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TRANSIT-BASED SMART PARKING IN THE SAN FRANCISCO BAY AREA: AN ASSESSMENT OF USER DEMAND AND BEHAVIORAL EFFECTS

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ABSTRACT

This paper presents early findings from an application of advanced parking technologies to increase effective parking capacity at a transit station during the first half of 2004 in the San Francisco Bay Area (CA). It begins with an extensive review of the literature related to transit-based smart parking management systems to illustrate the range of system configurations and their potential travel, economic, and environmental effects. Two important conclusions from this review are: (1) lack of parking spaces at transit stations may be a significant constraint to transit use and (2) pre-trip and, perhaps, en-route information on parking availability at transit stations may increase transit use to gain insight into parking information needs, the travel effects of a new monthly paid parking program, and the potential travel effects of a smart parking service. First, it was found that a potential market exists for a daily paid parking information service among current and new riders with relatively high incomes, high auto availability, and variable work locations and schedules. Second, the current monthly reserved paid parking service may have increased the frequency of BART use among subscribers, but it has not reduced net auto travel because of diversions to BART from carpool, bus, and bike modes for their main commute and increased drive alone access to the BART station.

INTRODUCTION

For nearly one hundred years, planners, politicians, engineers and environmentalists have wrestled with the challenge presented by the increasing prevalence of the automobile: where to put cars. Ranging from the earliest parking garages—renovated horse barns—to fully automatic parking structures, innovative thinkers have attempted to devise clever ways to park cars. Some of the more creative but less practical ideas generated over the years include the parking ferris wheel, a lazy susan for cars, and the "parking rack"—which allowed cars of any shape or size to be stored at a 30 degree angle through the use of a hydraulic valve (*1*, p. 26-29). A recent and promising contribution to the annals of parking innovations is the concept of smart parking—broadly defined as the application of advanced technologies to improve the speed and efficiency of locating, reserving, and paying for parking. Smart parking may achieve what many of its forerunners have attempted to: more efficient use of existing land dedicated to parking.

This paper presents early findings from an application of advanced parking technologies to increase effective parking capacity at a transit station during the first half of 2004 in the San Francisco Bay Area, California (USA). Project partners include the California Department of Transportation (Caltrans), California Partners for Advanced Transit and Highways (PATH), the Bay Area Rapid Transit (BART) District, ParkingCarma™, and the Quixote Corporation. Preliminary analyses indicated that the Rockridge BART station in Oakland (California) could benefit from a smart parking management system because parking demand exceeds supply. Informing this analysis were the following observations: parking typically fills around 7:30 am, more than 30 cars cycle through the parking lot and leave each morning, and the limited monthly reserved paid parking is fully subscribed. In addition, the Rockridge station is adjacent to Highway 24, an

important commute corridor from the East Bay to downtown Oakland and San Francisco.Project partners, thus, saw an opportunity to apply smart parking technologies in a field operational test with the goal of expanding effective parking capacity, transit ridership, and revenues.

This field test includes traffic sensors that count the number of vehicles entering and exiting a parking lot at the Rockridge BART station. Information collected by sensors is relayed to a central reservation system, which keeps a master tally of available station parking. The computer then relays this real-time information to the variable message signs (VMS) on a highway adjacent to the station to alert drivers to the availability of parking spaces. The smart parking reservation system allows travelers to check availability and reserve spaces by Internet, phone, cell phone, and PDA, up to two weeks in advance of a trip. Before and after surveys and focus groups will be used to evaluate the travel effects, economic potential, and system technology of the field test.

This paper begins with an extensive review of transit-based smart parking management systems implemented throughout the world to illustrate the range of system configurations and potential travel, economic, and environmental effects. This is followed by the survey of commuters at the Rockridge BART station that was implemented to better understand rider attributes (travel patterns, demographic characteristic, and attitudes); the travel effects of station monthly reserved paid parking; and the potential travel effects of a smart parking service. Literature and survey results were used to help tailor smart parking services to suit commuters' needs and increase transit use.

LITERATURE REVIEW

Parking problems are ubiquitous in almost every major city in the U.S. and internationally. It is well known that the limited availability of parking can contribute to roadway congestion, air pollution, and driver frustration. However, a problem that is less well recognized by the public is the negative effect of insufficient transit station parking on transit use. Research suggests a significant relationship between transit use and the provision of parking at transit stations (*2*,*3*).

Smart parking management systems have been successfully implemented in numerous European and Japanese cities to more efficiently manage parking capacity at transit stations. Quick, convenient auto access to park-and-ride lots can be essential to making transit competitive with the auto in suburban areas. These smart parking systems typically provide real-time information via VMS signs to motorists about the number of available parking spaces in park-and-ride lots, the departure time of the next train, and downstream roadway traffic conditions (e.g., accidents and delays). Transit-based smart parking systems are generally implemented to increase transit mode share and revenues, and thus may reduce vehicle travel, fuel consumption, and air pollution. The literature review in this section begins with an overview of selected transit-based smart parking applications and is followed by a discussion of available system evaluations.

Applications

In Europe, one of the most sophisticated smart parking systems, called STADTINFOKOLN, is located in Cologne, Germany. Orski (*4*) describes the system as providing:

> …up-to-the-minute information about parking availability both at suburban park-and-ride lots and at the 31 affiliated underground and surface parking facilities in Cologne's city center. This information is displayed on automatically updated variable message signs situated on approaches to the city, enabling city-bound motorists to decide in advance if they should leave their car at a suburban park-and-ride and complete their journey by train, or continue all the way by car. Drivers who decide to drive all the way into the center are guided to parking facilities that have vacant spaces with the help of directional signs that display the number of vacant spaces available at any given time (*4*, p. 54).

The parking guidance information component of this system uses loop detectors to monitor available parking spaces in facilities and then transmits messages via VMS signs. The software uses historical data by time to predict parking facility occupancy status. Planned improvements include forecasts of available metered on-street parking and a parking reservation system via the Internet, phone, or in-car terminal (or e-parking, see detailed description in subsequent section) (*4*).

Another example of an advanced smart parking system is the Frottmaning U-Bahn station park-and-ride lot (with 1,270 parking spaces) in Munich, Germany, on the A9 Autobahn. This system boasts three dynamic VMS screens along the nearby highway, which indicate the number of parking spaces, real-time transit schedules, and traffic news. Once motorists enter the parking facility, they are guided to the closest empty parking space by a real-time surveillance and control system. The smart "directing" system uses laser-scan detectors at entrance and exit lanes and ultrasound detectors at each parking space (*5*).

Similar systems are located in cities and regions throughout Europe including the German cities of Frankfurt, Koln, Stuttgart, and Dortmund; Geneva, Switzerland; the French cities of Grenoble, Chambery, Lyon, and Strasbourg; the English cities of Southampton and York; and Dublin, Ireland (*4*; *6*; *7*). Another smart parking management system is planned in Berlin, Germany (*8*).

In Japan, the Toyota smart parking management system was originally developed to support the park-and-ride lots at the city's two major transit stations as well as a tradition of minimal on-street parking. The central computer system gathers information (via phone lines) on available spaces at parking facilities as well as traffic flows to the city center (e.g., highway closures). Parking and/or traffic information is provided to drivers via telephone, suburban and urban VMS signs, radio, and entrance signs at parking facilities (*9*).

More recently, smart parking management programs have been initiated in the United States. In Chicago, a system is under development that would collect real-time data to provide en-route information via VMS signs to travelers about parking availability, the location of parking spaces in large lots or garages, departure times for the next train or bus, and advice to use transit when alternate roadway routes are congested (*10*). The project is sponsored by Northeastern Illinois' Regional Transportation Authority, Metra Commuter Rail Division, and the Illinois Department of Transportation in the Gary-Chicago-Milwaukee corridor (*4*). This system is described by Orski (*4*), as follows:

> Electronic guidance signs located along expressways and arterials that lead up to commuter rail stations will provide real-time information for motorists on the availability of parking. The intent is to offer alternative rail station choices at critical travel locations, based upon extent of parking available at each station. Where several satellite parking lots exist near a station, the variable message signs will show actual parking counts (or percentage utilization rates) at each lot, and direct motorists to the lots with the most available parking (p. 56).

In addition, a Smart Park project has been proposed for the Santa Clara Valley Transit Authority (VTA) along Highway 17/880 in Santa Clara County (San Jose area), California, would incorporate advanced technologies in park-and-ride lots to encourage drivers on congested roadways to use transit or rideshare (*11*). The project has been described as "an intermodal facility or system of park-and-ride lots capable of exchanging dynamic information with the regional transportation control systems" (*12,* p. 50). This information would include "data on downstream congestion, availability of parking spaces at individual Smart Park facilities, and transit performance" (*12*, p. 50).

System Evaluations

There appears to be only one published (English language) study that systematically evaluates the effectiveness of smart parking systems with respect to increasing park-and-ride lot use. Khattak and Polak (*13*) evaluate a real-time parking information system in Nottingham, England in which "real-time information was disseminated through the radio, while historical information regarding parking lots was disseminated though newspaper advertisements and leaflets" (p. 373). The results indicate that "drivers were more inclined to use the relatively under-utilized park-and-ride facilities instead of the city center car parks, if they received parking information from newspaper advertisements and leaflets" (p. 373). This study suggests the importance of pre-trip information with respect to parking choice and increased transit use.

Another study that suggests the potential significance of pre-trip traffic information with respect to mode change was conducted by Conquest et al. (*14*). In this study, on-road survey data was collected (3,893 motorists) and evaluated to examine the effect of traffic information on driver behavior. The study found that 23.4 percent of respondents would not change their mode, route, or departure time, but 50 percent were receptive to pre-trip information and as a result might alter their mode, route, or departure time (Conquest, et al. 1993).

Opinion surveys of the two systems described above (Frottmaning, Germany and Toyota, Japan) are generally described in the literature. Cervero (*5*) reports that the German Ministry of the Interior surveys cited the highway park-and-ride displays in the Frottmaning system as the main reason many motorists have shifted from driving to taking the train to work. A survey about the Toyota system indicated that after six months of operation: (1) 95 percent of respondents were aware of the signs, (2) 71 percent made use of the information, (3) 87 percent thought the system was helpful, and (4) 32 percent of those who used the system lived outside the city (*9*).

There is also limited evidence on the effect of parking capacity at transit stations on transit demand (*2*). One empirical study of parking-constrained commuter stations in the Chicago area (Metra) suggests that each additional parking space may generate between 0.6 to 2.2 additional transit users (*2*). The author notes that "on the margin, new riders may use parking spaces a bit more intensively than the average (e.g., carpools may be more common), but it seems unlikely that an additional parking space could attract as many as two new riders" (p. 575). In addition, the analysis indicates that increased parking capacity at constrained stations produced positive net social benefits. Ferguson (*3*) reports that "a market research study undertaken by Metra in 1985 identified a lack of parking at surburban rail stations as the single largest factor contributing to the observed ridership losses" (p. 108). In addition, a survey conducted for a smart parking management project that is under development in Chicago (described above), also indicates that parking availability affects transit ridership (*15*). The survey found that "although about 58% of all riders surveyed stated that they would simply park farther from the station if the parking lot nearest to the station was full, 18% of the riders stated that they would drive to their destination if their only choice was to travel to the next station downstream" (*15*, p. 2).

The results of surveys and focus groups for proposed smart parking systems linked to transit in Chicago and Santa Clara (described above) provide some insight into the information needs of parkers at transit stations. The survey results for the Chicago proposal indicate that "80 percent of the Metra riders traveling [during] peak-hour travel period[s] thought that signage needed to be improved, while only 57 percent of those traveling after…peak hours desired improved signage" (*15*, p. 2). It appears that time-constrained peak-hour travelers value timely information (i.e., open lot or spaces) more highly than off-peak travelers because this information may be critical to catching or missing a train. Focus group results from the Santa Clara proposal also identify single occupancy vehicle "drivers with fixed schedules and long commute distances" as a primary market for their proposed smart parking system (*11*, p. 5).

COMMUTER PROFILES

Two travel behavior surveys, one for commuters who did and one for commuters who did not use monthly reserved paid parking, were administered in person by PATH student researchers at the Rockridge BART station from the hours of 5:30 to 7:30 pm Monday to Thursday during the month of November 2003. One hundred and fifty eight surveys were completed for BART commuters who did not use monthly reserved paid parking. Sixty surveys were completed for BART commuters who did use monthly reserved paid parking. This constituted about 25 percent of the monthly reserved paid parkers.

What follows is a detailed discussion of the survey results. First, the general commute patterns of Rockridge BART station riders are presented. This is followed by a discussion of the demographic characteristics of BART riders at the station. Next is a description of rider attitudes toward BART, its current parking services, and potential smart parking services including daily paid and valet parking. The travel effects of the monthly reserved paid parking service are then explored as well as the potential effect of a new daily paid smart parking service. Finally, key conclusions from the survey are made and their implications for the design of the smart parking service are described.

Commute Travel Patterns

Table 1, below, presents the commute travel patterns of BART riders at the Rockridge station who use monthly paid parking and those who do not. The survey results indicate that the dominant destination location for BART commuters at this station is downtown San Francisco (74 percent for monthly paid and 80 percent for others). The lengthy time and monetary cost of auto travel in this origin-destination corridor provides the economic context for BART commute travel and station parking demand. Congestion on freeways in this corridor is severe and the cost of parking in downtown San Francisco is high. As a result, many commuters find BART travel, even with the additional cost of monthly paid parking, to be less expensive and more convenient than auto travel.

The auto is the dominant alternative to BART for commuters at the Rockridge station; 80 percent of paid parkers and 64 percent of other parkers use the auto when they do not ride BART. The top alternative commute modes for both groups are drive alone and carpool modes, but commuters with reserved paid parking are more likely to drive alone than carpool (50 percent of paid parkers drive alone versus 32 percent of other parkers). Buses, telecommuting, and motorcycles are also used occasionally as alternative commute modes.

The flexibility afforded by the auto relative to BART travel is a major reason commuters choose it most often as their alternative commute mode. Both monthly paid parkers and other parkers report that they do not use BART for their commute travel when they need a car before, during, or after work (63 percent for paid and 50 percent for other parkers). Other important reasons for both groups are time constraints (six percent for paid and 15 percent for other parkers) and variation in personal schedules (six percent for paid and 11 percent for other parkers).

Difficulty finding parking is an important barrier to BART use for those without reserved paid parking (9 percent).

Survey results related to frequency of BART commute use and propensity to take an alternative commute mode suggest that the monthly paid parking service is related to BART commute travel. Those with monthly paid parking commute more often via BART than those without it; 92 percent of paid parkers use BART four or more times a week versus 65 percent of other parkers. In addition, those with monthly paid parking are less likely to use a commute mode other than BART (28 versus 46 percent).

TABLE 1 Travel Patterns of BART Commuters at Rockridge Station

ATTRIBUTES	MONTHLY PAID	OTHERS
BART Use Frequency	***n=60***	***n=158***
Only occasionally	0%	7%
1-2 days per month	2%	6%
1-3 days per week	7%	22%
4-5 days per week	75%	53%
More than 5 days per week	17%	12%
Origin Station Area	***n=60***	***n=158***
Rockridge	95%	81%
Other East Bay	5%	17%
Other	0%	2%
Destination Station Area	***n=58***	***n=158***
San Francisco	74%	80%
East Bay	29%	20%
Alternate Commute Mode?	***n=60***	***n=158***
Yes	28%	46%
Top Reasons Why Don't use BART	***n=16***	***n=111***
Need car	63%	50%
Time constraints	6%	15%
Variation in personal work schedule	6%	11%
Too hard to park at BART	0%	9%
Top Alternate Commute Modes	***n=20***	***n=111***
Drive Alone	50%	32%
Carpool	30%	34%
Bus	5%	10%
Motorcycle	5%	0%

Demographic Attributes

In addition to commute travel patterns, the questionnaires also explored the demographic attributes of riders with and without monthly reserved paid parking. The results are presented in Table 2 (below).

Not surprisingly, the survey results suggest that riders with monthly reserved paid parking have demographic characteristics that differ from other riders at the station. First, the average household income of those commuters with monthly paid parking tended to be much higher than that of commuters without monthly paid parking (55 versus 32 percent have household incomes greater than $100,000). Thus, these riders are more likely to have the resources to pay for the additional BART parking costs. Second, riders with monthly reserved paid parking are more likely than other riders to have two cars available to their households (48 percent versus 40 percent). Thus, they have the means to drive and park at the station and have less incentive to carpool, bus, walk, or bike to the station. Third, those with monthly paid parking permits are somewhat less likely to belong to the professional/technical, sales, and education category (56 versus 60 percent) and somewhat more likely to belong to the manager/administrator and clerical/administrative support categories (39 versus 26 percent). The last two categories tend to go to work at the same place every day and have a fixed nine to five, five-day work schedule than the former categories, which tend to have variable work locations and schedules. Finally, those with monthly reserved paid parking are more likely to be men (55 versus 44 percent) and tend to be better educated (e.g., 15 versus seven percent have a Ph.D. or higher), older (40 versus 32 percent are 45 to 64 years old), and less likely to have a one-commuter household (47 versus 55 percent) than other riders. These characteristics are consistent with the distribution of income and occupation types of the monthly reserved paid parking riders.

Approximately 90 percent of commuters surveyed at the Rockridge BART station use a cell phone. Thus, many could easily access a smart parking service that includes cell phone reservation.

In general, these results suggest that the profile of those riders who use monthly reserved paid parking and those who do not differ most significantly with respect to income, auto availability, and flexibility of work schedule. High income and an available auto are necessary conditions to subscribe to monthly reserved paid parking and the constraint of a relatively inflexible five-day work schedule makes the monthly service particularly attractive to these riders. It appears that a market may exist for a daily paid parking service among other riders and new riders with relatively high incomes, high auto availability, and flexible work schedules.

TABLE 2 Demographic Attributes of Rockridge Station BART Commuters

ATTRIBUTES	MONTHLY PAID	OTHER
Gender	***N=60***	***n=156***
Female	45%	56%
Age	***N=60***	***n=155***
24 or Younger	7%	16%
25-44	50%	49%
45-64	40%	32%
65 or older	3%	3%
Key Education Levels Attained[a]	***N=60***	***n=157***
Some college	7%	13%
Associate's degree	5%	3%
Bachelor's degree	33%	39%
Some graduate school	8%	6%
Master's degree	28%	25%
Ph.D or higher	15%	7%
J.D.	3%	4%
Key Occupations[a]	***N=59***	***n=158***
Manager/Administrator	27%	22%
Clerical/administrative support	12%	4%
Sales	5%	9%
Professional/technical	46%	48%
Student	5%	13%
Use Cell Phone?	***n=60***	***n=157***
Yes	87%	91%
Household Commuters	***n=60***	***n=157***
One	47%	55%
Two	43%	32%
Three or more	10%	12%
Household Car Availablity	***n=60***	***n=157***
Zero	0%	3%
One	35%	43%
Two	48%	40%
Three or more	16%	14%
Household Income	***n=58***	***n=150***
Under $45K	14%	26%
Between $45K and 100K	31%	42%
Over 100K	55%	32%
Household Members by Age	***n=60***	***n=158***
Children Under 5	4%	8%
Children 6 to 18	16%	12%
Adults 19 to 64	78%	76%
Adults 65+	2%	4%

[a] Category does not sum to 100 percent because types with one or fewer responses were omitted.

Attitudes toward Current and Hypothetical BART Services

Attitudes toward BART services were also explored in the surveys. Key findings are described in Table 3. When asked about the quality of the BART parking service, most of the monthly paid parkers indicate that they like the convenience and reliability of their reserved spot (65 percent), but disliked the cost of the service (64 percent). Most of those without a monthly paid permit like that BART parking is free (36 percent) and the close proximity of parking to the station (27 percent), but dislike searching for parking (31 percent) and the fact that parking is often unavailable (28 percent).

TABLE 3 Attitudes Toward BART Services by Rockridge Station Commuters

ATTITUDES	MONTHLY PAID	OTHER
Top Parking Likes	***N=60***	***n=158***
First	Convenience & Reliability (65%)	No Cost (36%)
Second	Close proximity (20%)	Close Proximity (27%)
Third	Pay once a month (10%)	Well Lit (13%)
Fourth	Time flexibility (4%)	Secure (7%)
Top Parking Dislikes	***N=60***	***n=158***
First	Too Costly (64%)	Searching for parking (31%)
Second	Space not always available (25%)	Parking is often unavailable (28%)
Third	Waitlist for spot (4%)	Paying for parking (15%)
Fourth	Lack of enforcement (3%)	Poor lighting (5%)

Attitudes toward the current monthly reserved paid parking program and a hypothetical daily paid parking service were also explored in the survey. The results are summarized in Table 4 below. First, respondents were asked why they did or did not purchase paid parking. The primary reasons why commuters subscribe to paid parking are that searching for parking is a hassle (49 percent) and that parking is often unavailable when they need it (41 percent). Among those who have not subscribed to monthly paid parking, the primary reasons are the high cost (62 percent) and lack of monthly need (22 percent). When regular parkers were asked if they would use a paid daily parking service at the station, 15 percent said that they would, and 28 percent of those said, as a result, that they might use BART more often. When monthly paid parkers were asked if they might switch to daily paid parking, about 18 percent said that they might, and the majority of those said that they would not reduce their use of BART as a result.

TABLE 4 Attitudes Toward Daily Paid Parking at Rockridge BART Station

MONTHLY PAID		**OTHERS**	
Why monthly parking?	***n=59***	**Why not monthly parking?**	***n=157***
Searching for parking is a hassle	49%	Paid parking is too expensive	62%
Parking is often unavailable	41%	Don't need parking on a monthly basis	22%
Safety	4%	Not aware of the paid parking option	5%
More convenient	2%	Paid parking is already full	5%
Travel patterns changed	2%	No trouble finding a space	4%
Daily paid instead of monthly?	***n=60***	**Use daily paid?**	***n=157***
Very likely	10%	Yes	15%
Somewhat likely	8%	No	71%
Neutral	35%	mixed	9%
Very unlikely	47%	Uncertain	4%
Why daily paid?	***n=19***	**Why daily paid?**	***N=57***
Need daily not monthly	42%	Need daily not monthly basis	31%
Daily paid parking more affordable	53%	Daily paid parking more affordable	19%
More departure time flexibility	0%	More departure time flexibility	31%
Convenience & assured space	5%	Convenience & assured space	9%
If daily paid, use BART less often?	***n=31***	**If daily paid, use BART more often?**	***N=57***
Yes	?22.9%	Yes	28%
No	59%	No	47%
Mixed	13%	mixed	11%
Uncertain	3%	Uncertain	14%

Note: Only those who said that they would consider using daily paid parking were included in the calculations of whether BART use would increase.

Travel Before and After Monthly Reserved Paid Parking

The survey also examined the before and after travel patterns of monthly paid parking subscribers. The results are documented in Table 5 below. As the primary commute mode, BART travel increased by 15 percentage points, drive alone travel decreased by eight percentage points, and carpool, bus, and/or bike travel decreased by six percentage points when a commuter subscribed to monthly paid parking. With respect to BART access mode share, there was a significant increase in drive alone access (23 percentage points) and a decrease in carpool, bus, and walk mode shares (at least 19 percentage points). In general, it appears that monthly paid parking increased BART use among subscribers but may not reduce their overall auto travel because of diversions to BART from carpool, bus, and bike modes for the main commute mode and increased drive alone access to the BART station.

TABLE 5 Travel before and after joining monthly reserved paid parking at the Rockridge BART station.

MAIN COMMUTE MODE SHARE (N=59)	BEFORE	AFTER	CHANGE
BART	85%	100%	15%
Drive Alone Exclusively	8%	0%	-8%
Combination of Carpool & Bus	3%	0%	-3%
Combination Carpool, Bus & Bike	3%	0%	-3%
BART ACCESS MODE SHARE (N=47)	**BEFORE**	**AFTER**	**CHANGE**
Drive Alone	77%	100%	23%
Drive Alone & Carpool	2%	0%	-2%
Drive Alone & Bus	2%	0%	-2%
Carpool	11%	0%	-11%
Bus	6%	0%	-6%
Walk	2%	0%	-2%
BART FREQUENCY (N=50)	**BEFORE**	**AFTER**	**CHANGE**
Only occasionally	1	0	-1
1-2d/mo	1	1	0
1-3d/wk	6	3	-3
4-5d/wk	37	37	0
More than 5d/wk	5	9	4

SUMMARY AND CONCLUSIONS

Smart parking management systems that provide real-time information to motorists about the number of available parking spaces in park-and-ride lots, the departure time of the next train, and downstream roadway traffic conditions (e.g., accidents and delays) have been implemented in many cities in Europe and Japan. More recently, several transit-based smart parking management programs have been proposed in the U.S. The results of the literature on the potential effectiveness of these systems indicate that:

1. Lack of parking spaces at suburban rail stations may be a significant constraint to transit ridership;

2. Pre-trip and, perhaps, en-route information on parking availability at transit stations may increase transit ridership; and

3. Regular commuters are most likely to use parking information when it is linked to transit because this information may be critical to catching or missing a train during peak hours.

Commuter surveys at the Rockridge BART station were implemented to better understand rider attributes and the potential travel effects of a smart parking service.

More than three-fourths of the commuters at the Rockridge BART station are headed for work locations in downtown San Francisco. Congestion on freeways in the corridor from Rockridge to San Francisco is severe, and the cost of parking in the downtown is very high. As a result, many commuters find BART travel, even with the additional cost of monthly reserved paid parking, to be overall less expensive and more convenient than auto travel. On the other hand, many commuters at this station do not use BART everyday to commute to work; instead, they regularly travel to work by car because of its greater flexibility with respect to running errands before, during, and after work.

The demographic profile results suggest that those riders who use monthly reserved paid parking and those who do not differ most significantly with respect to income, auto availability, and variability of work location and schedule. High income and an available auto are necessary conditions to subscribe to monthly reserved paid parking, and the constraint of a relatively fixed work location and a nine to five work schedule makes the monthly service particularly attractive to these riders. These results suggest a potential market for a daily paid parking service among other riders and new riders with relatively high incomes, high auto availability, and variable work location and work hours.

The survey results do suggest that limited parking at the Rockridge station may be a barrier to BART commuting. In fact, nine percent of riders without monthly reserved paid parking indicated that this was the case. Many also stated that they dislike searching for parking (31 percent) and the lack of available parking (28 percent). The primary reasons why riders do not purchase monthly parking are the high cost (62 percent) and the lack of monthly need (22 percent). When these riders were asked if they would use a paid daily parking service at the station, 15 percent said they would and 28 percent of those said that as a result they might use BART more often.

Analysis of the travel effects of the current monthly reserved paid parking service indicates that it has increased the frequency of BART use among subscribers, but it may not have reduced their net auto travel because of diversions to BART from carpool, bus, and bike modes for the main commute and increased drive alone access to the BART station. Seventy-five percent of paid parkers use BART four to five times a week versus 53 percent of other parkers. As the primary commute mode, BART travel increased by 15 percentage points, drive alone travel decreased by eight percentage points, and carpool, bus, and/or bike travel decreased by six percentage points. With respect to BART access mode share, there was a significant increase in drive alone access (23 percentage points) and a decrease in carpool, bus, and walk mode shares (at least 19 percentage points).

While parking shortage problems are well recognized, the cost of providing additional capacity is frequently prohibitive. Smart parking may provide a sensible means to effectively increase parking capacity. The results of the before and after evaluation of the smart parking field test at the Rockridge BART station will contribute further insights into the potential benefits of transit-based smart parking.

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