

**PART 1**

**Finance**

# Consumer Responses to Advanced Automotive Electronics: User Survey on Electronic Toll Collection Systems

YOUNGBIN YIM

To improve toll collection services, toll agencies in California are considering an electronic toll collection system for state-owned toll bridges and toll roads. Potential benefits of this system seem apparent, yet little is known about how consumers respond to the new technology. In October and December 1990, several surveys were conducted among San Francisco Bay Area motorists. The surveys show that Bay Area motorists are highly receptive to electronic toll collection technology. The perceived benefits of the technology include reduced traffic congestion at toll gates and improved air quality. The surveys also suggest that demand for the electronic toll collection service among commercial users is more elastic with respect to cost than it is among motorists.

To improve toll collection, the California Department of Transportation (Caltrans) is considering an electronic toll collection (ETC) system for state-owned toll bridges and toll roads. The ETC system may offer significant benefits to both the users and the operators of toll facilities. Using ETC, motorists would be able to (a) pass through the toll plaza without stopping at a toll booth, unless traffic conditions prohibit it, (b) avoid cash toll payments on each trip or avoid purchasing commute ticket books, and (c) obtain records of all tolls paid for business purposes. The societal benefits expected from ETC include reduced traffic congestion at toll plazas, reduced fuel consumption per vehicle usage, reduced air pollution at toll gates, and a reduction of labor and overhead in toll operation (1).

Even though the benefits of ETC are potentially significant, how consumers respond to the ETC technology is largely unknown. In 1990 the Institute of Transportation Studies (ITS) of the University of California at Berkeley, in association with GLS Research, conducted several surveys of toll bridge users in the San Francisco Bay Area. The study was supported by Caltrans.

The objective of the surveys was to determine the level of interest among Bay Area motorists for ETC systems. The concerns were (a) the level of demand in subscriptions to the ETC service, (b) the preferred types of automated vehicle identification (AVI) tags, (c) the preferred mounting location or placement of AVI tags on the vehicle, (d) the desired method of payment for the ETC service, and (e) the perceived benefits of ETC. The surveys included a mail survey of the toll bridge users among Bay Area motorists, a telephone survey of mail survey respondents, and a telephone survey of

commercial users. The mail survey, conducted in October 1990, determined the overall interest in subscriptions to an ETC service among motorists who use the Bay Area toll bridges. The follow-up telephone survey, conducted in December 1990, determined the levels of interest in ETC when operational information was provided. A separate telephone survey of trucking firms conducted in December 1990 assessed commercial users' interest in ETC and their sensitivity to its operational aspects.

In the following paragraphs, discussion begins with a review of literature on similar studies. Then the methodology used in conducting the surveys is presented, followed by the findings of the surveys of motorists and commercial users.

## ETC TECHNOLOGY

To use an ETC system, a subscriber opens an account with the toll agency and obtains an AVI tag, or transponder, for the vehicle. The tag is flat, about the size of a candy bar, and can be placed either inside or outside the vehicle. Every time a motorist passes through a toll plaza, sensors read the tag and automatically deduct the toll from the balance in the motorist's account.

A number of ETC systems are currently in operation in states such as Texas, Louisiana, Florida, and New York. The Dallas North Tollway, operated by the Texas Turnpike Authority, has an ETC system covering its entire 14 mi, with another 3 mi under construction. One major advantage has been an increase in the processing capacity of the toll booths. Before implementation of the system, toll booths were processing 350 to 400 vehicles per hour per lane (2,3). After implementation, some toll booths were processing 700 to 750 vehicles, with approximately 40 percent of peak traffic motorists using AVI. The Texas Turnpike Authority estimates that dedicating a lane strictly to AVI would result in a processing rate of 1,200 to 1,500 vehicles per hour.

The Texas system uses Amtech Corporation's TollTag, which employs a radio frequency (RF) technology. TollTags are actually small transponders that reflect and modify continuous radio wave signals. Readers receive the signals from the RF module and transmit the data to a computer or some other logging device. The system, operating since 1989, includes 62 toll stations equipped with coin counting and AVI equipment. Amtech Corporation was retained to install and operate the system, shifting the liability from the public agency to the

private sector. Demand for the service has grown; in April 1990 AVI represented 13 percent of the transactions on the tollway on a weekly basis. During peak periods, 20 percent of the traffic used the ETC system.

The San Diego–Coronado Bridge was the first ETC system installed in California. It was initiated in October 1988 as a pilot project to test the ETC system and was discontinued in 1990. The Coronado system used AVI technology developed by X-CYTE Corporation. This system was based on acoustical wave technology tags that could be read by remote RF readers (4). Each RF tag was assigned a unique number of identifying the vehicle. An electronic tag the size of a credit card was attached to the windshield. The Grosse Ile Bridge in southwest Detroit also uses AVI surface acoustical wave (SAW) technology by X-CYTE. On a typical day, approximately 3,900 (65 percent) of the 6,000 daily transactions on this bridge are by AVI.

The Delaware River Port Authority uses an AVI system on its four toll bridges in the greater Philadelphia area. The system is manufactured by LazerData Corporation and uses an optical laser scanner designed for bar-code reading where a wide scan angle or long reading range is required. A bar-coded sticker is attached to the driver's side window. AVI patronage on these four bridges during April 1990 accounted for approximately 30 percent of the total traffic.

## PREVIOUS STUDIES

During the past few years, surveys have been conducted by various agencies in other states to learn about consumer attitudes toward ETC technology. These surveys have included the Dulles Fastoll by the Virginia Department of Transportation (VDOT), state toll facilities by the Illinois State Toll Highway Authority (ITHA), the Oklahoma Turnpike by the Oklahoma Turnpike Authority (OTA), the Florida Turnpike by the Florida Department of Transportation (FDOT), and three toll crossings—the Lincoln Tunnel, Goethals Bridge, and George Washington Bridge—by AT/Comm together with the Port Authority of New York and New Jersey (PNYNJ) (5). Between October 1989 and May 1990, AT/Comm also surveyed 54 U.S. and two European agencies to determine system designs, market potentials, and pricing structures of ETC (6).

In those surveys, toll agencies were concerned with similar issues, such as the level of demand for the ETC system, the preferred payment method, and the demographic profile of potential patrons of the system. Although the sample sizes varied and the return rates differed, similar responses were received. In general, the previous surveys suggested that toll patrons would be highly receptive to ETC technology but would be less receptive to electronic funds transfer (EFT) technology. The majority of the survey respondents (from 56 to 82 percent) expressed an interest in using the ETC system. For the toll payments, the respondents still preferred cash to credit cards or EFT systems. The EFT method was least desired among motorists, possibly because it is not perceived as advantageous. The surveys also suggested that toll users would expect to keep a minimum balance over \$20 to open an ETC account and would not mind paying \$20 to \$25 for the AVI tag deposit.

As expected, the motorists responding to the surveys were mostly commuters who used the toll facilities frequently. In the FDOT survey, 82.7 percent of the trips on the Florida Turnpike were to or from work. The AT/Comm study showed that 83 percent of the respondents traveling on the Lincoln Tunnel and the Goethals and George Washington bridges in New York were driving to or from work. The VDOT survey showed that nearly 75 percent of the respondents were traveling to or from work.

In the previous studies, more men responded to the surveys than women. The respondents were generally between 30 and 50 years of age, had two or more cars in their household, and had an annual household income of between \$25,000 and \$75,000.

## METHODOLOGY

As explained previously, the study was divided into three parts: (a) a mail survey of toll bridge users among Bay Area motorists, (b) a follow-up telephone survey of the mail survey respondents, and (c) a telephone survey of commercial users.

A major concern was whether or not the samples were truly representative. Even though the mail survey questionnaires were distributed randomly at toll gates, they were probably more likely to be returned by those who had a favorable response to the ETC technology. There were no techniques that could guarantee truly unbiased returns nor were there magic numbers that could completely mitigate biased responses. There were ways, however, in which statistical analysis could be made more rigorous to better control response biases.

At the outset of the study, it was recognized that there were at least three ways in which nonrandom samples could be generated: (a) distribution of questionnaires, (b) scheduling of distribution, and (c) nonresponse. Several approaches were used to assess and minimize the impact of these biases.

First, the results of the study were compared with other studies of similar situations, such as the PNYNJ and FDOT surveys.

Second, to control for nonresponse biases, the mail survey data were weighted according to the actual traffic volume and payment methods of individual bridges. In the Bay Area, tolls currently can be paid by several methods, including cash, commute tickets, and scrip tickets. Most of the respondents said they paid tolls either with cash or commute tickets. Only a fraction of respondents (0.5 percent) used methods other than cash or commute tickets. The cash users and commute ticket users were evenly divided. However, Caltrans records show that the ratio between cash users and commute ticket users is 3 to 1, suggesting that commute ticket users may have been slightly overrepresented in the sample data.

Third, for the follow-up surveys, the telephone survey method was chosen over the mail survey to provide better control over nonresponse biases. The Council of American Survey Research Organizations (CASRO) established the minimum standard for an acceptable response rate on the basis of the upper bound calculation formula. CASRO considers a 60 percent upper bound response rate to be acceptable for most opinion research applications. The response rate of the telephone surveys was over 90 percent.

Fourth, the sample size was made large enough to meet accepted standards for statistical precision. For example, assuming an unbiased sample of mail survey responses was obtained, 5,000 survey responses would have given an acceptable error of no more than  $\pm 1.4$  percent at the 95 percent level of confidence. This level of precision exceeds commonly accepted standards in public opinion research.

### Mail Survey

There are a total of eight toll bridges serving approximately 375,000 Bay Area patrons daily, including weekends. In October 1990, 30,000 survey forms were distributed at toll plazas during peak and off-peak hours according to the traffic volume on each bridge. Of the eight bridges, seven (the San Francisco/Oakland, Golden Gate, Richmond/San Rafael, San Mateo/Hayward, Dumbarton, Carquinez, and Benicia/Martinez) were surveyed. Antioch Bridge was excluded because of low traffic volume. Carpool, vanpool, and commercial users were also excluded because of technical difficulties in distributing questionnaires at toll gates. According to the Metropolitan Transportation Commission, 23 percent of the person trips on the San Francisco/Oakland Bay Bridge last year were generated by carpools and vanpools.

To increase the response rate, the mail survey questionnaire was designed to be short and concise, fitting onto one page. The self-administered questionnaire consisted of a short introduction to ETC and six closed-ended questions. Names and telephone numbers of respondents were solicited so that the mail survey could be followed by a telephone interview. Three issues were addressed in the mail survey: (a) general interest in subscriptions to an ETC service, (b) preference in AVI tag types and the placing or mounting locations of tags on the vehicle, and (c) travel characteristics of motorists, including the frequencies of bridge use and the purposes for primary trips.

The sample size of 30,000 for the mail survey was determined according to an expected rate of return of 15 to 20 percent. Even with a 15 percent return, the sample size would have been large enough to obtain statistically precise data for each bridge. The number of survey forms distributed was proportional to the annual average daily peak- and off-peak-hour traffic volume. Questionnaires were color-coded by bridge.

Of the 30,000 survey forms distributed, approximately 6,000, or 20 percent, were returned over a 2-month period. The highest response was obtained from the Dumbarton Bridge (almost 30 percent) and the lowest from the Benicia/Martinez Bridge (less than 10 percent). The response rate at other bridges ranged from 15 to 19 percent. An overwhelmingly large number of respondents (85 percent) expressed their willingness to participate in a follow-up telephone survey. Forms received after the cut-off date—November 2, 1990—were not processed. The number of forms processed was 5,095; a sample size of 5,000 was considered large enough to provide statistically significant results.

The returned questionnaires were edited and manually coded into categorized variables representing the survey questions. A special matrix format was prepared using the StatView statistical package. A numerical case number was assigned to each survey form after checking for errors. The quality of

data entry was also checked after completion of the entire matrix.

### Telephone Surveys

In December 1990 two telephone surveys were completed—one for motorists and the other for commercial users. The telephone survey of motorists was conducted to follow up on the mail survey. A random sample of motorists was selected from the pool of mail survey respondents who had expressed interest in the ETC service, and 1,000 telephone interviews were completed.

The telephone interviews consisted of 27 dichotomous and multiple-choice questions. These questions were designed to determine (a) the level of interest in ETC if tags were permanently affixed, (b) the preferred tag mounting location for permanently affixed tags, (c) an acceptable tag deposit cost, (d) the desired method of payment, (e) the perceived benefits of ETC, (f) usage of toll bridges, (g) modes of travel, and (h) the socioeconomic profiles of interested toll bridge users. The median interview time was approximately 10 min.

For the commercial users survey, 200 telephone interviews were completed with the owners or managers of trucking firms. The objective was to estimate the level of interest in ETC among current commercial patrons. A random sample of commercial users was selected from the list of approximately 1,200 firms that have existing accounts with Caltrans. In sampling the commercial user population, the firms were classified into three categories—small, medium, and large—according to the size of their accounts. More than 75 percent of the firms interviewed were classified as small firms and had an account size of less than \$1,000 a month. Approximately 20 percent of the firms interviewed were medium-sized firms with an account size between \$1,000 and \$4,999, and 2 percent were large firms that had an account size of \$5,000 or more. Three percent of the firms interviewed did not respond. This distribution matched the actual distribution of all commercial accounts with Caltrans. The median length of an interview was 7 min.

### Data Analysis

To estimate the overall receptivity of all bridge users to ETC technology, the sample responses were weighted by the actual traffic flows at each bridge. The percentage of traffic volume on each bridge was computed on the basis of Caltrans 1990 traffic transaction data. The weighted frequency distribution for the overall results on each question in the mail survey questionnaire, on the basis of average daily traffic volume, was obtained by the following:

$$w_{1a} = \left( \frac{v_a}{V} \right) / \left( \frac{n_{1a}}{N_1} \right)$$

$$r_{1a} = w_{1a}(n_{1a})$$

$$R_{1a} = \sum_{i=1}^7 r_{1i}$$

for each answer to Question 1, and so on. In the expressions above,

- $w_{1a}$  = weighting factor for Question 1 at Bridge  $a$ ,
- $v_a$  = annual average daily traffic volume on Bridge  $a$ ,
- $V$  = total annual average daily traffic volume on all bridges,
- $N_1$  = total number of sample respondents to Question 1 at all bridges,
- $n_{1a}$  = number of sample respondents to Question 1 at Bridge  $a$ ,
- $R_{1a}$  = total weighted number of responses to Question 1 at all bridges,
- $r_{1a}$  = weighted number of responses to Question 1 at Bridge  $a$ , and
- $i$  = number of bridges surveyed.

After the sample responses were weighted according to the traffic volume on each bridge, the weighted results were weighted again according to the actual distribution of commute ticket users and cash users. This approach was used to control possible nonresponse biases, because commute ticket users were considered more likely to respond favorably to ETC technology than were cash users. The commute ticket information used in the analysis was prepared by Caltrans and the Golden Gate Bridge, Highway, and Transportation District in 1990. Telephone survey data were not weighted because they represented a unique subset of motorists who expressed an interest in ETC, and comparable population-based data were not available.

## FINDINGS OF MOTORIST SURVEYS

The findings of the motorist surveys are presented in three parts: (a) travel characteristics of the toll bridge users among Bay Area motorists, (b) interest in using an ETC system, and (c) a demographic profile of the bridge users. These findings come from the mail and telephone surveys.

### Travel Characteristics

The mail survey showed that frequent users or commuters were overrepresented in the sample data. After weighting the survey data according to Caltrans records of toll payments, it was found that there were fewer commuters than shown in the sample data. The weighted results of the mail survey suggested that 46.5 percent of the patrons used toll bridges on a daily basis (five or more times a week), 16.9 percent used them 3 to 4 times a week, and 36.6 percent used them less than twice a week.

The mail survey also suggested that over half the weekday traffic on the Bay Area bridges was generated by trips to or from work. The weighted results suggested that work trips accounted for 67.1 percent of the total daily traffic transactions. Of the total bridge crossings, 10.3 percent were for personal business, 6.5 percent for social and recreational trips, 3 percent for medical or dental reasons, 2.4 percent for school, and 1 percent for shopping trips. Crossings in the "other trip" category accounted for 9.7 percent of the total traffic transactions. This travel pattern was fairly consistent on all bridges surveyed.

Commuter tickets were used more frequently by the daily bridge patrons than by those who crossed the bridges once or twice a week. In the Bay Area, commuter tickets could be purchased at a discount rate at toll agencies. Discount amounts were about 15 percent of the toll charge, although they varied from bridge to bridge. For example, the Golden Gate Bridge discount rate was 16.7 percent. The method of payment varied slightly among the bridges. On the San Francisco/Oakland Bridge, a higher percentage of motorists used cash than on the other bridges. On the Golden Gate Bridge, the pattern was reversed, with far more motorists using commuter tickets than on other bridges.

Ten percent of the telephone respondents used carpool or vanpool service on a regular or semiregular basis (more than three times a week). Approximately 11 percent used it less than twice a week. These respondents were not on the high-occupancy vehicle (HOV) lanes when they received the mail survey questionnaires.

### Interest in ETC

The surveys suggested that Bay Area motorists would be highly receptive to ETC technology. According to the mail survey, as many as 82.4 percent of the current Bay Area toll bridge users would be interested in subscribing to an ETC service. However, the follow-up telephone survey suggested that the ETC market would be sensitive to the tag types and tag mounting locations. If tags were to be permanently affixed, ETC interest would drop about 12 percent from the initial interest of 82.4 percent shown in the mail survey.

The interest in ETC varied somewhat from bridge to bridge. Respondents traveling on the Golden Gate Bridge showed a slightly greater interest in ETC than those traveling on the other bridges. The reason could be that there were more commuter ticket users on this bridge than on other bridges. As expected, frequent users were more receptive to ETC than were infrequent users. Similarly, commuter ticket users were more receptive to ETC than were those using cash. Obviously, frequent users were more likely to use commuter tickets than were infrequent users and, consequently, commuter ticket users or frequent users would be more receptive to ETC than would infrequent users.

An overwhelmingly high proportion (85 percent) of the mail survey respondents favored transferable tags over permanently affixed tags. The preferred tag type and tag location results were fairly consistent on all bridges. For the transferable tags, the only option given in the survey was inside the windshield. The majority of respondents (82 percent) from all bridges preferred a transferable tag placed inside the windshield. For permanently affixed tags, three placement locations were considered: (a) outside the windshield, (b) on the license plate, and (c) on the underside of the vehicle. If tags were to be permanently affixed, 57.4 percent of telephone survey respondents said they would prefer to have the tags mounted on the underside of their cars. Among the reasons were aesthetics and the possibility of vandalism when tags were placed in a visible location.

The telephone survey also suggested that there was a strong willingness to support the operational requirements of the ETC service. To use an AVI tag, subscribers would pay the



toll agency a one-time refundable deposit. The survey showed that imposing a tag deposit would not be a major deterrent. Nearly 9 out of 10 respondents (88.5 percent) said they would be interested in ETC even if a \$30 deposit were required. If the deposit were reduced to \$15, there would be an increase of 5.3 percent in interest to 93.8 percent. If it were dropped from \$15 to \$5, an additional 1.7 percent of the respondents would be interested in ETC—an increase to 95.5 percent.

To use ETC, it would be necessary to open an account with the toll agency. The minimum amount necessary to open an account could be as much as \$40. This amount was acceptable to 90 percent of the telephone survey respondents. Reducing the minimum amount to \$20 would increase interest in ETC to 95 percent. However, if earnings from the float were an important ETC cost recovery consideration, the revenue lost by changing the minimum amount from \$40 to \$20 would outweigh the revenue gained from an increase in the use of ETC by a ratio of nearly 2 to 1.

Nearly two-thirds of the telephone survey respondents (63.9 percent) said cash was their first choice as a method of payment. The second choice was credit card, and the least desired method was an electronic transfer of funds from bank accounts.

Seventy-two percent of the telephone survey respondents said they would be interested in receiving a monthly log of their bridge crossings because the log would be helpful for accounting purposes. However, if a \$1 monthly fee were charged for the service, there would be a 26 percent drop in interest to 46 percent.

Perceived benefits of ETC among the motorists included relief of traffic congestion, improved environmental quality, and increased safety. Nearly 90 percent of the telephone survey respondents believed that there would be less traffic congestion at toll plazas if ETC were implemented (see Figure 1). Of the telephone survey respondents, 77.5 percent said that vandalism would be a problem if the electronic tags could be seen (see Figure 2). Conversely, only 7 percent showed a strong concern that electronic tags would permit the police to track or trace their vehicle (see Figure 3). The general perception of the telephone survey respondents (71 percent) was that ETC would improve air quality because there would be less carbon monoxide produced by vehicles decelerating and idling at toll gates. Telephone survey respondents disagreed (75.2 percent) with the notion that ETC might en-

courage people to use their cars more often because it would be easier to cross the bridges.

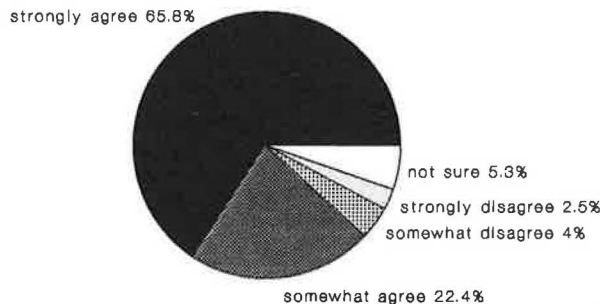
Caltrans is considering discontinuation of commuter discounts. If the commuter discounts on toll charges were discontinued, only half (48.9 percent) of the telephone survey respondents said they would still be interested in ETC. Respondents might have inferred that commuter discounts would still be offered to those not subscribing to ETC. In fact, if the commuter discount were discontinued, all motorists would be affected. Respondents traveling on the San Francisco/Oakland Bridge were more receptive to ETC without the commuter discounts than were respondents on the Golden Gate, Carquinez, and Benicia bridges. One reason for this response could be that the commuter discounts for those three bridges were more than those for other bridges. The Golden Gate Bridge discount is \$0.33 for a \$2 toll charge, and the discount on the Carquinez and Benicia bridges is \$0.25 for a \$1 toll. The discounts on other state-owned bridges are \$0.15 for \$1 tolls. There was a higher proportion of commute ticket users on the Golden Gate (78.1 percent), Dumbarton (59.8 percent), and Carquinez (52.3 percent) bridges than on other bridges.

The Golden Gate Bridge and the seven other Bay Area toll bridges are run by two separate agencies. Therefore, patrons would need to open two separate ETC accounts if they were to use ETC on all Bay Area toll bridges. Of the 205 respondents using all eight bridges, 68.3 percent said they would not be interested in opening two ETC accounts. Patrons of the Golden Gate Bridge appeared to use other bridges more frequently than other bridge patrons used the Golden Gate Bridge. Although nearly half of the Golden Gate Bridge respondents (45.6 percent) said they used other toll bridges at least once a month, only 15.1 percent of other bridge respondents said they used the Golden Gate Bridge that often. No matter how infrequently they traveled on other bridges, patrons did not seem receptive to having two separate accounts for toll payments.

**Demographic Profile of Users Interested in ETC**

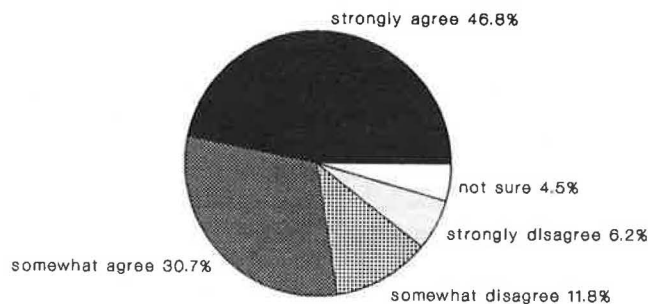
The telephone survey respondents using Bay Area toll bridges were in the upper middle or high income group, had a household income of over \$30,000 a year, and had two or more

*There will be less traffic congestion at the toll plazas once the ETC system is implemented.*



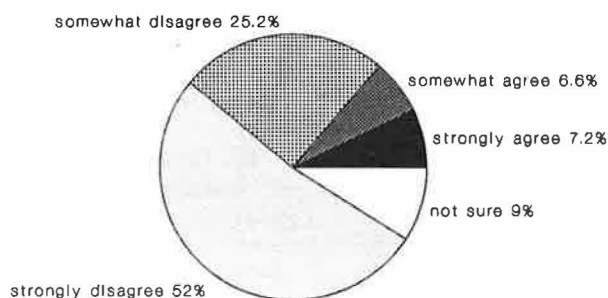
**FIGURE 1** Perception about traffic congestion.

*If the electronic tag is affixed to your car where anyone can see it, people will try to steal it.*



**FIGURE 2** Perception about vandalism.

*The electronic tag will allow the police to always know where your car is, and that is not good.*



**FIGURE 3** Perception about privacy.

cars and drivers in the family. On all bridges, a high proportion of respondents were in the income group between \$40,000 and \$60,000. The median household income of the sample population was between \$40,000 and \$50,000. However, the household incomes of respondents appeared to be associated with the individual bridge. Respondents from the Golden Gate Bridge had generally higher household incomes than those from other bridges. Over 30 percent of the sample population traveling on the Golden Gate Bridge had incomes over \$100,000 last year. Overall, respondents traveling on the Dumbarton Bridge had higher family incomes than other bridge respondents.

According to the telephone survey, it was estimated that the primary users of the Bay Area bridges interested in ETC would be between 30 and 50 years of age. The median age group was between 30 and 39. The second largest group was between 40 and 49. The San Francisco/Oakland, Richmond/San Rafael, Dumbarton, and Carquinez bridges had their highest proportion of respondents in the age group between 30 and 49. Of the telephone survey respondents, 78.2 percent were employed full time, and 3.6 percent were part-time employees. Only 10.9 percent were self-employed.

Tables 1–9 present the results of this survey compared with the results of surveys conducted in other states. (In the tables, CDOT refers to Caltrans.)

All of the surveys indicate that demand for ETC is a function of the frequency of toll facility use. The ETC technology was most favorably received by those who used the toll facilities frequently. Therefore, it is suggested that ETC be targeted at people who commute to work and at commercial users who frequently use toll facilities. The Caltrans surveys

**TABLE 1** Sample Size

	CDOT	VDOT	FDOT	ITHA	OTA	PNYNJ
Distribution	30000	10050	10400	--	30000	12000
Return rate	20%	25%	20%	--	10%	16%
Sample size	5095	--	--	1119	2688	900
Year surveyed	1990	1989*	1990	1989*	1989*	1990

\* estimated year where surveys were conducted.

**TABLE 2** Gender of Respondents

	CDOT	FDOT	PNYNJ
Men	69.4%	56.7%	77.0%
Women	30.6	42.4	23.0

**TABLE 3** Interest in ETC

	CDOT	VDOT	FDOT	ITHA	OTA
Positive	82.4%	65.0%	67.4%	69.0%	56.0%
Negative	17.6	10.0	32.4%	30.0*	--
Not sure	--	25.0	0.2	--	--

\* combined both negative and not sure.

**TABLE 4** Method of Payment

	CDOT	VDOT	FDOT	PNYNJ
Cash or check	63.9%	60.0%	59.6%	53.0%
Credit card	19.7	--	33.4	23.0
Electronic transfer	14.2	--	7.0	--
Not sure	1.6	--	0.0	--

**TABLE 5 Minimum Balance for ETC Account**

	CDOT*	PNYNJ
0	1.7	--
\$10	1.3	34.1%
\$20	2.7	42.0
\$30	1.3	13.7
\$40	90.0	--
\$50	--	10.3

\*Percentage of respondents desiring minimum balance between 0-\$9, \$11-\$19, \$21-\$29, and \$30-\$39 are not indicated above.

**TABLE 6 Tag Price**

	CDOT	ITHA	PNYNJ
\$50-65	--	4.0%	--
\$35-50	--	28.0	47.0%(\$30-50 with discount toll)
\$20-35	(\$30)92%	50.0	--
0	--	--	48.0 (agency pays for the tag)

**TABLE 7 Trip Purpose**

	CDOT	FDOT	VDOT	AT/Comm
To or from work	67.1%	82.7%	75.0%	83.0%
Business	10.3	10.1	--	--
School	2.4	1.2	--	--
Medical/dental	3.0	0.7	--	--
Social/recreation	6.5	3.9	--	--
Shopping	1.0	0.7	--	--
Other	9.7	0.7	--	--

**TABLE 8 Trip Frequency**

	CDOT	FDOT	PNYNJ
>5 times/week	46.5%	79.9%	74%
3-4 times/week	16.9	9.6	--
1-2 times/week	18.0	5.6	--
<once/week	18.6	4.9	--

**TABLE 9 Number of Drivers per Household**

	CDOT	FDOT
0	0.2%	--
1	14.1	19.5%
2	53.9	57.5
3 or more	31.7	23.0

well spread out between 1 and 3,500. However, the median number of all tractors or hauling units was 10. The frequency distribution of the number of all units (including those with a vehicle identification number) operated by the firms interviewed was spread out between 1 and 7,500, but the median number of all units was 30. Over 40 percent of the firms made bridge crossings between two and five times a day. One quarter of the respondents did not know how many crossings they made per day.

Among commercial users, 76.5 percent of the firms interviewed expressed an interest in using the ETC system. Unlike motorists, the commercial users did not seem to be influenced by the types of AVI tags. Rather, their willingness to use the system seemed to be closely associated with its cost. When asked about permanently affixed tags, interest remained the same. However, when asked about the deposit requirement, interest dropped. If a deposit were required to obtain a tag, only 41 percent of the respondents said they would be interested in ETC and 32 percent said it would depend on the cost of the deposit.

The survey also showed that the commercial users' interest in ETC was highly price sensitive. If the cost of the tag deposit were \$30, only 54.5 percent said they would be interested in ETC. If the deposit were decreased to \$15, interest would increase to 65 percent. If it were reduced to \$5, interest would increase to 72 percent. To attract commercial users, it would be highly desirable to keep the cost of the tag as low as possible.

Two payment methods were considered for commercial accounts: prepaid and billed accounts. These accounts could be paid in one of three ways: (a) automatic monthly electronic funds transfer from a company's bank account, (b) automatic monthly charge to a Visa or MasterCard account, or (c) check, cash, or money order. If tolls were paid by check, cash, or money order, there would be a monthly service charge of \$7. If they were paid by electronic funds transfer or by credit card, there would be no service charge. Between the two types of accounts, billed accounts (65 percent) were preferred to prepaid accounts (24 percent). Ten percent of the respondents were uncommitted. For either prepaid or billed accounts, cash payments were preferred. The second choice was an electronic transfer of funds from bank accounts. This finding suggests that commercial users are not as reluctant as motorists to use the automated banking system.

Every unit in a company's fleet that has its own vehicle identification number could have its own AVI tag. For instance, a typical tractor-trailer rig is made up of two units: the tractor or hauling unit and the trailer. If both units had tags, sensors at the toll plaza could read both tags and automatically calculate the total toll charge. Because the toll collector would not have to enter the total axles manually, drivers would get through the toll plaza faster. However, some companies frequently haul trailers that arrive from outside the Bay Area. These trailers probably would not have AVI tags. If a firm decided to use the ETC system, all of its hauling or tractor units would need an AVI tag. Tags for its own trailer units would be optional, and many units hauled from outside the Bay Area would not have tags. When asked the percentage of all trips that would be made by rigs that were not completely tagged (i.e., the tractor or hauling unit would have a tag but the trailer unit, or any other unit being hauled, would not), 10 percent of the firms interviewed said trailers

also suggest that demand for ETC among motorists is elastic with respect to the types of tags offered.

## FINDINGS OF COMMERCIAL USER SURVEY

The frequency distribution of the number of tractors or hauling units operated by the commercial respondents was fairly



would not be tagged most of the time. Only 45 percent of the firms interviewed said the trailers would be tagged at all times. If nearly 55 percent of the trailers were untagged, there could be operational problems for toll agencies.

## CONCLUSIONS

According to the surveys, over 82 percent of the toll bridge users in the Bay Area would be interested in using the ETC system. If AVI tags were permanently affixed, interest in ETC would drop to 70 percent. Most of the motorists interested in ETC preferred transferable tags to permanently affixed tags, and the preferred tag mounting location was inside the windshield. If tags were to be permanently affixed because of technological reasons, the most favored location of tag placement was the underside of the car. Mounting the tag on the outside of the windshield was the least desired location, mainly because of vandalism and aesthetics concerns.

The tag deposit of \$30 would be a relatively minor issue, and a minimum amount of \$40 to open an ETC account would also be acceptable to the vast majority of current toll bridge patrons.

Substantial benefits were perceived as being gained from ETC in at least two areas: (a) reduced traffic congestion at toll gates, and (b) improved air quality. The survey respondents were not concerned with tagged vehicles being more easily located by the police and did not believe that ETC might encourage an increased use of toll bridges.

Demand among commercial users would also be substantial. However, commercial users were more price sensitive to ETC operational issues than were motorists. Commercial users' interests in ETC was highly elastic with respect to the cost of the tag deposit and the method of payment.

## ACKNOWLEDGMENTS

This work was performed as part of the PATH program of the University of California, in cooperation with the State of California, Business and Transportation Agency, Department of Transportation, and FHWA.

The author wishes to acknowledge Wolfgang Homburger of ITS, Robert Jacobs of Caltrans, and Gary Stieger of GLS Research for their advice and comments.

## REFERENCES

1. D. A. Hensher. Electronic Toll Collection. *Transportation Research*, Vol. 25A, No. 1, Part A, Jan. 1991.
2. *Analysis of Automatic Vehicle Identification Technology and Its Potential Application on the Florida Turnpike*. Technical Memorandum 1. Center for Urban Transportation Research, University of South Florida, Tampa, June 1990.
3. *Analysis of Automatic Vehicle Identification Technology and Its Potential Application on the Florida Turnpike*. Technical Memorandum 2. Center for Urban Transportation Research, University of South Florida, Tampa, Oct. 1990.
4. T. McDaniel, G. Pratt, and J. Schmidt. *Automatic Vehicle Identification/Electronic Toll Collection (AVI/ETC), Demonstration Program on the Caltrans San Diego-Coronado Bay Bridge*. Final Report. Science Applications International Corporation; Division of Transportation Operations and Toll Bridges, California Department of Transportation, Sacramento, 1986.
5. *Preliminary Survey Results*. User Survey of Toll Bridges. Port Authority of New York and New Jersey, New York, 1990.
6. *Results of Market Research Conducted Between October 1989 and May 1990*. AT/Comm, Inc., Marblehead, Mass., 1990.

---

*The contents of this paper reflect the views of the author, who is responsible for the facts and accuracy of the data presented. The contents do not necessarily reflect the official views or policies of the state of California. This paper does not constitute a standard, specification, or regulation.*

*Publication of this paper sponsored by Committee on Taxation, Finance and Pricing.*