	.5	1.0	100.0
	Total	200	54.1	100.0	
Missing	System Missing	170	45.9		
	Total	170	45.9		
Total		370	100.0		

Question 27: Frequency of Transit Use (Days per Week)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	5 or more	112	30.3	56.0	56.0
	2 to 4	67	18.1	33.5	89.5
	one	9	2.4	4.5	94.0
	less than one	12	3.2	6.0	100.0
	Total	200	54.1	100.0	
Missing	System Missing	170	45.9		
	Total	170	45.9		
Total		370	100.0		

Question 28: Trip Purpose

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	School	84	22.7	42.0	42.0
	Work	71	19.2	35.5	77.5
	Other	45	12.2	22.5	100.0
	Total	200	54.1	100.0	
Missing	System Missing	170	45.9		
	Total	170	45.9		
Total		370	100.0		

Question 29: Overall Satisfaction

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	very satisfied	166	44.9	83.4	83.4
	somewhat satisfied	28	7.6	14.1	97.5
	somewhat dissatisfied	5	1.4	2.5	100.0
	Total	199	53.8	100.0	
Missing	System Missing	171	46.2		
	Total	171	46.2		
Total		370	100.0		

Question 31: Has Card Ever Malfunctioned?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	154	41..6	77.0	100.0 77.0
	No	46	12.4	23:0	
	Total	200	54.1	100.0	
Missing	System Missing	170	45.9		
	Total	170	45.9		
Total		370	100.0		

Question 32: Driver's Response to Malfunctions

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Made me pay	7	1.9	4.1	4.1
	Let me ride free	129	34.9	75.9	80.0
	Told me I had no money on card	1	.3	.6	80.6
	Told me my card had expired	6	1.6	3.5	84.1
	Told me the machine was broken	20	5.4	11.8	95.9
	Told me my card was faulty	4	1.1	2.4	98.2
	Other	3	.8	1.8	100.0
	Total	170	45.9	100.0	
Missing	System Missing	200	54.1		
	Total	200	54.1		
Total		370	100.0		

Question 34: Now that I have a Smart Passport Card I make more frequent bus trips than before.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	True	119	32.2	59.5	59.5
	False	75	20.3	37.5	97.0
	Don't Know	6	1.6	3.0	100.0
	Total	200	54.1	100.0	
Missing	System Missing	170	45.9		
	Total	170	45.9		
Total		370	100.0		

Question 35: Now that I have a Smart Passport I make trips to new places by bus

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	True	92	24.9	46.0	46.0
	False	105	28.4	52.5	98.5
	Don't Know	3	.8	1.5	100.0
	Total	200	54.1	100.0	
Missing	System Missing	170	45.9		
	Total	170	45.9		
Total		370	100.0		

Question 36: Now that I have a Smart Passport I use bus routes that I did not use before

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	True	97	26.2	48.5	48.5
	False	102	27.6	51.0	99.5
	Don't Know	1	.3	.5	100.0
	Total	200	54.1	100.0	
Missing	System Missing	170	45.9		
	Total	170	45.9		
Total		370	100.0		

Question 37: Form of Fare Payment before Passport

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Cash	159	43.0	79.5	79.5
	Monthly Pass	14	3.8	7.0	86.5
	Discounted Tickets	7	1.9	3.5	90.0
	Tokens	3	.8	1.5	91.5
	Other	2	.5	1.0	92.5
	Didn't Ride the Bus	15	4.1	7.5	100.0
	Total	200	54.1	100.0	
Missing	System Missing	170	45.9		
	Total	170	45.9		
Total		370	100.0		

Question 40: Former Passport Users: Reason for Discontinuing Passport

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Stopped using the bus	55	14.9	31.6	31.6
	Too much to spend at once each month	19	5.1	10.9	42.5
	Lost or stolen	17	4.6	9.8	52.3
	Moved	14	3.8	8.0	60.3
	Left school	29	7.8	16.7	77.0
	Lost job	2	.5	1.1	78.2
	Started car-pooling	4	1.1	2.3	80.5
	Bought a vehicle	18	4.9	10.3	90.8
	Using alternate fare system	3	.8	1.7	92.5
	Couldn't/haven't renewed	6	1.6	3.4	96.0
	Card malfunctioned often	1	.3	.6	96.6
	Other	5	1.4	2.9	99.4
	No response	1	.3	.6	100.0
	Total	174	47.0	100.0	
Missing	System Missing	196	53.0		
	Total	196	53.0		
Total		370	100.0		

Question 42: A Good Value?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	346	93.5	93.5	93.5
	No	16	4.3	4.3	97.8
	Don't Know	8	2.2	2.2	100.0
	Total	370	100.0	100.0	
Total		370	100.0		

Question 43: Easy to Use?

		Frequency	Percent	Valid Percent	Cumulative Percent
valid	Yes	351	94.9	94.9	94.9
	No	14	3.8	3.8	98.6
	Don't Know	5	1.4	1.4	100.0
	Total	370	100.0	100.0	
Total		370	100.0		

Question 44: Easy to Buy and Renew?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	312	84.3	84.3	84.3
	No	38	10.3	10.3	94.6
	Don't Know	20	5.4	5.4	100.0
	Total	370	100.0	100.0	
Total		370	100.0		

Question 45: Useful, Can Use on Any Bus in the County?

		Frequency	Percent	Valid Percent	Cumulativ Percent
Valid	Yes	305	82.4	82.4	82.4
	No	28	7.6	7.6	90:o
	Don't Know	37	10.0	10.0	100.0
	Total	370	100.0	100.0	
Total		370	100.0		

Question 46: Safe, Don't Have to Carry Money?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	342	92.4	92.4	92.4
	No	22	5.9	5.9	98.4
	Don't Know	6	1.6	1.6	100.0
	Total	370	100.0	100.0	
Total		370	100.0		

Question 47: Gender

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	170	45.9	45.9	45.9
	Female	200	54.1	54.1	100.0
	Total	370	100.0	100.0	
Total		370	100.0		

Question 48: Age Distribution

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	15 or under	65	17.6	17.6	17.6
	16 to 24	130	35.1	35.1	52.7
	25 to 34	54	14.6	14.6	67.3
	35 to 49	61	16.5	16.5	83.8
	50 to 64	35	9.5	9.5	93.2
	65 to 74	13	3.5	3.5	96.8
	75 or older	12	3.2	3.2	100.0
	Total	370	100.0	100.0	
Total		370	100.0		

Questtion 49: Employment Status

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	student	182	49.2	49.2	49.2
	Full-time Employed	83	22.4	22.4	71.6
	Part-time Employed	49	13.2	13.2	84.9
	Retired	34	9.2	9.2	94.1
	Other	22	5.9	5.9	100.0
	Total	370	100.0	100.0	
Total		370	100.0		

Question 50: Household Income

		Frequency	Percent	Valid Percent	Cumulativ Percent
Valid	Under $9,000	71	19.2	19.2	19.2
	$9,000 to $14,999	36	9.7	9.7	28.9
	$15,000 to $19,999	20	5.4	5.4	34.3
	$20,000 to $29,999	24	6.5	6.5	40.8
	$30,000 to $39,999	14	3.8	3.8	44.6
	$40,000 or more	51	13.8	13.8	58.4
	Don't Know/Refused	154	41.6	41.6	100.0
	Total	370	100.0	100.0	
Total		370	100.0		

Question 51: Do you have a driver's license?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	139	37.6	37.6	37.6
	No	231	62.4	62.4	100.0
	Total	370	100.0	100.0	
Total		370	100.0		

Question 52 : Do you have a credit card?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	97	26.2	26.2	26.2
	No	273	73.8	73.8	100.0
	Total	370	100.0	100.0	
Total		370	100.0		

Question 53: Do you have an ATM card?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	171	46.2	46.2	46.2
	No	199	53.8	53.8	100.0
	Total	370	100.0	100.0	
Total		370	100.0		