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ABSTRACT

Urban sprawl makes conventional transit less competitive and points to the need for more innovative and flexible demand-responsive transit systems in the future. To increase their efficiency, such systems can take advantage of the emerging advanced public transportation systems technologies, e.g., vehicle location and information systems. However, little is known about how consumers might respond to such systems and what they desire. This paper explores the demand for a consumer-oriented Personalized Demand Responsive Transit (PDRT) service in the San Francisco Bay Area. Such a system could provide services to the traveling public for journeys to work and to non-work destinations. Results from six focus group meetings and a computer-assisted telephone survey of commuters and non-commuters are reported. While about 60% of those surveyed were willing to consider PDRT as an option, about 12% reported that they were "very likely" to use PDRT (N=1000). Many were willing to pay for the service and valued highly the flexibility in scheduling the service. Spatial analysis of the survey responses suggests localities where a PDRT may be field-tested.

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EXECUTIVE SUMMARY

Publicly required Demand Responsive Transit (DRT) services commonly suffer from extremely high subsidies when compared to fixed transit services. For example, in Los Angeles, the cost per trip of MTA (Metropolitan Transportation Authority)-operated ADA service ranges from $18 to $22 per trip and the customers pay $2 to $3 per ride in 2000. The average subsidy cost for MTA's fixed transit customers per trip is about $0.50. Clearly, the ADA DRT service is far more expensive than the fixed transit service. The high operating cost of ADA DRT is largely due to the labor-intensive system, high labor costs and inefficiencies due to service vehicles traveling without or with few passengers. The lack of computer and communications technology to operate the system reliably and efficiently has also been the major barrier. A medium sized ADA DRT system typically requires ten to twelve operators to answer calls, make reservations, and dispatch vehicles. The cost reduction strategies for PDRT include the use of an autonomous dial-a-ride system and reduction of travel miles of empty vehicles. Autonomous dial-a-ride is an automated call handling, scheduling, and vehicle dispatching system, which can improve DRT performance.

Recent developments in innovative transportation and communications technologies can support new forms of demand responsive transit services that can effectively serve relatively low-density urban and suburban areas. Given the current trends, it is expected that demand-responsive transit services will grow, with future systems having a range of services that vary by geography, time of day/week and market segment. Yet even if a higher level of demand-responsive transit service is technologically feasible, little research has been done on the attributes of a system that might be attractive to travelers. Much of what we know about traveler behavior with respect to demand-responsive transit is based on services that operate in rural areas, that serve very specific origins and destinations such as airports, or that are operated as adjuncts to standard fixed-route services, either for limited off-hour support or, more commonly, for ADA compliance.

The paper explores the behavioral responses to a demand-responsive system. This study fills an important gap in our understanding of the traveler demand for a DRT system. It combines qualitative and quantitative analysis techniques to understand consumer propensity to use a premium demand responsive service and their willingness to pay for the service. The focus group and behavioral survey results are consistent and indicate that:

- About 12% of those surveyed expressed a strong willingness to use the PDRT service indicating that there is significant potential to attract travelers to DRT.
- The willingness to pay for PDRT was relatively high, with a good portion of potential users willing to pay premium fares of $10 for a 30-minute trip.
- Many of the respondents expressing interest in the system were not deterred much by the longer wait times for pick-ups and by PDRT taking longer than their current commute or most frequent trip.
- Security was a concern for many potential users sas indicated by their preference for conducting criminal/driving background checks on all van drivers and being dropped off at the front door after dark, for safety reasons.

- Respondents seemed to value the reliability of the PDRT service, followed by the cost of service, convenience of pick-up and drop-off locations, and the number of other pick-ups and overall travel time.
- Respondents expressed a slightly greater preference for the on-demand than the fixed-schedule service, as expected. A very desirable component of PDRT, as indicated by preferences of potential users is the flexibility in scheduling pick-up times.
- Many respondents in the San Francisco Bay Area had access to information and communications technologies, in particular the Internet and cellular telephones, which can help them make reservations and obtain DRT schedule information.

In this study zipcodes were used to identify counties or sub-regions that contain a large population segment likely use the PDRT service. This helped identify potential PDRT providers and locations where field-testing of the service can be undertaken, including Napa and Sonoma counties. It also permitted us to identify areas within the existing BART service region where feeder services needed improvement. However, a line of future research follows from the fact that our results are based on stated willingness to pay for DRT. It is advisable to do more DRT demonstration projects not only to provide a choice in terms of modes and enhance mobility, but also to gain more revealed preference data, so we can plan better for such systems and recommend or not recommended them in other contexts. Comparing revealed and stated preference data from several regions will allow a more accurate picture of willingness to pay for DRT to emerge.

DRT services range from those offered by the public sector largely using taxpayer dollars to those offered by the private sector in profitable market niches. Considering that the goals of decreasing congestion, improving air quality and increasing mobility are in the public interest, it makes sense to provide some public support for PDRT in areas where demand exists but the service has not yet been initiated. The ultimate aim will be to stimulate the private sector provision of DRT. Despite their willingness to pay a premium for PDRT, it is still unclear whether or not the fares discussed in this paper could cover the costs of providing DRT services. Though the analysis indicates that, with an appropriately personalized DRT, user fees could significantly offset the cost of DRT service.

While this study has answered questions about demand for DRT, many questions remain about the supply of such a service. The data and analysis presented in this paper are focused on the San Francisco Bay Area; thus, their application is limited to US cities and counties. It is not fully clear how much cost savings are possible with innovative transportation and communications technologies. There is a need to do field-testing of relevant technologies and market analyses in specific locations to address the business aspects of such a service. Because potential PDRT service models can differ from currently available DRT modes, it might be useful to simulate (using Monte-Carlo methods) the variations in the cost elements of DRT services. This can help us estimate DRT costs and service provider profit margins, given the demand assessed in this study.

INTRODUCTION

Low-density urban sprawl shows little signs of abating. A substantial US population faces problems of limited mobility and accessibility due to the lack of alternative transportation modes. Demand-Responsive Transit (DRT) services help enhance mobility, especially in low-density areas, both suburban and rural. Such systems provide personalized door-to-door service on demand and have flexible routing and scheduling. They often use relatively small vehicles with occupancy of 4 to 20 persons (Lave et al. 1996). These services are often distinguished from the conventional taxi by their ride-sharing feature. DRT is a common form of paratransit (the term means "alongside transit"). According to the Transportation Research Board Committee on Paratransit, an estimated 22,884 private paratransit companies operated in 1998 and more than 500 public transit agencies provided DRT services, largely to riders that are ADA (Americans with Disabilities Act) eligible.

Publicly operated DRT services, where available, commonly suffer from extremely high subsidies when compared to fixed transit services. For example, in Los Angeles, the cost per trip of MTA (Metropolitan Transportation Authority)-operated ADA service ranges from $18 to $22 per trip and the customers pay $2 to $3 per ride. The average subsidy cost for MTA's fixed transit customers per trip is about $0.50. Clearly, the ADA required demand responsive transit service is far more expensive than the fixed transit service. The high cost of operating ADA DRT is largely due to the labor-intensiveness of the system, high labor costs and inefficiencies such as many service vehicles traveling without or with few passengers. Perhaps the lack of computer and communications technology to reliably and effectively operate the system has been major barrier. A medium sized DRT system typically requires ten to twelve operators to answer calls, make reservations, and dispatch vehicles. The cost reduction strategies for PDRT include the use of an autonomous dial-a-ride system and reduction of travel miles of empty vehicles. Autonomous dial-a-ride is an automated call handling, scheduling, and vehicle dispatching system, which can improve performance.

Recent developments in innovative transportation and communications technologies can support new forms of demand responsive transit services that can effectively serve relatively low-density urban and suburban areas. Given the current trends, it is expected that demand-responsive transit services will grow, with future systems having a range of services that vary by geography, time of day/week and market segment. Yet even if a higher level of demand-responsive transit service is technologically feasible, little research has been done on the attributes of a system that might be attractive to travelers. Much of what we know about traveler behavior with respect to demand-responsive transit is based on services that operate in rural areas, that serve very specific origins and destinations such as airports, or that are operated as adjuncts to standard fixed-route services, either for limited off-hour support or, more commonly, for ADA compliance.

This paper explores the behavioral responses to a demand-responsive system. It begins with the background of the PDRT study, followed by the methodology used for focus group meetings and a large-scale survey. The paper reports on the results of the focus group study and CATI telephone survey. Limitations of the study are then presented. Conclusions and implications are

discussed. Note that this paper is focused primarily on the US context. Therefore, the data and analysis presented in this paper are applicable to the context in which the study was undertaken.

BACKGROUND

The benefits of the proposed PDRT include:

1. Improved mobility for all travelers including elderly, handicapped, students, and commuters,
2. Increased the level of service for the elderly and disabled.
3. Improved service in low demand areas
4. Improved transit service by making the service reliable and accessible
5. Greater efficiency achieved through improved overall DRT performance, improved communications and dispatch system, increased driver productivity, reduced labor needs, and reduced operating cost.

Little research has been done to determine whether such services could garner adequate public support to be economically viable in a low-density suburban environment, even if technological improvements in providing such services were beneficial. The objective of this study is thus to understand service attributes that would attract travelers to a Personalized Demand-Responsive Transit (PDRT). The spatially, socially and economically diverse San Francisco Bay Area presented a good opportunity to explore the demand for such a system. The study also seeks to gauge the level of support for such a service, in terms of how many people might be encouraged to choose this mode, whether they are willing to pay higher premiums for such a service, and whether they have access to technologies that can help them make reservations and obtain schedule information.

For most individuals, the decision to take transit depends on trade-offs between attributes of transit and of the personal vehicle, such as travel time/cost, exclusivity and flexibility of service, safety and security, and comfort and convenience. This study explores the tradeoffs through six focus groups, followed by a large-scale telephone survey of travelers in the San Francisco Bay Area. Using the behavioral survey, we investigated travelers' use of the existing transit service and their willingness to use the PDRT service. Survey respondents were introduced to two types of transit services: (1) "on-demand" service, described to participants as similar to a taxi service with the van making multiple pickups; and (2) "fixed-schedule" service, described to participants as a service with pick-ups and drop-offs made at fixed but convenient locations. In addition, participants were asked to respond to questions regarding the cost of the service, important attributes (e.g., cost, reliability and flexibility), preferred payment and reservation methods, and their perceptions of private and social benefits from the service.

Growth Trends and the Future of DRT Systems

The rebirth of DRT service is a significant innovation in public transportation within the United States. A precursor to DRT service was the jitney. However, these early services went out of business largely due to political and economic reasons (Lave et al. 1996; Slater 1997). Presently, there are thousands of DRT services operating in the United States. According to the TRB

Committee on Paratransit, in 1986, there were 6,300 private paratransit companies in the United States and these firms together operated more than 200,000 vehicles, representing more than 350,000 drivers and other staff, making more than 1.4 billion passenger trips. In September 1998, an estimated 22,884 private paratransit companies operated more than 370,000 vehicles in the US.

Compared with conventional transit, a DRT service can be more personalized, more comfortable and provide door-to-door capability. However, the cost of providing such a service is relatively high and it is a labor-intensive mode. In some cases, the costs are comparable to taxicabs. Presently, in the US these services are most commonly operated by social service agencies to transport their clients or by transit districts, counties, and cities for persons with special needs or qualifying conditions (Cervero 1997). Nevertheless, in many rural and small towns where labor rates are low, DRT services are available.

Despite uncertainties about DRT's value as a general approach to providing public transit services, DRT services have continued to grow since the early 1970s, especially with the introduction to the Americans with Disabilities Act (ADA) of 1990. The ADA required fixed-route transit operators to provide complementary paratransit services for persons who are unable to use fixed-route services within their service areas. During the 1970s, less than 100 public transit agencies provided DRT services in the US. In 1990, some 500-transit agencies carried 8.86 billion passenger trips, of which 68 million (less than 1%) were demand responsive trips. By 1996, demand responsive trips had increased to about 95.4 million, 1.2% of the 7.96 billion passenger-trips provided. The data do not count the growth attributed to increased transportation spending for Medicaid transportation, airport shuttle operations, or increasing human service agency transportation, which is paid for through other, non-Federal Transit Administration grant programs.

The time may be right for a rebirth of Demand-Responsive Transit, at least in the San Francisco Bay Area. Figure 1 shows the diversity of transportation modes in the Bay Area. The San Francisco Bay Area is expected to have a 20% increase in its driving population by 2010 without adding additional freeways or significant infrastructure, and this trend is observed in many large metropolitan areas. In lower density areas, DRT services can respond to individual travelers' needs and their door-to-door service offers many advantages over a fixed-schedule and fixed-route system (Lerman 1980). Efficiency of these systems is often higher than that of conventional fixed-route, fixed-schedule services. DRT systems are likely to prosper where fixed-route systems have not: Suburban areas with lower population densities. The advantages of DRT include 1) providing service to those who have little or none, 2) improving service during off peak hours, 3) serving new markets consisting of those who have limited access to transportation (TRB 1974), and 4) reducing congestion as travelers choose transit rather than private vehicles for a growing percentage of their trips.

DRT was desired by non-disabled passengers from lower density areas who used the service as transportation to transfer stations like bus stations or large service centers like shopping malls and public buildings (TRB 1974). DRT services in the early 1970's brought much interest among transit authorities and academics to evaluate the concepts and develop innovative DRT systems. Early DRT demonstration projects (e.g., in Peoria, IL, 1964; Flint, MI, 1968; Mansfield, OH, 1970) were unable to draw enough consumers to support the system even with public subsidies.

Nevertheless, Dial-a-Ride has been popular for some time (Daganzo 1976, 1984; Potter 1976; Stein 1978; Teal 1993; Stone et al. 1993; Dial 1995; Malucelli et al. 1999; Cortes and Jayakrishnan 2002). Yet these services, such as the "Dial-a-Ride" in Boston area, a service that was later tested in other urban regions including King County, Washington, had problems of low ridership and high operating cost (Multisystems, Inc. 1977; Comsis Corporation 1988; TransVision Consultants 1993).

Other studies show conflicting results regarding DRT viability in providing an effective transit service aimed at the traveling public at large (Hall 1970; Louviere 1979; Demetsky et al. 1982; Miller 1989; Jeffrey Parker and Associates 1991; European Conference of Ministries of Transport 1987; Feldman 1987). These studies revealed much uncertainty about the overall effectiveness of the DRT service as well as their future. Some of these studies emphasize the need to modernize dial-a-ride systems with new technologies. Another reason for low performance was that the system was not attractive to consumers. An efficient system (measured by high ridership and low cost) must take advantage of the new transit technologies and it should be perceived as better than consumers' present mode. Yet we have little understanding of consumer preferences regarding what will make them favor DRT over other modes of transportation.

The role of technology

Advanced public transit technologies further improve the climate for new DRT services. The users can have door-to-door comfortable and reliable service and they can be given the most current, real-time DRT information about the vehicles. Furthermore, service to a broader consumer market is possible. Such systems can operate more effectively with vehicle monitoring and dispatching technologies (Teal 1994; Khattak et al. 1996; Lave et al. 1996; Khattak and Hickman 1998). Specifically, several functions that are required for demand-responsive operations—such as trip reservation, scheduling/dispatching, financial management, and communication with the consumer—can be greatly enhanced with information and communications technologies (Rahimi et al. 2000 and Lave et al. 1996). In fact, the Transportation Research Board has developed a Handbook to guide transit agencies in acquiring demand-responsive transit software. Software available in the market is able to use relatively inexpensive computers to support many of the DRT functions. The history of computer use in DRT is described in more detail in Lave et al. (1996).

Personalized Demand-Responsive Transit

To understand how a DRT service can provide a real choice to travelers and respond to their mobility needs, the California PATH program at University of California at Berkeley in conjunction with Caltrans is developing an innovative DRT system. This will initially be a public-private partnership that will facilitate the provision of a technologically advanced and cost-effective DRT. This consumer-based personalized demand responsive transit system will not only provide services to the elderly and handicapped but also serve commuter and other trip types. If the service is to be fully or largely supported by its riders without subsidies, then we must understand consumers' willingness to pay premium fares for such a system. The service will provide door-to-door service like taxicabs as well as semi-fixed route structure like the current DRT system—though the service is expected not to entail direct competition with private taxicabs.

There are some personalized demand responsive systems being field-tested. For example, the City of Corpus Christi in Texas is presently conducting a field test of an Autonomous Dial-A-Ride Transit (ADART) demand responsive service. In Los Angeles, the Mobility Allowance Transportation System (MATS) service has been implemented. MATS allow a customer to call the bus driver to schedule his or her trip and the bus driver can deviate about one-half miles from the scheduled route. Each bus driver has a cellular phone. While both ADART and MATS are in their early stages of development, their benefits are expected to include improved communications and dispatch, reduced operating cost (no human operator), increased driver productivity, reduced labor needs, improved service in low demand areas, and increased the level of service for elderly, disabled persons. A similar automated dial-a-ride system is planned to be implemented with the Smart DRT project in two communities, Castro Valley in Alameda County and the City of Millbrae in San Mateo County in the Bay Area.

A unique aspect of PDRT is that the design system will be based on clearly identified demand and consumer needs. It will communicate with the users via new technologies that include the Internet, cellular telephones and Personal Digital Assistants (PDAs). Consumer input into all aspects of the service will ultimately shape the design of the system with full utilization of the available advanced public transit system technologies, including advanced vehicle location, in-vehicle route guidance, computerized vehicle dispatch and scheduling, and digital communications systems. This study focuses on exploring the commuter and other repetitive trip markets for PDRT.

METHODOLOGY

Two complementary data collection methods used in this study are focus groups and a large-scale telephone survey. Our methodology for determining consumer preferences regarding PDRT is presented in Figure 2 and discussed below.

Focus Groups

Individuals were recruited to participate in focus groups at three separate focus group facilities. As with most focus groups, participants were not randomly chosen. The results of these groups are therefore not representative of a larger population (i.e., participant attitudes cannot be determined to reflect the views of a majority of similar people) as would be the case with a quantitative selection methodology. Nonetheless, focus groups are of value in exploring the range of issues and concerns people have about transportation access and mobility. They are also useful for understanding how people react to the personalized demand responsive transit system, both intellectually and emotionally, when presented with information.

The six groups met in March 2000 and were selected based on geographical locations including East Bay, South San Francisco, and the Peninsula. Participants were recruited with random telephone calls by the focus group facilities where the groups were held, using recruitment screeners. Trained professionals moderated the groups according to consistent guidelines.

Each group had between 6-10 participants, who were mixed in terms of age, income level,

education, gender, and race and ethnicity. The participants consisted of drive alone commuters and Park-and-Ride and transit users. The focus groups were selected with some attention to the goal that the system be funded entirely from ridership revenues. Since the effectiveness of such a system depends on its reception among relatively affluent travelers who will consistently pay premium fares, we set a minimum annual income requirement of $40,000 for a single person household and $60,000 for a household with more than one person. (These people nevertheless often face and contribute to traffic congestion and often do not have a real choice, other than private auto.) Likewise, participants who said they would always drive to work and would never consider public transportation under any circumstances were excluded from the focus groups. Individuals were paid incentive fees of $50 for their participation in the study.

Focus group participants were first asked whether they consider and weigh alternative transportation modes before choosing the best way to reach their destination. Then they were asked about their overall attitudes toward the public transit service in the Bay Area, including the perceived benefits using public transit and reasons for not taking public transit. The moderator gave a brief description of a personalized demand responsive transit system. The description did not include the specificity of what type of DRT we were proposing. Rather it was a brief description of DRT in order to generate ideas and a discussion. In the discussion, a fixed-route system, on-demand service and a combination of both was brought up by the participants. The participants were asked about what amenities and attributes they preferred and the expected advantages and disadvantages of DRT. Another discussion topic was whether DRT should be operated by private firms or public agencies, and why would the system appeal to them? The results of the focus groups provided the basis for developing a large-scale telephone survey.

CATI Survey

A large-scale survey was conducted in May 2000 was followed by the focus group study. The survey was administered using the computer aided telephone interview (CATI) technique. The sample was drawn from households in all nine Bay Area counties by random digit dialing according to telephone prefixes and area codes. The sampling frame is based on a database of all working residential telephone exchanges and working blocks (sampling areas such as county or zipcode). The sample is pulled using a pure unweighted methodology from nine counties based on household density in each county. The assumption was that each possible telephone number within each county had an equal chance of being selected.

Calls were made to each number up to five times or until the call was answered, and a 50% response rate was achieved among those households that did eventually answer the call.
One thousand telephone interviews were completed. This sample size was determined based on the expectation that there should be enough respondents from both commuter and non-commuter groups to develop statistically reliable profiles of each group's travel preferences.

Other important subgroups for sampling were defined by mode. Their relative occurrence in the commuter population, according to the 1990 census data, is: 68.2% drive alone, 13% rideshare, 11.2% take public transit and 7.6% choose another transportation mode. We estimated

that sufficient numbers will be obtained in the drive-alone category but the rideshare and public transit categories may not be sufficient to draw statistically significant conclusions.

To prevent any response bias by gender, an interviewing quota of no more than 52% female respondents was imposed. It has been well documented that women tend to respond more readily to surveys than do men. By imposing a gender quota we increased the chance that the resulting sample population was representative of the Bay Area adult population with respect to gender. Multiple contact attempts and refusal conversion procedures were used to minimize non-response bias. Interviews were conducted with those who met the predetermined criteria; only individuals who were at least 18 years old were considered eligible for interviewing; non-residents and those who had language barriers were excluded from the survey; if the primary travel mode was walking or bicycling, the interview was terminated.

The survey questions were directed to five subject areas, concerning:

- General trip characteristics of commuters and non-commuters by mode, frequency, origin and destination, and specific routes people normally take.
- The perception of the existing public transit service.
- The personalized demand responsive transit service as an alternative to other methods of transportation.
- The Availability of communication devices such as the Internet, a personal digital assistance unit, and cellular phones.
- Demographic profiles of survey participants.

The PDRT was introduced in the following ways: "Now I'd like to talk about a personalized transit service that is being proposed for the Bay Area as an alternative to other methods of transportation. Suppose a personalized transit service was available that took you from your neighborhood to wherever you wanted to go—your workplace, school, shopping, etc. Which of the following five features of this service would be MOST IMPORTANT to you? SECOND most important? THIRD most important? FOURTH most important?" Next, the respondents were asked: "The personalized transit service being planned for the Bay Area would use comfortable, air-conditioned vans, and pickups would be scheduled for convenient times. If <u>you</u> were planning such a service, what is the MAXIMUM number of pickups that you think should be allowed per trip; what is the MAXIMUM number of people you think each van should hold?" Then respondents were told "Two different types of personalized transit service are being considered. The first type of service is called "On-Demand Service." It would be like a taxi service with the van making multiple pickups. You would have to phone or use the Internet to schedule pick-ups ahead of time. You would then be picked up at your front door and dropped off at the front door of your destination. The second type of service is called "Fixed Schedule Service." Pick-ups and drop-offs would be made at fixed but convenient locations in your neighborhood and near your workplace, school, or other destination. The vans would run at convenient times throughout the day. You would not have to schedule the pick-up ahead of time—just show up at the pick-up location." Then respondents were asked, "How likely do you think you would be to use the Fixed Schedule type of personalized transit service for your commute or most frequent trip away from home? Please use a five-point scale where one means "not at all likely" and five means "very likely."

Limitations

Survey data must be interpreted with caution. There is potential for certain biases that are inherent in survey research. These include:

- Self-selection bias: The respondent feels strongly about transportation or related issues and therefore is more likely to respond to the survey than others.
- Prominence bias: The respondent considers only the most important attribute of the service in making a choice (though this was controlled through survey design).
- Non-commitment bias: The respondent overstates his or her willingness to use and pay as there is no actual use or payment involved.
- Justification bias: The respondent's answers to preference questions are influenced by their actual choice and a need to justify revealed behavior.
- Scenario bias: The respondent is unable to assess the true value of the service.

Some of these biases can be corrected by the survey design and survey administration techniques. Another method of correction is sample balancing through weighting responses using socio-economic variables shown in census data or other regional databases. To minimize survey bias, we emphasized that questions be designed to obtain unbiased responses, i.e., not giving information about PDRT that will pre-dispose the sample towards giving positive responses. Additionally, the sample was selected using the scientific sampling method, and the survey was administered using the CATI technique to maximize consistency and minimize missing data. The survey design was based on the input from focus groups and the responses were compared with other data such as census information. Within the constraints of such survey analysis all attempts were made to ensure that the survey accurately represents the Bay Area resident population. The sample was compared with the 2000 census data. T-tests were performed and they showed that the sample was fairly representative of the Bay Area population when compared in terms of age, ethnicity and modal split. Table 1 shows the age group comparison of the study sample with the 2000 census data (t-test, p-value = 0.02). As expected, sample balancing did not substantially influence the overall conclusions presented in this paper. The findings presented in this paper are based on un-weighted data. There was very little missing data, beyond the skip patterns.

FOCUS GROUP RESULTS

The focus groups were designed to explore attitudes among two sets of commuters: those who drive to work alone, and those who drive alone to public transportation and then take some form of public transportation to their work. The response to the PDRT service, which was described as a semi-fixed PDRT, was positive among all participants. The results also showed that:

- Participants carefully plan their commutes. Throughout the groups, it was clear that people spend time to think about their commute. They consider and weigh a large number of factors before determining the best way for them personally to reach work each day. These include time, cost, reliability, flexibility, comfort, convenience, safety, security, ease of use and stress. In addition, many commuters have experimented, testing different methods of getting to work so they can personally decide which one is best for them.

- The most important factors seem to be cost, safety and convenience. That is, if the commuter considers the service to be too expensive to use, unsafe in some way, or simply too inconvenient, any other benefits the service offers would not even be considered and the commuter would decide not to use the service. In addition, if the commuter has unanswered questions about these issues, they may not fully investigate the system. That is, if they are concerned about its safety but have no assurances of the ways in which it is safe, they may not consider it as a transportation mode despite its being, in fact, very safe.
- Participants wanted the service to be tailored to their schedules, giving them the flexibility to go into work a half hour later or stay a half hour later, or leave work earlier, if needed. Flexibility combined with not having to drive represents an opportunity to lessen the stress in their lives by making their commute more pleasant.
- They favored the idea that the service will be limited to only a few passengers per van, being driven by a safe and professional driver who is taking them door-to-door. Some parents said they would consider the service as a safe and convenient way to provide transportation to their older children, who often need to be picked up from school or from after-school activities.
- The exclusivity of PDRT service appeals to potential passengers. An important concern is safety, the sense that this service would be limited to people who call ahead and give their name and address and phone number, and would exclude people who are just coming off the street. They also believe that the van would pick up other people in their own neighborhood, giving them an additional sense of comfort about their fellow van passengers.
- Another appeal of the service for the Park-and-Ride participants is that it would prevent them from having to deal with the big crowds and harried rushing that are part of their experience riding public transit.
- Many of the drive alone travelers liked the idea of having someone else drive, and saving the wear and tear not only on their car, but also on themselves. Sitting in traffic every morning and night is stressful, and being able to sit in a comfortable seat and read the newspaper while being driven to their destination appealed to the participants.

CATI SURVEY RESULTS

The focus groups provided a rich base to help design the CATI survey, which sought to assess the value of a PDRT with specific features, and consumers' willingness to pay for it. The questionnaire contained screening questions, details of commute or most frequent trip, stated preference questions about on-demand and fixed-schedule PDRT, and technology access/socioeconomic variables. The main objective was to elicit desired features of a PDRT service, e.g. cost, acceptable waiting time and number of stops, and required travel-time (Figure 3).

Table 2 shows that more than half of the respondents commute to work, less than ten percent commute to school, and 3.7% commute to work and school about equally. Approximately one third do not commute. This last group of non-commuters was asked to provide details of their most frequent trip which could be for shopping, personal business, driving children, etc. The modal choice of the respondents is as expected; most travelers drive alone (79.6% of the commuters and 83.3% non-commuters drive alone) followed by transit (12.8% and 8.5% for commuters and non-

commuters respectively) and carpool (6.6% for commuters and 8.2% for non-commuters). Few respondents use Park-and-Ride. The one-way travel time for trips taken by cars was 31.7 minutes, though the median was 25 minutes (reported by 634 respondents). Transit travel time was 42.9 minutes, though the median was 40 minutes (reported by 82 respondents). Both travel time distributions were approximately bell-shaped. The modal split of the sample is relatively consistent with the Bay Area 2000 census.

The technology access variables, shown in Table 3, indicate that about half of the respondents own a cellular telephone, two thirds have access to the Internet at home and half at work, over two thirds have access to a personal computer at home and have a cable television subscription. These figures are consistent with a similar San Francisco household survey conducted in 1999 to evaluate TravInfo impacts (Yim 2001). Furthermore, relatively new technological devices were also owned by the persons responding to the survey (or by member(s) of their immediate family). Approximately two fifths of the respondents have pagers, one fifth have Personal Digital Assistant, and very small number of respondents have vehicle navigation unit in their vehicle. As expected, the market penetration of these new devices has increased substantially compared with a similar survey conducted in 1999 (Yim 2001). Thus potential DRT users can communicate with the service via several information and communications technologies, some of which have achieved greater than 50% market penetration, e.g., cellular telephones and the Internet.

Fifty-two percent of the respondents were female and most respondents lived in households with others. There were very few respondents who reported not having any cars, minivans, trucks or motorcycles in their households. Many respondents worked full-time (47.1%), though quite a few were not employed (33.4%). Among those employed, one third were Professionals. A majority of the respondents had either graduated from college or attended some college. In terms of race, a majority reported themselves to be white, as expected. The age distribution of the respondents is fairly even and includes a relatively large portion of those 65 or older (15%). A significant portion (28.8%) reported having household incomes (before taxes) greater than $80,000 and a few reported incomes lower than $20,000. However, as is often the case in such surveys, quite a few respondents refused to state their income (25.5%). Overall, the respondents are educated and higher income, as expected of the Bay Area residents.

PDRT Scenarios

The stated preference questions related to on-demand PDRT service and fixed-schedule PDRT service and were divided into three sections. Table 4 shows the responses and the definitions of on-demand and fixed-schedule service as described to the respondents. The respondents were questioned about their willingness to use the service in three distinct scenarios:

- Scenario 1 provided only limited information about the services, simply a description of the on-demand and fixed-schedule service, and the respondents were asked about their willingness to use the service.
- Scenario 2 asked respondents if they were willing to use the on-demand and fixed-schedule services, given certain levels of PDRT costs, travel times and wait times. The ranges of travel times and costs for the hypothetical service scenarios were determined based on prevailing

conditions in the San Francisco Bay Area, e.g., respondents were asked if they will be willing to pay $10, $7, $5, $3, $1 for a 30-minute and 15-minute door-to-door trips. Note that the preferred procedure for asking willingness to pay questions is to first ask about a higher payment point and lower it subsequently, if the respondent is unwilling to pay.

- Scenario 3 asked respondents about their willingness to pay for each of the services, both before and after a set of attitudinal questions were asked. The attitudinal questions sensitized respondents to issues such as transit driver background checks that they might not have considered before.

In the limited information case (Scenario 1), 17.3% and 14.5% of the respondents reported that they will be very likely to use on-demand and fixed-schedule services respectively (N=1000); an additional 12.1% to 13.9% were likely to use the service (where two numbers are reported, the first one is for the on-demand service, and the second one for fixed-schedule service). However, many reported that they were not at all inclined to use on-demand or fixed-schedule services—22.8% reported that they were unlikely to use either of the two PDRT services; these respondents were not asked many of the questions in Scenarios 2 and 3. For those willing to use the on-demand PDRT service, the reported median weekly usage was 3 days—though some said they could use the service seven days a week. Slightly more individuals preferred the fixed-schedule PDRT service compared with the on-demand service. Overall, the reported PDRT usage results are realistic, and a relatively conservative estimate of those who might be willing to try the service ranges from 14% to 17% of the respondents.

At least 62.7% of the respondents were willing to consider PDRT and were asked detailed questions in Scenario 2. Among those willing to consider using the PDRT (the PDRT pre-disposed), 73.0% (469 out of 642) and 62% (389 out of 627) were willing to pay between $5-$10 for a 30 minute door-to-door trip. (A 30-minute door-to-door trip will be meaningful to most respondents, given that on average, they reported auto and transit trip times of 31.7 and 42.9 minutes respectively.) Interestingly, more people were willing to pay the $10 per trip for the on-demand service (29.6%) than for the fixed-schedule service (19.1%). One important factor that explains this is the way the services were described: The on-demand service was described as being similar to a taxi service and the fixed schedule service more like conventional transit (fixed but convenient pick-up and drop-off locations). For shorter trips of 15 minutes, 75.3% and 68.9% of the pre-disposed respondents were willing to pay between $3-$5 using on-demand and fixed-schedule services, respectively.

A majority of the PDRT predisposed were willing to use the service despite an average 20-minute wait time for pickup and 54.5% were willing to take PDRT despite it taking 15 to 20 minutes longer than their current commute or most frequent trip. At the desired/acceptable levels of cost, wait time, trip length, and scheduling times, respondents that were very likely to use PDRT services are about 21% (of the PDRT predisposed). The closest category of "likely to use PDRT" is about 24%. Overall, among those predisposed to PDRT (62.7% of all respondents), many were willing to pay for the service, wait for the pick-up and were accepting of the fact that PDRT may take longer than their current mode. Furthermore, the differences in responses between the on-demand and fixed-schedule transit are not substantial.

In Scenario 3, before asking attitudinal questions, the respondents were asked to reiterate their PDRT usage preferences if both on-demand and fixed-schedule services were available. As expected, those very likely to take PDRT remained at 13.8% of the total 1000 respondents (22.0% of the 627 who were predisposed to transit). Responses to the attitudinal questions are shown in Table 5. They indicate a strong preference for flexibility in scheduling pick-up times, conducting criminal/driving background checks on all van drivers and being dropped off at the front door after dark for safety reasons. There is also some agreement with driving in the Bay Area being so difficult that respondents would much rather use PDRT than drive. The respondents were not overly concerned or burdened by having to wait on hold for scheduling a pick-up time, vans driving through their neighborhoods at all hours, van drivers forgetting to pick them up, respondents having access to the Internet while on the van and lack of luggage storage space on the van. Many respondents were neutral about the driver knowing the respondents' residential location, safety of PDRT relative to conventional transit and vans getting stuck in traffic delays.

Answering these attitudinal questions may have sensitized the respondents to some of the risks and advantages of PDRT. Probably the awareness of the risks reduced the proportion of those very likely to take PDRT, from 13.8% (N=138 respondents) to 12.2% (N=122 respondents). The important point is that about 12% of the total respondents consistently show a high willingness to use the PDRT service, despite their awareness of PDRT risks.

Respondents were asked about the importance of PDRT attributes. Table 6 indicates that the key PDRT attributes are: Reliability of the PDRT service (32.5% rated it as most important to them), followed by the cost of service, convenient pick-up and drop-off locations, number of other pick-ups and overall travel time (in that order). The median for maximum number of other pickups is 4 and the preference for maximum number of people in a van is 8. Respondents preferred to pay on a per use basis, though some (33.4%) were inclined to pay a monthly fee. Most respondents were willing to schedule the service 24-hours in advance and use the telephone to make their reservations (70.1%). Interestingly, 25.0% preferred to schedule PDRT through the Internet.

The perceived personal benefits of PDRT were greater convenience, relatively lower travel cost, travel time savings and lower stress/frustration (in that order). The perceived social benefits, in order of importance, were traffic congestion reduction, air pollution reduction, greater mobility/accessibility and "other" benefits such as noise reduction, safety improvements, and possible "road rage" reduction.

Marketing PDRT to the public in the area served is likely to be crucial to attracting customers. Most PDRT predisposed respondents (62.3%) preferred to receive detailed PDRT information from pamphlets, though many felt that television (43.1%) and radio (17.4%) might be the best places for PDRT to advertise the service.

We explored relationships between willingness to use PDRT and contextual/socio-economic variables. Cross-tabulations show that there is strong statistical association between willingness to use and age. In general, older people belonging to the age group 55 or more are more willing to use PDRT than younger people belonging to the age group 18-24 ($p < 0.05$). Females are marginally more likely to use on-demand PDRT services than males ($p = 0.059$). Auto ownership is

marginally associated with the willingness to use the fixed schedule services, with those having fewer autos more likely to use the service ($p = 0.072$). In particular, people with one or two autos are more inclined to use fixed services than those with three or more autos.

Spatial Analysis of the Survey Results

Zip codes of respondents covering all the nine-county Bay Area were used to geo-code the data. Each zip code contains between 5-10 sample respondents, based on the proportion of population residing in the zip code area, though respondents could not be traced to their residential location. All maps produced for the study cannot be presented here due to space limitations, though a sample map is shown in Figure 4. It shows a concentration of those willing to use the on-demand PDRT service within the East and South Bay as well as in some of the outlying areas, including Napa, and Sonoma counties. These counties also have more low-income populations and BART (Bay Area Rapid Transit) does not serve them. Given that PDRT can serve low-density areas relatively well, we recommended that PDRT be considered in these two counties. Finding the exact locations for PDRT implementation must be done at the local level and with full involvement of various stakeholders. One surprising outcome of the spatial analysis is the realization that a number of potential PDRT users are located in the relatively high-density East Bay area, within the BART service area. This has prompted us to develop plans with BART to improve the feeder system. The important point is that using this methodology, we were able to identify certain locations that would be more receptive to such a service.

CONCLUSIONS AND IMPLICATIONS

This study fills an important gap in our understanding of the traveler demand for a DRT system. It combines qualitative and quantitative analysis techniques to understand consumer propensity to use a premium demand responsive service and their willingness to pay for the service. The focus group and behavioral survey results are consistent and indicate that:

- About 12% of those surveyed expressed a strong willingness to use the PDRT service indicating that there is significant potential to attract travelers to DRT.
- The willingness to pay for PDRT was relatively high, with a good portion of potential users willing to pay premium fares of $10 for a 30-minute trip.
- Many of the respondents expressing interest in the system were not deterred much by the longer wait times for pick-ups and by PDRT taking longer than their current commute or most frequent trip.
- Security was a concern for many potential users sas indicated by their preference for conducting criminal/driving background checks on all van drivers and being dropped off at the front door after dark, for safety reasons.
- Respondents seemed to value the reliability of the PDRT service, followed by the cost of service, convenience of pick-up and drop-off locations, and the number of other pick-ups and overall travel time.
- Respondents expressed a slightly greater preference for the on-demand than the fixed-schedule service, as expected. A very desirable component of PDRT, as indicated by preferences of potential users is the flexibility in scheduling pick-up times.

- Many respondents in the San Francisco Bay Area had access to information and communications technologies, in particular the Internet and cellular telephones, which can help them make reservations and obtain DRT schedule information.

In this study zipcodes were used to identify counties or sub-regions that contain a large population segment likely use the PDRT service. This helped identify potential PDRT providers and locations where field-testing of the service can be undertaken, including Napa and Sonoma counties. It also permitted us to identify areas within the existing BART service region where feeder services needed improvement. However, a line of future research follows from the fact that our results are based on stated willingness to pay for DRT. It is advisable to do more DRT demonstration projects not only to provide a choice in terms of modes and enhance mobility, but also to gain more revealed preference data, so we can plan better for such systems and recommend or not recommended them in other contexts. Comparing revealed and stated preference data from several regions will allow a more accurate picture of willingness to pay for DRT to emerge.

DRT services range from those offered by the public sector largely using taxpayer dollars to those offered by the private sector in profitable market niches. Considering that the goals of decreasing congestion, improving air quality and increasing mobility are in the public interest, it makes sense to provide some public support for PDRT in areas where demand exists but the service has not yet been initiated. The ultimate aim will be to stimulate the private sector provision of DRT. Despite their willingness to pay a premium for PDRT, it is still unclear whether or not the fares discussed in this paper could cover the costs of providing DRT services. Though the analysis indicates that, with an appropriately personalized DRT, user fees could significantly offset the cost of DRT service.

While this study has answered questions about demand for DRT, many questions remain about the supply of such a service. The data and analysis presented in this paper are focused on the San Francisco Bay Area; thus, their application is limited to US cities and counties. It is not fully clear how much cost savings are possible with innovative transportation and communications technologies. There is a need to do field-testing of relevant technologies and market analyses in specific locations to address the business aspects of such a service. Because potential PDRT service models can differ from currently available DRT modes, it might be useful to simulate (using Monte-Carlo methods) the variations in the cost elements of DRT services. This can help us estimate DRT costs and service provider profit margins, given the demand assessed in this study.

REFERENCES

Cervero, R. *Paratransit in America: Redefining mass transportation*. Praeger Publishers, Westport, Conn. 1997.

Comsis Corporation, *Cost analysis methodology for demand-responsive service*, Urban Mass Transit Administration and the Maryland Department of Transportation, 1988.

Cortés C. and R. Jayakrishnan, "Design and operational concepts of a high coverage point-to-point transit system," TRB CD-ROM, Transportation Research Board, Washington, D.C., 2002.

Daganzo, Carlos. "An approximate analytic model of many-to-many Demand Responsive Transportation Systems" *Transportation Research* 12(5), 1978 pp. 324-333.

Daganzo, C. "Checkpoint dial-a-ride systems," *Transportation Research, Part B*, Vol. 18, No 4/5, 1984, pp. 315-327.

Demestsky, M., et al., *Decision procedures for paratransit market selection and service evaluation*, US Department of Transportation, May 1982.

Dial, R. "Autonomous dial-a-ride transit introductory overview," *Transportation Research C*, Vol. 3, No 5, 1995, pp. 261-275.

European Conference of Ministers of Transport, *Transportation for disabled people, developing accessible transport: the role of demand responsive services*, 1987.

Feldman, L., *Regional paratransit operation evaluation and five-year transit development plan*, Androscogging Valley Council of Government, June 1987.

Hall, Edward, *Personalized transit study*, Final report and recommendations, City of Phoenix, Arizona, 1970.

Jeffrey A. Parker Associates, *Mobility management and market oriented local transportation*, US Department of Transportation, Advanced public Transportation Systems Program, March 1991.

Khattak A., H. Noeimi, H. and Al-Deek, "A taxonomy for Advanced Public Transportation Systems." Research Report UCB-ITS-PRR-93-9, *Journal of Public Transportation*, Vol. 1, No. 1, pp. 43-68, 1996.

Khattak A., and M. Hickman, "Automatic vehicle location and computer aided dispatch systems: Commercial availability and deployment in transit agencies," *Journal of Public Transportation*, Vol. 2, No. 1, pp. 1-26, 1998.

Kikuchi, S. "Vehicle Routing and Scheduling Development for Transportation of Elderly and Handicapped Persons" *Transportation Quarterly* 41(2), 1987, pp. 207-227.

Lave R., R. Teal, and P. Piras, *A handbook for acquiring demand-responsive transit software.* TCRP Report 18, 1996.

Lerman, S., et al. "A Model System for Forecasting Patronage on Demand Responsive Transportation Systems" *Transportation Research*, 14A (1), 1980 pp. 13-23.

Louviere, J., *An analysis of user cost and service trade-offs in transit and paratransit services*, US Department of Transportation, UMTA / TSC Evaluation Series, Service and methods demonstration program, August 1979.

Malucelli, F., M. Nonato and S. Pallottino. *Demand Adaptive Systems: Some proposals on flexible transit*. In Operational Research in Industry*,* T.A. Ciriani, et al., Editors, McMillan Press: London, 1999, pp. 157-182.

Miller, J., *Shared-ride paratransit performance evaluation guide*, Pennsylvania Transportation Institute and US Department of Transportation, November 1989.

Multisystems, Inc., *State of Wisconsin Urban Mass Transit Demonstration Program: Merrill project*, final report, January 1977.

Potter, B., "Ann Arbor's dispatching system," *Transportation Research Record 608*, TRB, National Research Council, Washington, D.C., 1976, pp. 89-92.

Rahimi M., M. Dessouky, J. Gounaris, G. Placencia, & M. Weidner, *A task decomposition model for dispatchers in dynamic scheduling of demand responsive transit*, McTrans Report, University of Southern California, Los Angeles, CA, June, 2000.

Teal R., "Using smart technologies to revitalize demand responsive transit," *IVHS Journal*, 1(3) 1994. pp. 275-293.

Teal, R.F. "Implications of technological developments for demand responsive transit," *Transportation Research Record 1390*, TRB, National Research Council, Washington, D.C., 1993, pp. 33-42.

TransVision Consultants Ltd., *Evaluation of handyline: Vancouver's automated paratransit information system,* BC Transit, March 1993.

TRB, *Demand Responsive Transportation Systems and Services*, Transportation Research Board Special Report 154, 1974.

Slater C. "General Motors and the Demise of Streetcars," *Transportation Quarterly*, Vol. 51, No. 3, 1997, pp. 45-66.

Stein, D.M. “Scheduling dial-a-ride transportation systems,” *Transportation Science*, Vol. 12, No 3, 1978, pp. 232-249.

Stone, J.R., A. Nalevanko and J. Tsai. “Assessment of Software for computerized paratransit operations,” *Transportation Research Record 1378*, TRB, National Research Council, Washington, D.C., 1993, pp. 1-9.

Yim Y., *TravInfo Evaluation: Traveler Response Element, Broad Area Study, Phase II Results,* PATH Research Report, UCB-ITS-PWP-2001-04, University of California at Berkeley, 2001.

LIST OF FIGURES AND TABLES

Table 1. Age Group Comparison between Bay Area 2000 census and the study sample—N = 927. (Refused to answer or no answer responses were treated as missing cases for comparison)

Age Group in Years	2000 census Percent (%)	Study sample Percent (%)
18 - 24	11.1%	11.5%
25-34	19.8	17.0
35-44	23.4	23.5
45-54	19.2	19.7
55-64	11.4	12.1
65+	15.1	16.1

Table 2: Screening of respondents and their travel patterns.

Variable	Percent	Sample size
Age 18+ and Permanent resident of the San Francisco Bay Area	100	1000
Female	52.0	1000
Commute or not:		1000
Work commute	54.1	
School commute	5.6	
Commute to work and school equally	3.7	
Not commute	35.2	
Not sure, don't know, refused	1.4	
Commute mode:		
Drive alone	80.5	634
Carpool	6.6	
Transit	12.8	
Park-and-ride	0.9	
Most frequent trip mode, if non-commuter:		
Drive alone	83.3	366
Carpool	8.2	
Transit	8.5	
Park-and-ride	0.0	

Table 3: Technology access and socioeconomic variables (N=1000, unless stated otherwise).

Variables	Percent	Variables	Percent
Technology Access Variables			
Own cellular phone	54.7	Access to personal computer at home	76.1
Have Internet access at home	67.8	Own a pager either personally or any member of immediate family	40.6
Have Internet access at work	51.1	Have a personal digital assistant either personally or any member of immediate family	17.9
Have a cable television subscription	73.5	Have a navigation unit in car either personally or any member of immediate family	4.6
Socioeconomic Variables			
Female	52.0	Education:	
		Up to high school	22.3
		Up to college	51.0
		Graduate	18.6
		Vocation	1.4
		Refused or DK	6.7
Household size:		Race:	
1 person	16.2	White	65.7
2 persons	30.7	Black	5.4
3 persons	18.6	Asian	8.3
4 persons	8.4	Hispanic	7.2
5 or more persons	5.1	Other	2.8
Refused or DK	5.5	Refused	10.6
Auto ownership:		Age:	
0 vehicles	3.1	18-34	26.5
1 vehicle	21.5	35-54	40.1
2 vehicles	33.5	55-64	11.2
3 vehicles	20.5	65+	14.9
4 or more vehicles	16.0	Refused or DK	7.3
Refused or DK	5.4		
Occupation:	(N=666)	Income:	
Professional	33.6	Up to 19K	6.8
Manager	15.6	20K-39K	11.5
Sales-clerical	18.9	40K-59K	16.4
Craft	6.8	60-79K	11.0
Service	19.4	80+	28.8
Labor	4.7	Refused or DK	25.5
Refused or DK	1.1		

Table 4: Questions regarding Personalized Demand Responsive Transit (PDRT).

Scenario 1: Limited information about PDRT attributes (see note below)		
Variable categories	On-Demand PDRT Service	Fixed-schedule PDRT Service
PDRT Usage:	(N=1000)	(N=1000)
Not at all likely	34.7	36.9
…	14.1	12.8
...	20.7	21.5
…	12.1	13.9
Very likely	17.3	14.5
DK	1.1	0.4
Scenario 2: More information about PDRT attributes		
Use PDRT for 30-minute door-to-door trip and pay:	(N=642)	(N=627)
$10	29.6	19.1
$7	14.3	13.7
$5	29.1	29.2
$3	17.4	20.4
$1	6.2	11.5
DK or “no” to all questions	3.3	6.1
Use PDRT for 15-minute door-to-door trip and pay:	(N=642)	(N=627)
$5	45.3	34.6
$4	10.1	11.5
$3	19.9	22.8
$2	13.2	15.3
$1	4.2	8.5
DK or “no” to all questions	7.2	7.3
Use PDRT if average wait for pick-up was:	(N=642)	(N=627)
20 min	51.6	41.8
15 min	16.8	19.5
10 min	22.0	26.6
5 min	5.6	8.3
DK	4.0	3.8
Use if PDRT took longer than current commute most frequent trip by:	(N=642)	(N=627)
20 min	36.1	32.2
15 min	18.4	21.2
10 min	27.4	30.0
Same	11.1	11.0
Faster	2.3	3.8
	4.7	
PDRT Usage at desired attribute levels (5-point scale):	(N=642)	(N=627)
Not at all likely	7.5	5.1
...	15.3	12.6
	31.2	31.7
	24.3	26.8
Very likely	21.3	22.0
DK	0.5	1.0

Note: In Scenario 1, The “On-Demand Service” was described as: “It would be like taxi service with the van making multiple pickups. You would have to phone or use the Internet to schedule pick-ups ahead of time. You would then be picked up at your front door and dropped off at the front door of your destination.” The “Fixed-schedule Service” was described as “Pick-ups and drop-offs would be made at fixed but convenient locations in your neighborhood and near your workplace, school, or other destination. The vans would run at convenient times throughout the day. You would not have to schedule the pick-up ahead of time — just show up at the pick-up location.”
DK = Don’t Know; Modes are in bold. 22.8% (228 respondents) were not at all likely to use either on-demand or fixed-schedule PDRT services..

Table 5: Attitudinal questions on a five-point scale about PDRT (772 respondents).

Question wording	Completely Agree/ … / Completely Disagree (%)	DK
I would only use the van service if it took me door-to-door, like a taxi or airport shuttle	17.1 / 16.3 / 25.9 / 14.8 / 25.6	0.3
I don't want the van picking me up at home because I don't want the driver to know where I live	45.6 / 18.9 / 19.4 / 7.4 / 8.2	0.5
I would like to be able to schedule pick-up times for the same time each day	19.6 / 11.7 / 14.6 / 17.1 / 35.6	1.4
I don't believe a public agency could effectively run a van service like this	21.0 / 14.6 / 27.7 / 15.2 / 20.3	1.2
Background checks should be conducted on all van drivers to make sure they have a good driving record and no criminal history.	3.1 / 1.4 / 3.4 / 8.0 / 83.7	0.4
I don't mind a central pick-up place during daylight hours, but after dark I would want to be picked up and dropped off at my front door for safety reasons	8.4 / 7.9 / 18.0 / 20.7 / 44.4	0.5
I think this sort of van system would be much safer than other forms of public transportation like buses, MUNI, and BART	16.8 / 17.7 / 29.1 / 16.8 / 17.7	1.7
I wouldn't use the van service if I knew I'd have to wait on hold for more than a minute to schedule a pick-up time	34.8 / 21.4 / 20.7 / 10.8 / 11.9	0.4
I would be concerned about vans driving through my neighborhood at all hours of the day and night	40.4 / 19.7 / 20.1 / 8.8 / 10.5	0.5
My big worry about scheduling a van to pick me up at my door is that they will forget me	27.6 / 23.8 / 23.7 / 13.1 / 11.0	0.8
I would like electrical and phone outlets on the vans so I could plug in my laptop and access the Internet	47.5 / 15.3 / 11.7 / 8.8 / 15.7	1.0
Public transportation is so poor in the Bay Area that I would much rather use a personalized transit service than take public transportation	11.7 / 15.2 / 28.2 / 18.1 / 25.1	1.7
Even though the vans can use carpool lanes, I still worry about them getting stuck in traffic delays	17.1 / 18.8 / 25.0 / 21.2 / 17.0	0.9
I would be concerned that there wouldn't be enough storage space on the vans for computer bags, briefcases, backpacks, etc..	37.2 / 22.3 / 19.4 / 11.0 / 9.2	0.9
I would consider using this type of transit service because it is far more personal than other forms of public transportation...	11.3 / 11.9 / 27.2 / 26.0 / 22.9	0.6
I think a personalized transit service would be much more reliable than other forms of public transportation	8.3 / 11.4 / 35.6 / 19.9 / 23.7	1.0
Driving in the Bay Area is so difficult that I would much rather use a personalized transit service than drive myself.....	15.8 / 15.4 / 25.5 / 16.8 / 25.5	0.9

Notes: Five-point measurement scale used, ranging from completely disagree (=1) to completely agree (=5)
DK = Don't know.

Table 6: Response to questions about PDRT. (At least 228 respondents reported that they were not at all likely to use PDRT and were not asked many of the PDRT questions.)

Variable categories	Responses	Sample Size
PDRT attributes		
Importance of PDRT attributes:		1000
Reliability	32.5	
Cost	26.1	
Convenience	20.7	
Number of other pickups	14.2	
Overall travel time	6.5	
Preference for maximum number of pickups	Median = 4.0; Range = 1 – 30	1000
Preference for maximum number of people in van	Median = 8.0 Range = 1 – 50	1000
Payment preference:		772
Per use	50.5	
Weekly fee	14.5	
Monthly fee	33.4	
DK	1.5	
Reservation method:		653
Tel	70.1	
Cell phone	4.7	
Fax	0.2	
Internet	25.0	
Other or DK	0.0	
Willingness to schedule PDRT in advance:		642
24 hours	77.3	
12 hours	7.9	
3 hours	7.8	
1 hour	3.9	
0.5 hour	0.8	
0.25 hour	0.6	
DK	1.7	
Preference for pick-up schedule:		642
Same time every day	44.2	
call each time	54.2	
DK	1.6	
Personal and social benefits		
Perceived personal benefits of PDRT:		638
More convenient	30.7	
Costs less	14.3	
Saves travel time	12.2	
Less stress	11.8	
Other or DK	31.0	
Perceived social benefits of PDRT:		638
Congestion reduction	36.8	
Pollution reduction	36.2	
Access	13.0	
Other or DK	14.0	

Figure 1: Major features of the Bay Area transportation network

Figure 2: Summary of Research Methodology

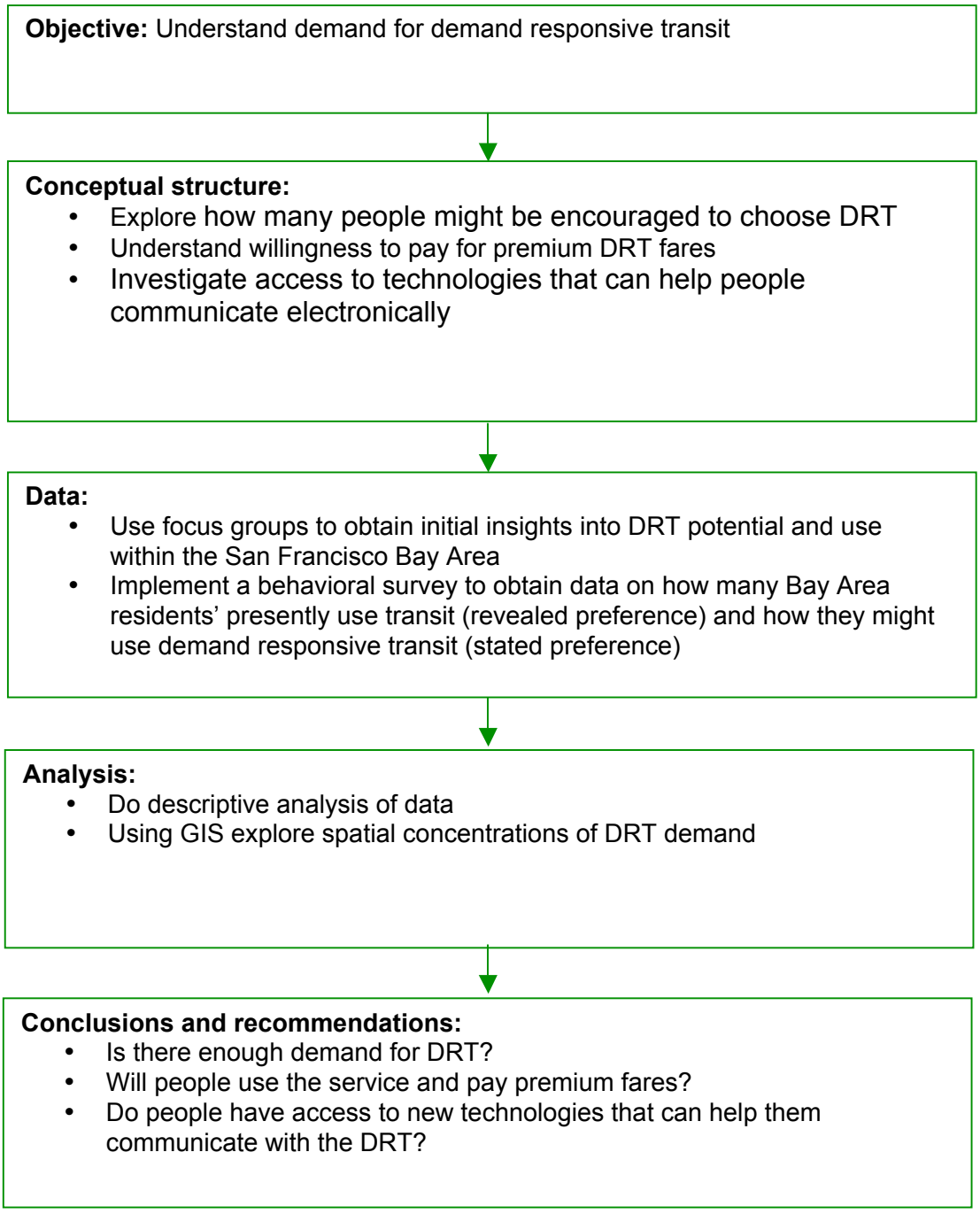
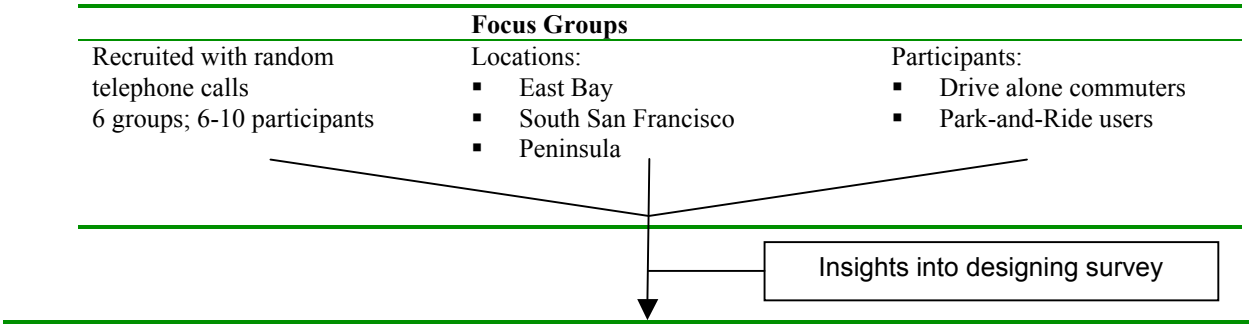
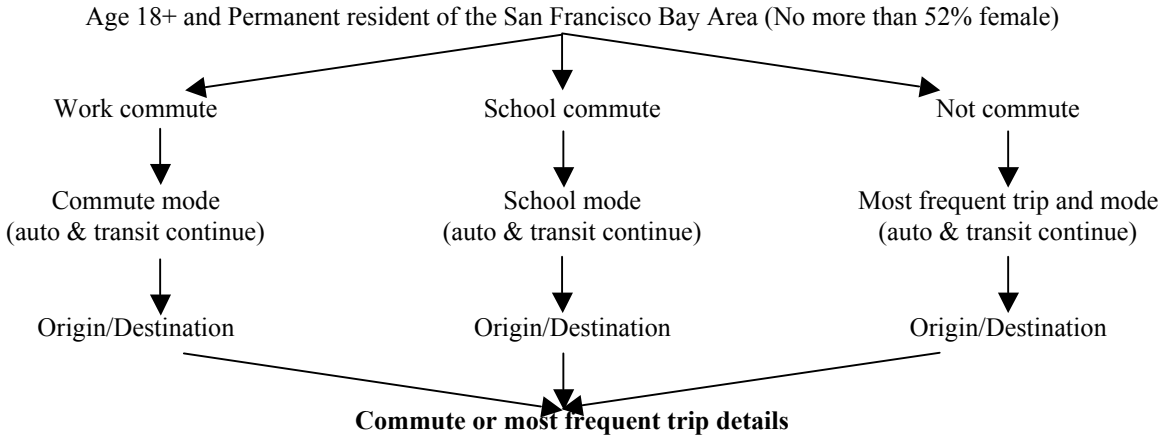


Figure 3: Focus groups and survey structure



Survey: Screening of respondents



- Travel time, distance and cost (given mode), parking and associated costs
- Trip frequency, working hours, departure and arrival times, routes, Intermediate stops
- Unexpected congestion/transit problems and response
- Perceptions of mode attributes—reliability, stress, convenience, comfort, flexibility, etc.

Stated preferences for Personal Demand-Responsive Transit

- Important features of PDRT—reliability, cost, time, etc.
- On-demand transit service—attributes (time, cost, scheduling method), chance of use
- Fixed-schedule transit service—attributes (reservation preferences, time, cost), chance of use
- Attitudinal questions about PDRT—wait time, reliability, comfort, convenience, privacy, security, safety
- Preferences for payment method, PDRT information dissemination and advertising

Socioeconomic variables

- Technology use (cellular phones, PDAs, In-vehicle navigation tools)
- Household size
- Number of vehicles and VMT
- Employment status and type
- Education
- Race
- Age
- Income

Figure 4: Spatial distribution of on-demand PDRT service.