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Personalized Demand Responsive Transit Systems:
Are Travelers Willing to Use and Pay for Personalized Demand-Responsive Transit Services?

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ABSTRACT

An aging population in the US, low-density urban sprawl and the accessibility needs of certain groups (particularly disabled and aged) increasingly point to more flexible demand-responsive transit systems in the future. This paper describes the important aspects of a consumer-oriented Personalized Demand Responsive Transit (PDRT) service. The system will provide services to the traveling public for journeys to work and for journeys to other destinations. A PDRT that responds to the travelers' needs and takes advantage of the emerging advanced public transportation technologies to increase efficiency may be successful and sustainable in the long term. To understand travelers' willingness to use and pay for PDRT, focus groups and a CATI (Computer-Assisted Telephone Interview) survey of automobile and transit travelers were conducted in the San Francisco Bay Area. The objective was to investigate service attributes that will attract travelers to PDRT. Specifically, we examine the factors that are likely to influence the decision to take "on-demand" PDRT (similar to a taxi service with a van making multiple pick-ups) and "fixed-schedule" PDRT (pick-ups and drop-offs are made at fixed but convenient locations). The results of six focus groups and the survey indicate that the idea of a personalized transit service may appeal to commuters as well as non-commuters. There is significant potential to attract travelers to PDRT; about 15% (N=1000) of those surveyed reported that they were "very likely" to use the PDRT service and another 47.7% (N=1000) were willing to consider PDRT as an option. A majority of these PDRT pre-disposed were willing to pay between $5-$10 for a 30 minute trip using fixed-schedule service (62%; N=627) and on-demand service (73.0%; N=642). A majority of the PDRT predisposed were also 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. Responses to attitudinal questions revealed a strong (positive) 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). The results show that a reasonably priced PDRT service that is reliable and meets customer expectations (of cost, travel time and wait time) can be successful. Respondents were quite realistic in their expectations about the PDRT service attributes, especially the longer travel times and wait times involved in using PDRT. More detailed findings and their implications are discussed in the report.

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INTRODUCTION

The US population is aging and low-density urban sprawl shows no sign of abating. Limited accessibility is a problem that is faced by certain population groups such as the elderly and disabled. The Americans with Disability Act (ADA) of 1990 requires that appropriate public transportation be provided for the disabled. Specifically, under ADA, companies that operate fixed-route buses must also provide paratransit van service for people who, because of a disability, are unable to use lift-equipped regular buses some or all of the time. Given these trends and policies, it is expected that demand-responsive transit services will continue to grow.

The objective of this study is to understand traveler response to Personalized Demand-Responsive Transit (PDRT) service. Like the fixed transit service, demand-responsive transit service suffers from low ridership and high operating cost. Demand-responsive transit services tried so far were often not cost-effective, possibly due to flaws in the design concept, lack of computer/communication technology to efficiently operate the service, and non-consideration of traveler/user needs. Most of the systems provided the services without asking what type of demand-responsive service would attract travelers. This study is aimed at understanding the user side of personalized transit service. The study investigates service attributes that will attract travelers. For most individuals, the decision to take transit depends on trade-offs between attributes of personalized transit and the personal vehicle, such as travel time, travel cost, wait time for pick-ups, exclusivity of service and flexibility, safety and security, and comfort and convenience. This study explores the tradeoffs using six focus groups and a behavioral survey of travelers in the San Francisco Bay Area. Potential users also provide their preferences for “on-demand” PDRT, described to the respondents as being similar to a taxi service with the van making multiple pickups; and “fixed-schedule” PDRT, described to respondents as a service with pick-ups and drop-offs made at fixed but convenient locations. Respondents also provide information on willingness to pay for the service, important service attributes (e.g., reliability and flexibility) payment method and reservation preferences, and perceptions of private and social benefits.

BACKGROUND

Demand-Responsive Transit (DRT) is an alternative travel method to personal vehicle, bus/light-rail, and carpool/vanpool. The DRT concept is interesting and has the potential for improvement of transportation accessibility to those who are elderly or disabled as well as to those who may not want to drive to work or shop. In the past, the DRT field tests had shown its inability to draw enough consumers to support the system even with public subsidies. "Dial-a-ride" in the 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; Dave Systems 1977; Huron River Group 1977; Maine DOT 1986; Comsis Corporation 1988; TransVision Consultants 1993). The reason was simply that the system was not attractive to consumers. In order for consumers to be attracted to the "Dial-a-ride" service, the new service should be better than what they were using (i.e., light-rail, bus transit, personal vehicle) in terms of important aspects (Urban and Hauser 1995). Yet we have little understanding of consumer behavior regarding what will make them favor DRT over other modes of transportation.

Traditionally, DRT systems were designed to provide mobility to the elderly and handicapped with an affordable and efficient alternative transportation service. Although DRT was originally aimed at meeting the needs of this special segment of the population, once it was

implemented, it became popular among people from other groups (TRB 1974). One such group was non-disabled passengers from lower density areas who used this service as transportation to transfer stations like bus stations or large service centers like shopping malls and public buildings. The popularity of DRT service in the early 1970's brought much interest among transit authorities and academics to evaluate the concepts and develop innovative DRT systems. Since the 1970s, numerous studies have been conducted on this subject (Hall 1970; UMTA 1974; Louviere 1979; Demetsky et al. 1982; European Conference of Ministries of Transport 1987; Feldman 1987; Jeffrey Parker and Associates 1991; Miller 1989). But the studies had shown conflicting views on its viability for providing an effective transit service aimed at the traveling public at large. These studies revealed much uncertainty about the social and economic effectiveness of the DRT service as well as their future. Thus, this paper introduces a new PDRT concept that will be based on the needs of consumers.

Growth Trends and Future of DRT Systems

Despite the many uncertainties that go into designing a DRT system and its service market, DRT services continued to grow since the early 1970s, especially with the introduction to the Americans with Disabilities Act (ADA) of 1990. The ADA had served as a catalyst for development and implementation of DRT systems and provided much needed funding for existing systems.

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. 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, transporting more than 1.4 billion passengers. In September 1998, an estimated 22,884 private paratransit companies operated more than 370,000 vehicles.

Even though fixed route systems are becoming more accessible, there will always be those who cannot use the fixed route and thus the ADA requirement must be met. Consequently DRT systems are seeing increases in ridership. The need for paratransit will continue to increase as access and facilities become more usable by people with disabilities. Paratransit service is generally expensive, so for it to expand in less dense areas that do not have a transit system, funding will become the key issue.

Most DRT services required heavy subsidies from federal, state, and local agencies. Almost all DRT services have not been able to recover their operating costs from fare-box revenues. Funding for new DRT systems from federal or state agencies has been a significant stumbling block especially in under-financed cities. However, surveys prior to1975 revealed that of the 22 reported DRT services in the US, all but 3 systems required federal or state subsidies to cover costs. Because of consistent citizen support, however, DRT systems have been effective in raising local funds for transit operation. The DRT system has traditionally been viewed as a public service, thus continued funding from the public sector whether from federal, state or local is expected and in fact is essential for their operation.

The need for a highly productive and efficient DRT system is apparent considering the high public subsidy programs required to operate current DRT services. Furthermore, it is necessary to develop innovative public transit systems to improve mobility and cope with the growing number of vehicle ownership and increased vehicle miles traveled. By Year 2010, the San Francisco Bay Area is expected to have at least 20% increase in its driving population without adding additional freeways or significant infrastructure.

Observations on the Current Personalized DRT Service Characteristics

Paratransit systems can generally be divided into two categories: one with direct service route (i.e. taxi cab services) and one in which sharing is allowed (i.e. DRT systems). The capacity of the direct service is severely limited by number of vehicles and its services do not extend to all segments of the population (Daganzo 1978). DRT systems on the other hand represent a broad class of public transportation options characterized by capital and or temporal flexibility in serving demand (Lerman 1980). Most of the DRT services were in small and medium sized cities that have few or no fixed-route bus systems (TRB 1974). For lower density areas, they 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 always higher than that of conventional fixed route, fixed-schedule services.

DRT systems have most prospered where fixed-route systems have failed; suburban areas with lower densities of population. Among the advantages DRT has over traditional fixed-route services DRT (TRB 1974) are that it 1) provides service to those who have little or none, 2) improves service during off peak hours, 3) improves overall economic results of systems, and 4) serves new markets for those who have limited access to transportation.

A DRT system is typically made up of small radio dispatched vehicles. The vehicles, operating on city streets with flexible schedules, respond to the requests as received by a central dispatcher. The dispatcher and scheduler combines customer information regarding vehicle position, number of riders, pick up time desired, and route characteristics (TRB 1974). When a request is made it joins a queue of requests awaiting pick up. When a vehicle arrives to pick up a customer, the customer joins another queue of passengers already riding a given vehicle. This information is processed to the dispatcher so that s/he may make route decisions based on the customer pick up and drop off times (Daganzo 1978). A typical routing and scheduling process will include the reservation, routing and scheduling (stop list preparation), vehicle monitoring, schedule adjustment and statistics and accounting records preparation (Kikuchi 1987). The DRT service is normally required to verify the eligibility to use the service since it is designed to service the elderly and handicapped.

With APTS technologies, the personalized DRT systems can operate more efficiently with vehicle monitoring and dispatching technologies than the traditional DRT services (Khattak et al. 1996; Khattak and Hickman 1998; Lave et al. 1996; Teal 1994). The users can be informed with the most current, real-time DRT schedule information.

Personalized Demand-Responsive Transit

The California PATH program in the Institute of Transportation Studies at the University of California, Berkeley, in conjunction with the California State Department of Transportation (Caltrans), is developing a new innovative DRT system based on consumer needs of the general

population at large. The Consumer-based Personalized Demand Responsive Transit (PDRT) system will not only be oriented to commuters but also directed to providing services to the elderly and handicapped. It can be best described as a DRT service that is fully supported by users. It will provide door-to-door service like taxi cabs as well as semi-fixed route structure like the current DRT system.

The unique aspect of the PDRT is that the design of the system will be based on consumer needs. Their 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.

METHODOLOGY

Focus Groups

Individuals were recruited to participate in focus groups at three separate focus group facilities. The six groups met in March 2000 and were selected based on geographical locations (East Bay, South San Francisco, and the Peninsula). The participants consisted of drive alone commuters and Park-and-Ride transit users. Participants were recruited with random telephone calls by the focus group facilities where the groups were held, using recruitment screeners. Trained professionals, who had consistent guidelines for moderation, moderated the groups.

Each group had between six and ten participants, who were mixed in terms of age, income level, education, gender, and race and ethnicity. Since any form of personalized transit will be more expensive to use than mass transit modes, 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. In addition, participants who said they would always drive to work and would never consider public transportation under any circumstances were excluded from the focus groups.

CATI Survey

A "Broad Area" survey was conducted in May 2000 by a private marketing research firm using the computer aided telephone interview (CATI) technique. Results of the focus groups provided important information for the questionnaire. The sample was drawn from households in all nine Bay Area counties by random digit dialing according to telephone prefixes and area codes. The random digit dialing method was used mainly because it can ensure that all households that have a telephone are included in the sampling pool, regardless of whether or not their telephone numbers are listed. Since over 95% of Bay Area households have a telephone, the exclusion of non-telephone households from the sampling pool should not pose a serious problem for the representativeness of the resulting sample.

One thousand telephone interviews were completed. This sample size was determined based on the expectation that there should be enough respondents from 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 would be obtained in the drive-alone category but the rideshare and public transit categories might 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 were able to ensure that the resulting sample population was representative of the total adult population of the Bay Area with respect to gender. Multiple contact attempts and refusal conversion procedures were employed 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 in the survey; if the primary mode was walking or bicycling, the interview was also terminated.

Repeated calls were made up to five times and a 50% response rate was achieved (of those households that answered the call). A company specializing in scientific sampling supplied the sample. The sampling frame is based on a database of all working residential telephone exchanges and working blocks (sampling areas such as county or zip code). The sample was "pulled" using a *pure unweighted methodology* from nine counties based on household density in each county. Each possible telephone number within each county had an equal chance of being selected. Using this sampling method, completed interviews from the pulled sample, if dialed exhaustively, are quite representative of the population under study.

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 reaction 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 think a great deal 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 has to offer 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, perfectly 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 they need to. That aspect of the service feels very convenient to them, and 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 has many aspects to it. One 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 definitely appeals to many of these people.

Attitudes About Public Transit in the Bay Area

Park-and-Ride focus group participants were generally more positive about public transit than Drive Alone commuters. Though neither group had much praise for the overall system of public transit in the Bay area, many participants who use BART were fairly positive about their overall BART experience, despite having some real frustrations. Many participants characterized the region's public transit system as disjointed, uncoordinated, inconvenient and poorly planned. Their major complaints centered around the Balkanization between systems; noting that there was no pass available for all systems (i.e. one pass that was good on Muni, BART and the buses, for example), and that the systems do not coordinate with each other, specifically that there was no one scheduling a bus to meet the train that just pulled in. Such scheduling coordination between systems would make the travel more seamless, something that participants highly valued when designing their mode of commuting.

The Bay Area has many transit services scattered around the region. Many participants voiced the perspective that public transit — specifically BART (the regional rail system) — is too expensive, though others felt that public transit commuting costs are fairly reasonable in the area.

CALTRAIN: Most participants did not use CALTRAIN to commute, though those who did are very positive about it. In general, they found the trains to be clean, comfortable, well maintained, reliable and reasonably priced. However, several did note that recent construction had made the trains less reliable when it came to keeping their schedule.

BART: Participants were mixed about BART. Many felt that it was convenient and efficient for what it was — a service to bring people in and out of the city, rather than one that moves people within the city. They strongly desired to have BART schedules coordinated with other public transit systems within the city, because the problem of getting from their destination BART station to their offices can be the piece of the transportation puzzle that prevents them from using public transit altogether.

While some participants said BART is well maintained, and most everyone agreed it is vastly better than Muni and substantially better than the buses, many said it has become dirtier over the years and less well policed. Due to concerns about cleanliness, they strongly support the rule prohibiting food and drink on BART and wish it were more strictly enforced. They also said that it is very crowded during rush hours making it difficult to get a seat if you are not getting on at the beginning or end of the line. Although BART riders were described as generally orderly and polite, waiting in line to enter the train and go through the turnstiles, many participants still experienced the crush of crowds and long lines to be very stressful.

The largest single group of complaints about BART was that there were always mechanical problems with trains, elevators, escalators, ticket machines and turnstiles; that these maintenance problems cause an inordinate amount of delays through creating long lines and delayed or halted trains. In addition, parking at BART stops is so difficult to obtain in the morning that virtually everyone in the Park-and-Ride groups had to leave their house by 7:00 a.m. at the latest, since the BART parking lots are filled by 7:15 a.m. In addition, women were more likely to express concerns about safety on BART, particularly in relation to poorly monitored garages and parking lots. Participants also complained that many of the station staff are rude and unhelpful.

Buses: Participants were fairly negative about the bus system, though they did distinguish between commuter lines and local lines. They described bus drivers who are rude and unhelpful; buses that feel unsafe because of the other passengers on them and inadequate security on the buses themselves. They described commuter buses as being more pleasant due to having fewer problem passengers. Many participants talked about how the experience of riding on a bus has gotten much worse over the years, particularly on buses whose routes go through "bad" parts of town.

Muni: Participants were almost universally negative about Muni, saying it has declined dramatically over time. Many participants consider it so unreliable, dirty, unpleasant or unsafe that they no longer consider it to be a commuting option for them.

Casual carpooling: Only a few participants had ever participated in casual carpooling, and those few who had were generally positive about it. For those who had not, they had a wide range of concerns primarily about safety. They did not want to get into a car with a stranger, and they were concerned about getting into a car with someone who just happens to be an unsafe driver. Women were far more vocal in expressing these safety concerns than were men.

Vanpooling or organized carpooling: Many participants had experienced some kind of car or vanpooling at some point and were generally positive about the experience itself. Some people became friends with their fellow carpoolers and described the experience as social and fun; others just appreciated the savings in gas and wear and tear on their car; still others simply liked not having to drive every day and leaving the driving to someone else. However, almost everyone in the group was no longer in a carpool. They said that it is hard to arrange where they live in the suburbs because not enough people around them are going to the same place. They also said that the lack of flexibility in the carpool schedule made it hard to maintain, in case someone had to go in late for a doctor's appointment, stay late at work or leave early to attend a child's soccer match.

Participants offered a range of reasons for not participating in an organized carpool. Many of these concerns could shape their initial assessment of the appeal of a personalized transit system. First, many said they simply need the flexibility to leave their home or office at whatever time they need to. They do not want to be held accountable for holding up other people because they are late, and they do not want to be kept waiting by someone else who is running late. They feel that coordinating schedules between different people can be too complicated and take too much time and effort. Participants with children frequently said they need to have their car with them at work in the event of an emergency at school. In addition, some people feel that others are not very safe drivers, and do not want to be trapped in a car on a regular basis with someone who is not a cautious driver. Others noted that carpooling in some instances does not actually save time since there are not consistent car pool lanes on the entire route. The hassles of having to coordinate with other people's schedules are only considered worthwhile by most people if the end result is a shorter commute time. Many people also felt there were not enough perks to prompt them to carpool, such as free or cheap parking for carpool cars at or near their offices.

What are the Perceived Advantages to Using Public Transit?

All participants could perceive advantages to using public transit, even if they did not use it themselves. In some instances it is faster to use public transit than to drive since traffic congestion is so bad at certain times of day. Public transit can be cheaper than driving, particularly when their employer does not offer free or subsidized parking. In many cases it is the prohibitive cost of monthly parking that made participants decide to use public transit rather than drive.

By not driving, people can have time to read, sleep, think or just sit and relax. People reported experiencing a high level of stress from sitting in bumper-to-bumper traffic and coping with angry, rude or aggressive drivers each day. Others felt that driving on the highways is getting more and more dangerous, and that public transit was safer than driving their own cars. Some participants also feel that public transit is better for the environment, and stated that they would be inclined to use it for environmental reasons if a convenient and affordable public transit system were available to them.

Government or Privately Run PDRT?

Despite their positive views, participants felt strongly that the system should be privately run. They want a program with a high level of service, responsiveness and professionalism, and they feel that a government service is incapable of operating in that way. They think that only a private business would be sensitive to consumer needs and concerns, and that the need to make the business financially successful would force the company to do a good job running the service. They said that a government entity simply would not care whether the service was working well or not, and that it would be poorly maintained and operated. They think the customers' concerns would matter and their needs would be more likely to be met with a private company.

CATI SURVEY RESULTS

The CATI survey was directed to assessing the value of PDRT with specified 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, i.e., cost, acceptable waiting time and number of stops, and required travel-time. The structure of the questionnaire is shown in Table 1.

Table 2 shows that 54.1% of the respondents commute to work, 5.6% commute to school, 3.7% commute to work and school about equally, and the rest (35.2%) do not commute at all (Table 2). This last group of non-commuters was asked to provide details of their most frequent trip (shopping, personal business, driving children, etc.). The modal choice of the respondents is as expected; most travelers drive alone (79.6% commuters and 83.3% of the 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). Very few respondents Park-and-Ride. Those using pedestrian or bicycle modes for their commute/most frequent trip were excluded from the survey.

The technology access variables, shown in Table 3, indicate that a majority of the respondents (54.7%) own a cellular telephone, have access to the Internet either at home (67.8%) and/or at work (51.1%), have access to a personal computer at home (76.1%) and have a cable television subscription (73.5%). These figures are consistent with a similar San Francisco household survey conducted in 1999 to evaluate TravInfo impacts (Yim 2000). Furthermore, relatively new technological devices were also owned by the persons responding to the survey (or by member(s) of their immediate family): Pager 40.6%, Personal Digital Assistant 17.9%, and vehicle navigation unit 4.6%. As expected, the penetration of these new devices has increased substantially compared with the 1999 TravInfo survey (Yim 2000).

Fifty-two percent of the respondents were female and most lived with others. There were very few respondents (3.1%) 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, 33.6% were professionals. A majority of the respondents had either graduated from college or attended some college. In terms of race, a majority classified themselves as white (as expected). A significant portion (28.8%) reported having household incomes (before taxes) greater than $80,000 and few reported incomes lower than $20,000 (6.8%). 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 with higher incomes, as expected of the Bay Area residents.

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:

- The first scenario provided only limited information about the services (a brief description of the on-demand and fixed-schedule service) and the respondents were asked about their willingness to use the service.
- In Scenario 2, respondents were asked about their willingness to use the on-demand and fixed-schedule services, given certain levels of PDRT costs, travel times and wait times.
- Finally, in Scenario 3 respondents were asked about their willingness to pay for both the services 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. 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 will 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 conservative estimate of the usage ranges from 14% to 17% of the respondents.

At least 62.7% (N=627) 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), 62% (N=627) and 73.0% (N=642) were willing to pay between $5-$10 for a 30 minute trip using fixed-schedule and on-demand services respectively. Interestingly, more people were willing to pay the $10.0 per trip for the on-demand service (29.6) than 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). 68.9% to 75.3% of the respondents were willing to pay $3-$5 for a 15 minute trip using fixed-schedule and on-demand 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 is 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 the respondents), many were willing to pay for the service, were willing to wait for the pick-up and were accepting of the fact that PDRT may take longer than their current mode. Note that 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 22.0% (N=627). Responses to the attitudinal questions are shown in Table 5. They indicate a strong (positive) 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 very bothered 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 having a door-to-door van service, 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 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 22.0% (N=627) to 18.0% (N=772). This may also have occurred partly due to the difference in sample sizes, since the non-predisposed were not asked the attitudinal questions and the subsequent PDRT usage question. The important point is that about 15% of the total respondents (N=1000) show a high willingness to use the PDRT service.

Respondents were asked about the importance of PDRT attributes and related questions. 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 travelers 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 "road rage" reduction.

Typically, once a new system is integrated into an area, marketing it to the general public becomes crucial. Residents may not be aware of what their new DRT service offers, so it is important that the segment of the population to be served is made aware its availability. 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.

CONCLUSIONS

The focus group and survey results are consistent and indicate that the idea of a PDRT service may appeal to commuters as well as non-commuters. There is significant potential to attract travelers to PDRT. Conservatively, about 15% of those surveyed were very willing to use the PDRT service and another 15% were likely to use the service (N=1000). The main contribution of the paper comes from providing valuable information on designing PDRT from the consumers' perspective. Insights are obtained on willingness to pay for the PDRT service, important service attributes (e.g., reliability and flexibility), payment method and reservation preferences, and private and social benefits of the service. A reasonably priced PDRT service that is reliable and meets customer expectations (of cost, travel time and wait time) can be successful in the long-term. It must also take advantage of the new public transportation technologies that increase the efficiency of PDRT (Teal 1994; Khattak et al. 1996).

Our future research efforts will focus on:

- Exploring relationships between willingness to use the service and trip characteristics, technology access and socioeconomic variables.
- Determination of counties or sub-regions that contain a large population segment likely use the PDRT service.
- Identification of potential PDRT providers for field-testing the service.

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Table 1: Summary of survey structure

Screening of respondents		
Age 18+ and Permanent resident of the San Francisco Bay Area (No more than 52% female)		
Work commute	School commute	Not commute
Commute mode (auto & transit continue)	Commute mode (auto & transit continue)	Most frequent trip and mode (auto & transit continue)
Commute to work trip Origin/Destination	Commute to school trip Origin/Destination	Most frequent trip Origin/Destination
Commute or most frequent trip details		
Travel time, distance and cost (given mode)		
Trip frequency		
Working hours, departure and arrival times, routes		
Intermediate stops		
Parking and associated costs		
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—traffic delays, wait time, reliability, comfort, convenience, privacy, security, safety, on-board access to tech (Likert scale)		
Preferences for payment method, PDRT information dissemination and advertising		
Socioeconomic variables		
Number of vehicles, technology use (cell phones, PDAs, Navigation tools), gender, household size, VMT, employment status and type, education, race, age, income		

Table 2: Screening of respondents and their travel patterns

Screening results		
Age 18+ and Permanent resident of the San Francisco Bay Area—52% female		
Work commute = 54.1% (N=1000)	School commute = 5.6% (both work + school equally = 3.7%)	Not commute = 35.2% (not sure, don't know, refused = 1.4%)
Commute mode: Drive alone = 79.6+0.9% (N=634) Carpool = 6.6% Transit = 12.8% Park-and-ride = 0.9%		Mode for most frequent trip Drive alone = 83.3% (N=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	**Response—Percent**
Technology Access Variables	
Own cellular phone	54.7
Have Internet access at home	67.8
Have Internet access at work	51.1
Have a cable television subscription	73.5
Access to personal computer at home	76.1
Own a pager (personally or any member of immediate family)	40.6
Have a personal digital assistant (personally or any member of immediate family)	17.9
Have a navigation unit in car (personally or any member of immediate family)	4.6
Socioeconomic Variables	
Female	52.0
Household size: 1 person / 2 persons / 3 persons / 4 persons / 5 or more persons / refused or DK	16.2 / 30.7 / 18.6 / 8.4 / 5.1 / 5.5
Auto ownership: 0 vehicles /1 vehicle / 2 vehicles / 3 vehicles / 4 or more vehicles / refused or DK	3.1 / 21.5 / 33.5 / 20.5 / 16.0 / 5.4
Employment: Full-time / part-time / self / not employed or refused	47.1 / 9.9 / 9.6 / 33.4
Occupation: Professional / manager / sales-clerical / craft / service / labor / Refused or DK	33.6 / 15.6 / 18.9 / 6.8 / 19.4 / 4.7 / 1.1 (N=666)
Education: up to high school / up to college / graduate / vocation / Refused or DK	22.3 / 51.0 / 18.6 / 1.4 / 6.7
Race: White / Black / Asian / Hispanic / other / refused	65.7 / 5.4 / 8.3 / 7.2 / 2.8 / 10.6
Age: 18-34 / 35-54 / 55-64 / 65+ / refused or DK	26.5 / 40.1 / 11.2 / 14.9 / 7.3
Income: up to 19K / 20K-39K / 40K-59K / 60-79K / 80+ / refused or DK	6.8 / 11.5 / 16.4 / 11.0 / 28.8 / 25.5

Table 4: Stated preference 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: Not at all likely / ... / Very likely / DK (5-point scale)	**34.7** / 14.1 / 20.7 / 12.1 / 17.3 / 1.1 (N=1000)	**36.9** / 12.8 / 21.5 / 13.9 / 14.5 / 0.4 (N=1000)
Weekly usage frequency in number of days (Not at all likely group omitted)	Median = 3.0, Range = 0 – 7 (N=653)	Median = 3.0, range = 0 – 7 (N=627)
Preference for: On-demand / Fixed-schedule / both / neither / DK	41.4 / **55.3** / 1.9 / 0.6 / 0.8 (N=638)	
Scenario 2: More information about PDRT attributes		
Use PDRT on 30 minute trip and pay: $10 / $7 / $5 / $3 / $1 / DK or "no" to all questions	**29.6** / 14.3 / 29.1 / 17.4 / 6.2 / 3.3 (N=642)	19.1 / 13.7 / **29.2** / 20.4 / 11.5 / 6.1 (N=627)
Use PDRT on 15 minute trip and pay: $5 / $4 / $3 / $2 / $1 / DK or "no" to all questions	**45.3** / 10.1 / 19.9 / 13.2 / 4.2 / 7.2 (N=642)	**34.6** / 11.5 / 22.8 / 15.3 / 8.5 / 7.3 (N=627)
Use PDRT if average wait for pick-up was: 20 min / 15 min / 10 min / 5 min / DK	**51.6** / 16.8 / 22.0 / 5.6 / 4.0 (N=642)	**41.8** / 19.5 / 26.6 / 8.3 / 3.8 (N=627)
Use if PDRT took longer than current commute/most frequent trip by: 20 min / 15 min / 10 min / same / faster	**36.1** / 18.4 / 27.4 / 11.1 / 2.3 / 4.7 (N=642)	**32.2** / 21.2 / 30.0 / 11.0 / 3.8 (N=627)
PDRT Usage at desired attribute levels: Not at all likely / ... / Very likely / DK (5-point scale)	7.5 / 15.3 / **31.2** / 24.3 / 21.3 / 0.5 (N=642)	5.1 / 12.6 / **31.7** / 26.8 / 22.0 / 1.0 (N=627)
Scenario 3: Before and after responding to attitudinal questions about PDRT		
PDRT Usage if both services available—before attitudinal questions: Not at all likely / ... / Very likely / DK (5-point scale)	5.9 / 12.6 / **31.7** / 26.8 / 22.0 1.0 (N=627)	
Attitudinal questions about PDRT (Table 5 below)		
PDRT Usage if both services available—after attitudinal questions: Not at all likely / ... / Very likely / DK (5-point scale)	9.5 / 16.1 / **33.5** / 22.4 / 18.0 0.5 (N=772)	

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. N= 228 (22.8%) were not at all likely to use either on-demand or fixed-schedule PDRT services and did not respond to Scenarios 2 and 3.

Table 5: Attitudinal questions about PDRT (N= 772). Modes are in bold.

Question wording	**Percent**	**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.

Variable categories	Responses
PDRT attributes	
Importance of PDRT attributes: Reliability / cost / convenience / # of other pickups / overall travel time	**32.5** / 26.1 / 20.7 / 14.2 / 6.5 (N=1000)
Preference for maximum number of pickups	Median = 4.0, range = 1 – 30
Preference for maximum number of people in van	Median = 8.0, range = 1 – 50
Payment preference: Per use / weekly fee / monthly fee / DK	**50.5** / 14.5 / 33.4 / 1.5 (N=772)
Reservation method: Tel / Cell phone / Fax / Internet / Other or DK	**70.1** / 4.7 / 0.2 / 25.0 / 0.0 (N=653)
Willingness to schedule PDRT in advance: 24 hours / 12 hours / 3 hours / 1 hour / 0.5 hour / 0.25 hour / DK	**77.3** / 7.9 / 7.8 / 3.9 / 0.8 / 0.6 / 1.7 (N=642)
Preference for pick-up schedule: Same time every day / call each time / DK	44.2 / **54.2** / 1.6 (N=642)
Personal and social benefits	
Perceived personal benefits of PDRT: More convenient / costs less / saves travel time / less stress / Other or DK	**30.7** / 14.3 / 12.2 / 11.8 / 31.0 (N=638)
Perceived social benefits of PDRT: Congestion reduction / pollution reduction / access / Other or DK	**36.8** / 36.2 / 13.0 / 14.0 (N=638)
PDRT Information and advertising	
Preference for receiving information about PDRT: Telephone / Internet / Pamphlet / DK	7.3 / 29.9 / **62.3** 0.6 (N=772)
Preference for PDRT advertisement: TV / Radio / Newspaper / Magazine / Brochure / Billboard / Internet / Other / DK	**43.1** / 17.4 / 22.0 / 0.1 / 3.8 / 5.7 / 5.8 / 2.1 (N=772)

Note: N = 228 respondents reported that they were not at all likely to use PDRT and were not asked many of the PDRT questions.