Evaluating Second Car System, an Electric Vehicle Sharing Experiment in Tama New Town District, Inagi City, Tokyo

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Abstract

In September 1999, the Association of Electronic Technology for Automobile Traffic and Driving (JSK) experimented with the concept of a "Second Car System" in Tama New Town District, Inagi City, Japan. There were several goals of the experiment, including: 1) to examine the practicality of shared-use vehicles accompanied with intelligent transportation system technologies, and 2) to ascertain the potential issues that might arise in the course of commercializing such a system. A fleet of 30 electric vehicles was used to serve for 242 participants at eight locations in the residential area of Tama New Town. The Second Car System provided residents, who have no access to their first car, with vehicles to drive errands.

Two modes of operation were investigated during the five phases of the project that ran from September 1999 until February 2002. Initially the Second Car System was introduced free of-charge, i.e., at no cost to the users. During the last phase of the project, fees were introduced. During the initial free operation phases, the project received an overwhelming public response with 242 residents availing themselves with the system. Tama New Town District residents were highly appreciative and satisfied with the service features and operation of the Second Car System. Soon after fees were imposed, the number of users dropped drastically to 20. The experiment ended in February 2002, with only 35 users remaining.

The Second Car project failed to recruit as many users as was anticipated. The lower than expected use of the system may be attributed to three factors: 1) a high degree of vehicle ownership, 2) inefficient public transit in the area, and more importantly (3) fee was not imposed on the outset led to drastic drop out of the project after fare collection.

Despite lower than expected use of the system after fee was imposed, results from a public hearing carried out one month prior to the end of project indicated that most users were greatly satisfied with the service. The most satisfactory services are: 1) operation center accessibility; 2) vehicle availability; and 3) booking system. There was strong support to extend the project as some residents had already started selling their own cars. Some suggested to expand the service areas to enhance the attractiveness of the system.

This paper mainly focuses on: 1) user attitude and behavior, in particular on their decision making while using the Second Car system; 2) benefits from applying ITS technologies in the system; and 3) positive and negative lessons gained from the experiment.

Keywords: shared-use vehicle systems, car sharing, electric vehicles, ITS technologies, user travel behavior

Introduction

During the 1960s, Japan experienced very high economic growth, which became the impetus of high population concentration in the Tokyo metropolitan area. Consequently, immediate demand for housing supply rose sharply. To meet such demand, the metropolis of Tokyo decided to develop Tama New Town in the Tama hills district in 1963 and started construction in 1968. Tama New Town covered an area of 3,253 hectares, located approximately 30 kilometers west of central Tokyo. The Tama New Town development area encompasses four cities, namely: parts of Tama City, Hachioji City, Machida City, and Inagi City. Approximate populations for each city as of August 2002 are 145,859, 536,000, 377,546, and 72,157, respectively *(1, 2, 3, 4).*

In October 1998, the New Energy Development Organization (NEDO) wanted to test the application of ITS technologies designed for Clean Energy Vehicles and has sponsored the Association of Electronic Technology for Automobile Traffic and Driving (JSK) to do research and development regarding this matter. In September 1999, JSK started experimental demonstrations of the EV Sharing Systems, including the Rental Car System for the City Center in Minato Mirai 21 of Yokohama and Second Car system for Residential Area in Tama New Town Inagi, Tokyo *(7, 8).*

Travel to work by train is a major public transport modal choice in Japan. It is well established that approximately 95 percent of Tama New Town residents travel to work in the Tokyo Metropolitan area by train and the rest by bus and private transport, generally leaving wives and children at home *(8).* The rail systems in Japan are highly efficient with services running through all regions of the country. The vast majority of services are operated by Japan Railway (JR), which split into seven regional networks when it was privatized in 1987, but still runs as a single company. In addition, there are fourteen smaller rail companies, which are based in the major cities and surrounding areas (more detail can be viewed at www.jtbusa.com/enhome/basicj.asp). Notwithstanding Japan reputation as having one of the most efficient public transport networks, local public transportation systems, particularly, in suburban areas like Tama New Town, are still less accessible. There are a few intra-city buses and taxis operating infrequently among railway stations, schools, shopping malls, recreational centers and so on. Most of the wives drive their husbands to the station and drop off their children at nearby schools. Households that have more than two family members, and whose head of household commutes by car, tends to have the potential to buy a second car since the wife has to bring the kids to school or parents to public facilities like the hospital. To satisfy this potential demand for a second car, the Second Car System (SCS) concept was introduced in September 1999, by the Association of Electronic Technology for Automobile Traffic and Driving (JSK). The primary aim of the SCS experiment was to provide service to residents who have no access to their first car, including those who have cars at home but would prefer to use other modes of transport to meet their travel needs *(5, 6, 7, 8).* The SCS experiment in Tama New Town District concentrated mainly on Inagi City area. As of August 2002, the city has approximately 28,851 households and population of 72,157.

The number of registered vehicle in Inagi City is relatively high compared to other parts of Japan. As of March 1999, the number of registered passenger cars was 6,467 and the number of small compact cars was 12,614. In March 2000, the number of registered passenger cars increased to 7,029 and for small compact car, the number dropped to 12,465. In March 2001, the number of registered passenger cars increased again to 7,641 while the number of small compact cars dropped to 12,232 *(8).* It is important to note that the number of registered vehicle of both types is approximately 75% of the number of households in Inagi City (28,851 households as of August 2002). Surveys conducted before and during the SCS experiment showed that 94% of users owned their car: 82% of the household users had one car, 11% had two cars, 1% had three cars and 6% had no car *(8, 9).* Ownig a second or third car required more parking space, and due to a shortage of parking, the cost for monthly parking is relatively high approximately ¥15,000 to ¥25,000 (US$150 - US$250) depending upon area. On-street parking is generally prohibited.

This paper mainly focuses on 1) user attitude and behavior, in particular on decision making for using the SCS, 2) benefits from applying ITS technologies, and 3) positive and negative lessons gained from the experiment. The following sections provide an overview of the SCS experiment with details on the use of ITS technologies, as well as the results and lessons learned during the field trials.

Second Car System Experiment Overview

The Second Car System demonstrated in Tama New Town, Inagi city, Tokyo was designed primarily for housewives, whose families could not readily own a second family car due to parking constraints. The System made it possible for these families to drive errands in the Tama New Town residential areas and other locations within the system. The system provided users with electric cars on an advanced reservation-basis.

The field trial for the Second Car System in Tama New Town began in September 1999. The experiment was divided into five phases with starting dates as follows: Phase 1-September 1999; Phase 2-January 2000; Phase 3- September 2000; Phase 4- January 2001; and Phase 5- December 2001. Table 1 indicates the operational phases, vehicles, users, and port system. It was decided from the outset that fees would not be charged during the first four phases of the project, but would still estimate the cost of actual mileage use during a rental trip. This estimated cost information was determined in real-time by the system management center and to transmitted to the vehicles at the end of the trip, where it was displayed on a screen so that users could know the realistic cost before entering the fee charge period. The rationale was to investigate the users' response and interaction/acceptance towards the fee. The SCS field trial was to use environmentally-friendly electric vehicles (EVs) fully equipped with advanced technology. JSK's goal in the SCS experiment was to examine the practicality of shared-use EVs combined with ITS technologies, as well as to ascertain potential issues that might arise in the course of commercializing such a system *(7).* Shared-use of one vehicle among neighborhood residents would make it easier to secure a parking space. It would not impose a large financial burden on the users because the cost of operating the vehicle would be shared among users. Moreover, shared-use of EVs would reduce energy consumption, reduce land allocation for parking facilities, and alleviate the environmental impact in a sustainable way *(7).*

A fleet of 30 to 50 Daihatsu Atray and Toyota e-com EVs was used to serve more than 200 residents, located at eight different locations in Tama New Town residential area. The location of the EV stations is described in more detail in subsequent sections.

ITS-Based Second Car System Components

The ITS-based Second Car System experiment consists of the following components: operation center, in-vehicle system, electric vehicle stations, system functions, and ITS technology application. Figure 1 provides a visual representation of the system components. Details of each component are described below.

(1) Operation Center

The operation center mainly consists of a server computer, a vehicle supervisory computer, a firewall computer and a communication control computer. The server computer manages information pertaining to the users, the vehicles, the EV stations, and the landmark information. Also, the server computer has Internet web server functions. The operation center system is connected to the Internet, and a firewall is installed to protect any illegal access to the system. The vehicle supervisory computer monitors vehicle status. The communication control computer controls communication between the center and the vehicles. Two lines were dedicated to receive communication from vehicles and another two lines to send communication to the vehicles. In addition, one telephone line was installed for voice call from vehicles, and for the telephone reservation call.

(2) In-Vehicle System

The in-vehicle system consists of a communication controller, an integrated circuit (IC) card reader, a car navigation unit, a communication unit (cellular phone), hands-free set and a car key cylinder (in glove box located in the console inner car). The communication controller controls the interfaces with each connected unit. The car navigation unit detects current vehicle position using a global positioning system (GPS) receiver, and displays a map and current vehicle position and direction on a liquid crystal display (LCD) monitor. Messages from the operation center or internal vehicle operation guidance message are displayed on the LCD monitor. The key cylinder in the glove box is unlocked only when the IC card is authenticated. The mobile communication is carried out through the cellular phone as a type of line connection. Every data communication event takes approximately a minute to communicate with the operation center as a p2p (peer-to-peer) connection procedure is needed for each communication transmission event.

(3) EV Stations

There were eight Second Car System stations located within a 200 meter-radius of users' residences. Each EV has an onboard inductive battery charger. The passive equipment at the EV station consists of a switch box and an outlet box at the carport. Two to five electric vehicles are positioned at each EV station. Figure 2 shows the locations and the number of EVs distributed at each station, which is dependent on the density of users in that area. The Second Car System adopted round-trip port policy meaning that users would have to return the car to the station that they rented from. This round-trip policy helps avoid any imbalance of vehicles (i.e., distribution) at each station.

(4) System Functions

The functions of the Second Car system are as follows:

- **Reservation and EV Assignment**

To use the SCS vehicles, users are required to make a reservation at least two hours in advance. Reservations can be made via the Internet or by a telephone call to the operation center. To reserve, the user inputs the date and time, duration, and destination of the trip. Destinations are input by selecting from a list of specified landmarks. During the rental trip, if a user wanted to make a stop on the way, the car remained reserved for that user. The system calculated mileage from a table of road length between landmarks registered in the database. The equivalent mileage for air conditioning use was also added. It is important to determine the mileage during the rental as this relates to battery consumption and recharging, which is critical for EV use. A reservation is accepted if a vehicle at the station has sufficient charge for the required mileage at the start of the rental.

- **Unmanned Rental/Return System**

The operation center sent the reservation information to the assigned vehicle 10 minutes before the rental trip started. Any communication error dealing with concurrent call requests were handled within this 10-minute window. At the time the trip start, information on the start and return times were sent to the operation center. The operation center monitored the rented vehicles and their return times. When the rental return time was due and a return notice was not received, the system sent an alarm signal that was displayed on screen for operation center staff, and to the in-vehicle LCD screen for the user.

- **Vehicle Supervision**

The operation center monitored each vehicle every 30 minutes during the course of the rental. The center system received the data on the remaining battery charge, mileage and locations detected by GPS from each vehicle every 30 minutes. In case of an abnormal occurrence in a vehicle (e.g., vehicle out of charge, flat tire, etc.), the information is transmitted from the vehicle with the vehicle position to a screen in the operations center. For example, if the remaining battery went under a critical point, a warning message is displayed on the screen and also sent to the vehicle. Otherwise, vehicle position was not normally monitored closely. Any text message can be edited and sent to any vehicle to be displayed on the LCD screen. Initiated manually, the doors locking and unlocking command can be sent to any vehicle in case a user forgot to lock doors or left things behind at the time of return.

- **Rental Fee Display**

In the field trial, although use of the EVs was free of charge during the first four phases, fees were calculated for the actual rental duration and mileage by the operation center. The calculated fee was displayed on the onboard LCD screen of the vehicle at the end of the rental trip. The purpose of displaying the fee was to make the user aware of the cost of using the vehicle. Raising awareness of the cost of using the EVs was thought to enhance users' acceptance of fees that will be imposed in a commercialized implementation. During the fee-of-charge period, the use of vehicles was limited to four hours a day. However, in the case of charging a fee, the limitation of four hours of rental for a user per day was not necessary. It was assumed that the rental trip duration and the number of trips per user would decrease once fees started being charged.

(5) Applied ITS Technologies

One advantage of shared-use vehicle systems is that it is well suited for testing new technologies like ITS, particularly when integrated with clean propulsion vehicles such as EVs and hybrid electric vehicles. The ITS technology applied in the SCS program enabled several functions: reservations, user-identification, battery management, fail-safe procedures, post-trip processing, and energy consumption calculation *(8).*

By applying ITS technology, intelligent communication and reservation systems were set up to provide vehicle location identification, vehicle tracking, dispatching, and reservations from several sources such as the Internet and telephone. On-board navigation and travel information was also available to assist within a shared-vehicle, and smart-card technology was employed for vehicle access control. All of these ITS technologies make a shared-use vehicle system more efficient, easier to manage, and far more friendly to the users *(12 ,13, 14).* In general, ITS can help create fundamental breakthroughs in safety, congested reduction, driving comfort, and environmental friendliness.

At present, ITS technologies are being used in many car sharing experiments including Praxitele, CarLink, UCR IntelliShare, Public Car in Kyoto, Honda's ICVS activities, Toyota's Crayon system in Toyota City, the City Car System in Yokohama and the Second Car System in Tama New Town. Praxitele, initiated in 1997 in Saint-Quentin-en-Y velines using 50 self-service electric vehicles to serve for nearly 500 participants. Each vehicle was equipped with ITS technology, a global positioning system (GPS) and car navigation system. These systems, coupled with a digital communication link, allowed the center system to keep track of the entire fleet and to reserve vehicles for customers. Furthermore, the praxitele system adopted platooning to easily move the empty vehicles from one location to another *(10, 11).* Honda in Japan has also used platooning technology to relocate their cars from one place to another. In the UCR IntelliShare system, 46 electric vehicles are available to University of California Riverside faculty, staff, and student employees at five stations set up on and near campus. The cars are available to run errands in the Riverside area or to drive to another location in the system. In order to make this shared vehicle system convenient to users and operators, the system also introduces the latest ITS technology. UCR IntelliShare provides users with smartcards to access the station kiosks, the station buildings, and the vehicles themselves. In order to manage the system, a system management center monitors the location and operational status of each vehicle, e.g., battery state-of-charge, odometer, etc., using advanced vehicle monitoring technology. These data allow the system to intelligently determine the availability of vehicles for other users (more details can be found in *(12, 13, 14).*

Figure 1 illustrates the Second Car System's use of ITS technologies. The Second Car System experiment provided an opportunity to introduce new technologies like ITS to Tama New Town District residents as well as to get acquainted with the use of clean propulsion vehicle and ITS technology. In addition, through the development of center-management systems and in-vehicle systems, JSK has developed widely applicable ITS-core-architectures for rental-car/car sharing systems, which effectively promotes ITS technologies *(8).* The ITS systems were utilized in the Second Car System in the following manner.

- **Mobile Phone Communication**

Use of ITS technologies allows the system to communicate through mobile phone communication. Mobile phone communication is a means of communication between vehicle and the operation center through a personal digital cellular phone, using a type of line switching. As for the digital data transmission, the field strength was sometimes too weak to communicate with the center system. Therefore, the in-vehicle cellular phone was used for voice communications as well.

- **Unmanned Rental/Return system**

Unmanned rental/return of vehicles was made possible through an in-vehicle system that has the capability of authenticating a user's identity. Reservation information, which included the position of the station, rental date and time and user information, was sent to the vehicle 10 minutes before the rental started. The vehicle to be used was the one to which the reservation information was transmitted. The authentication of a user's identity was carried out locally using the in-vehicle system, not via the operation center. When the user holds his or her IC card up to the rear window where the reader is installed, the reader detects it. The in-vehicle system checks the IC card data with user information sent from the operation center, authenticating the user's identity, and unlocking the doors and key cylinder in the glove box. The user picks the key from the glove box, starts the ignition and then drives away. During the return operation, the in-vehicle system detects the vehicle being at the original station, and that the user locked the doors using the IC card. The events of trip start and trip return are sent to the operations center system via a cellular phone.

- **Monitoring Vehicles States**

Use of ITS technologies allows the operation center to get the vehicle's state-of-condition, such as the remaining battery charge, as well as the motor and brake operational status every 30 minutes during the rental period. Advanced vehicle monitoring technology and cellular phone installed inside the car made it possible to monitor vehicle status. These data allow the system to intelligently determine the availability of vehicles for other users *(14).*

- **Hands-Free Phone**

While driving, users can communicate with operation center staff using the hands-free phone installed inside the car. When a user pushes the in-vehicle call button, the in-vehicle system sends the vehicle state-of-condition with current vehicle position to the center system by data communication, then changes the mode to the voice communication, and calls the center telephone.

Overview of Second Car System Experiment Results

The overall SCS experiment has altogether five phases starting from September 1999 to February 2002. For the first four months of the initial phase, there were 30 Daihatsu Atray Electric Vehicle provided in Tama New Town residential areas serving 88 members. Later in January 2000, Toyota Motor Company joined the project by sending 20 Toyota e-com to cushion the incremental number of users from 88 to 217. At the time the project was about to enter phase 3, Toyota withdrew from joining and moved all Toyota e-com electric vehicles to another car sharing experiment in Kyoto. Therefore, the Second Car System electric vehicles remained at 30. During this period the number of members declined from 217 to 210. However, this decline made little impact on the system. The Second Car System organization made significant marketing efforts in order to gain new users, which was very successful. The numbers of users increased from 210 to 300 during the fourth phase *(8, 9)*. Users of the system were those who have a private car and those who have no car. The majority of the users were housewives, government officials, office workers, and elderly with age brackets of 26-30, 31-35, 36-40, 4-1-45, 50-60, and

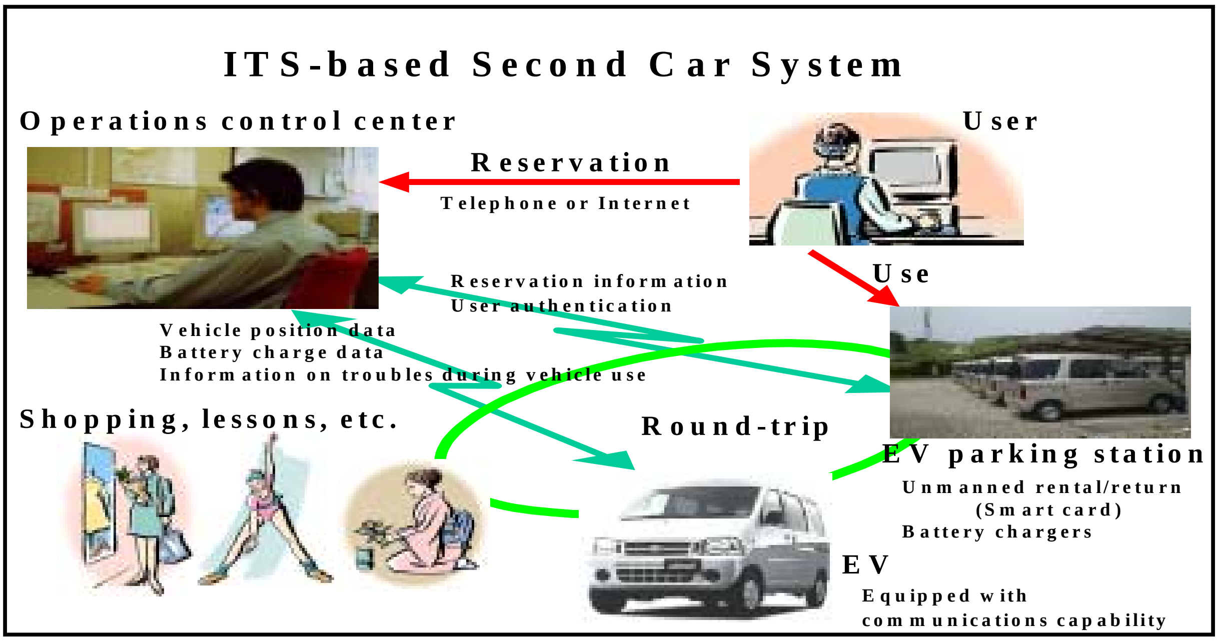

FIGURE 1 Second Car System operation using Intelligent Transportation System

61-higher respectively. A large number of users were in the age bracket of between 36-40. There were eight stations during all phases serving these members, illustrates in Figure 2. A round-trip policy was used in the system to eliminate the need for vehicle relocations. Nevertheless, the number of actual users did not match with the project's expected users. Table 1 below indicates number of real users and expected number of user, vehicles and its ratio, stations and station policy.

Results of the SCS experiment are divided into 2 sections: the first section focuses on survey results during the free-of-charge period (phases 1 to 4), and the second section focuses on the survey results of the charge portion of the experiment (phase 5).

1 Free of Charge Operation Period

Data from vehicle operation and system management were collected between September 2000 and February 2001 (phases 1 to 4). Analysis of the information collected reveals some useful operational aspects of the system, as well as some interesting behaviors associated with the SCS experiment. In terms of the operational aspect, use of the EVs was largely short in both duration and mileage. Average trip mileage driven was approximately 9 km while the average trip time of use was 1.9 hours. Figures 3 and 4 show the mileage and the rental hour distribution, respectively. The data indicate that the limited driving range of the electric vehicles poses no problem for use as a second car in residential areas. Further, it was found that users faithfully observed vehicle return times. 94% of trips were within the reserved mileage plus or minus 5 km. Figure 5 presents the difference between estimated and actual mileage. The system of estimating mileage using landmarks provides sufficient practical accuracy to enable one vehicle to be rented several times a day. As a result, there were no problems caused by insufficient battery charge *(7)*.

With respect to vehicle operating cost, it was found that increasing the number of users per vehicle resulted in an increase in vehicle use rate (the number of times a vehicle is rented per day). See Figure 6 for vehicle operating/use rate and time usage. With an average of 7.7 users per vehicle, the operating/use rate was improved to 1.9. This resulted in significant reduction in the operating cost per vehicle.

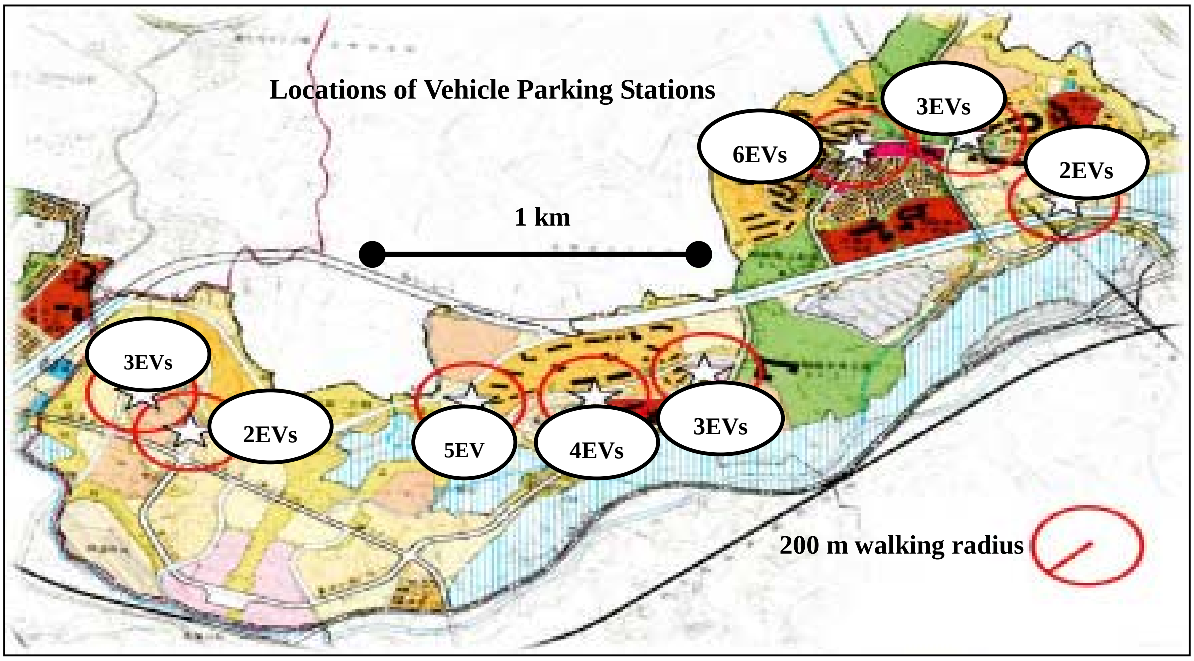

FIGURE 2 Second Car System stations and the distribution of its EV at each station

In terms of operational cost, personnel costs accounted for the majority portion of the total operating cost. To reduce personnel costs, users were required to recharge battery each time they returned a car to a station, and therefore, the EVs were recharged during idle times between rentals. This made a car more readily available for the next user, resulting in more frequent use. The recharge accounted for an increase in reservation acceptance by about 9% while personnel costs were reduced to about half of previous field trial in November 1999 (as shown in the monthly operating cost per vehicle in Figure 7). Thus, the recharge during idle between rentals was very effective *(7)*.

To reduce personnel costs further, a number of measures were taken. Reservations were accepted over the Internet 24-hours a day, reducing the work of handling reservations by telephone and thereby cutting personnel costs. Users were responsible for connecting the inductive battery charge at the end of vehicle use. In addition, users had to perform simple cleaning when the vehicle interior became dirty. This policy was intended to heighten awareness of vehicle sharing and to reduce personnel costs of maintenance work.

During the experiment, several faults occurred in the mobile communication system. Average error occurrence was 0.3 times per day per vehicle. Consequently, operation center staff had to stay until the end of business hours. The cause of the mobile communication errors was investigated and fixed after the field trial. It was found that the error was due to some mobile communication interference, and that the noise from the EV power system had affected the onboard mobile communication unit. By improving the mobile communication system, personnel costs were reduced.

Fees were not collected during the first four phases of the field trial. To avoid a potential monopoly of vehicle use by small number of people, a limit of the rental duration for each user was set to a maximum of four hours per day. However, there was no limit on the number of times a user could use a vehicle. There was also a minimum rental duration, which was initially set to 30 minutes. Later, this minimum rental time was changed to 15 minutes. The rationale for the change was to enable users to reserve and use a vehicle within the desired time and duration. Service was not offered on Sundays and holidays when the availability of a vehicle at home would likely reduce the use of the system. Despite manned business hours were established between 9AM and 6PM, users could use the car earlier from 8AM to 9AM and later from 6PM to 8PM when the operation center was not staffed. The cars were not allowed to use at night time (i.e., after 8PM to 8AM).

TABLE 1 Second Car System operation periods, its vehicles, users, and port system

Descriptions	First phase (September 99)	Second phase (January 00)	Third phase (September 00)	Fourth phase (January 00)	Fifth phase (12/01-2/02)
Number of EVs	30 Daihatsu EV	50 Daihatsu and Toyota EVs	30 Daihatsu EV	30 Daihatsu EV	28 Daihatsu EV
Number of real users	88 users	217 users	210 users	300 users	35 users
Number of expected users	220 users	300 users	600 users	N/A	N/A
Number of stations	8 stations	8 stations	8 stations	8 stations	8 stations
Vehicle usage ratio	2.9/vehicle	4.3 users/vehicle	7.0 users/vehicle	10.0 users/vehicle	1.25 users/vehicle
Fee charged period	None	None	None	None	Charged
System policy	Round-trip only	Round-trip only	Round-trip only	Round-trip only	Round-trip only

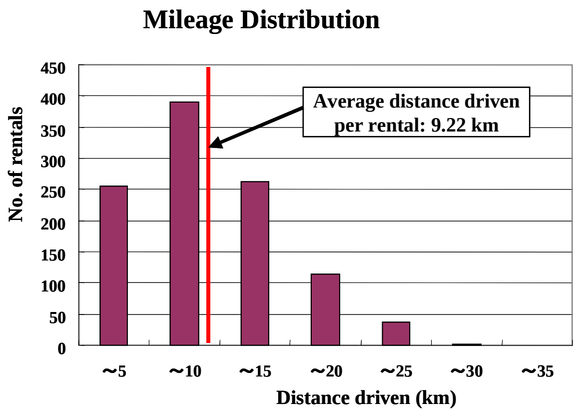

FIGURE 3 Mileage distribution

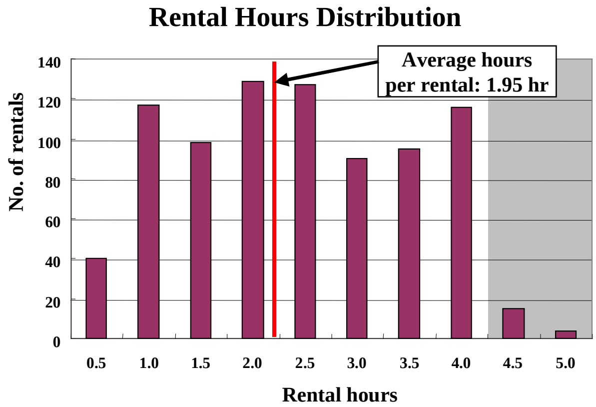

FIGURE 4 Rental hour distribution

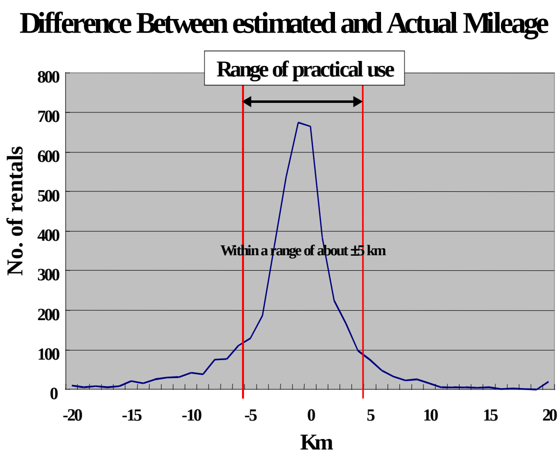

FIGURE 5 Difference between estimated and actual mileage

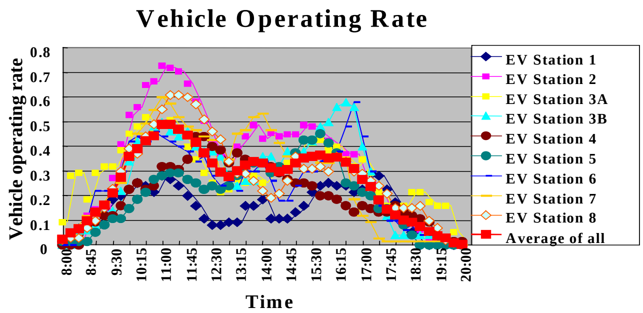

FIGURE 6 Time and vehicle operating/use rate

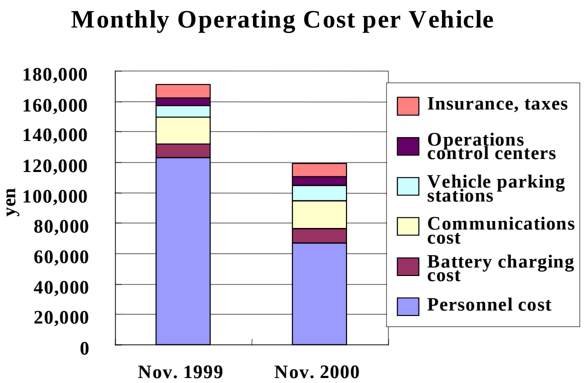

FIGURE 7 Monthly operating cost per vehicle

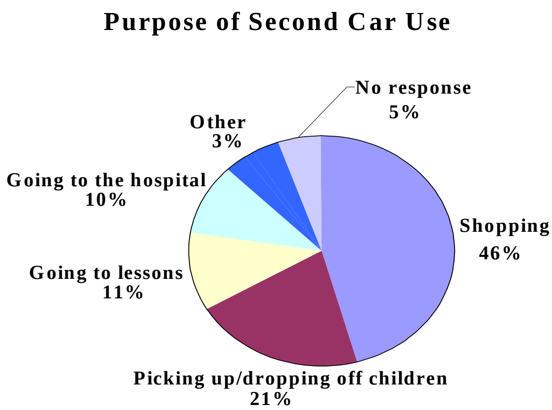

FIGURE 8 Second Car usage purpose

In the data collection process, users were asked about how they used the Second Car System electric vehicles. Figure 8 describes the trip purposes of the system. The trip purposes included shopping (46%), picking up and dropping off husband or children (21%), going to attend some lessons (11%), driving parents to hospital (10%) and others (3%) *(9)*. The SCS field trial provided an opportunity to foster friendship among users. The Second Car System played a very important role in bridging the relationship among users (generally, Japanese would rather respect individual privacy. The communications among residents living in the same area are quite occasional unless they are well-acquainted or friends). Users often discussed how the system worked, how convenient the system was, what they would do if an unexpected problem happened, and what annoyed them the most while using the vehicle and so on. The SCS became the talk of the town, thus the word of mouth became the most powerful tool in marketing the system. The project received overwhelmingly public attention and appreciation with a high level of satisfaction of service features and operation during these free-of-charge phases. As a result, the number of users increased from 210 to 300. Furthermore, most users enjoyed using the Second Car System because it could meet their demand in terms of friendly environment, convenience, and economics. According to the public hearing carried out during phase 1 through 4, the results suggest that the majority of users wished to have their towns designed as a livable city with sustainable transportation; they thought the Second Car System could meet their needs.

2 Fare Collection Operation Period

During the fifth and last phase of the project (November 2001 to February 2002), use of the EVs was no longer free. Sufficient data gathered from the first four phases provided guidance on the fees to charge. As soon as fees were imposed, the number of users drastically dropped from 300 to 20. It was apparent that high technological devices of the SCS experiment had no significant influence to promote use the system. Similarly, the unique features of the system, such as the use of clean, quiet and environmentally friendly vehicles, though well recognized by the users, provided little incentive to continue using the system. Financial or economic reason far outweighed technology and the appeal of environmentally friendly vehicles. The fees had strong impact on users decision not to avail themselves with the second car service. Many reasons were raised as to why people stopped using the system despite there was no unpleasant accident prior to the fee collecting phase. Users who dropped out from using the EVs cited several reasons including complexity of the system, walking distance to second car station was too far and cost of vehicle usage was too expensive. According to data collection and observation from the experiment, there are many additional reasons, which could be linked with the drastic drop of number of users. Some of these are discussed below.

- **No fee was collected from the beginning of the experiment**

Most users expressed that they were not aware that fees would be charged for use of the vehicle later in the field trial. Most would have known this, but chose to ignore it as they thought they would stop using the system once the fees were imposed. Some were upset by the notice that users must have paid for the use of the vehicles. Users questioned why fees were not collected since the beginning of the project. It appears that by not collecting fees at the start had strong negative impact on users. Since the majority of users were housewives, each seed of money coming out from their pocket has its value to spend, particularly for selecting modal choices where their private transport mode is available at disposal. Generally, women are considered a primary caretaker of the household and bear a family obligation. Evidence in the United States shows that women take a greater share of household responsibilities. Of their travel activities, 65% are spent in education-related journeys like taking children to school and approximately 30% for shopping trips *(20)*. This type of activities women take directly influence their travel behavior. Women's travel behavior are far more complex and different from men such as travel distance, the mode of travel and the complexity and purpose of trip making. When trip making occurs, women make more stops to run household errands on both inward and outward commutes, irrespective of the number of persons in a household or its structure *(20)*. Because women are usually responsible for household expenses in Japan, they tend to spend as little money as possible, and to spend it wisely on their purchases including the choice of a transport mode. Paying to use shared vehicle, like the Second Car, would be second or third choice as their own car is still available anytime they need.

- **High vehicle ownership**

The level of car ownership is another critical factor. Vehicle ownership in Inagi City is relatively high for Japan. As of March 1999, the number of registered passenger cars was 6,467 and the number of small compact cars was 12,614. In March 2000, the number of registered passenger cars increased to 7,029 and for small compact car, the number dropped to 12,465. In March 2001, the number of registered passenger cars increased again to 7,641 while the number of small compact cars dropped to 12,232 *(8).* It is important to note that the number of registered vehicle of both types is approximately 75% of the number of households in Inagi City (28,851 households as of August 2002). Surveys conducted before and during the SCS experiment showed that 94% of users owned their car: 82% of the household users had one car, 11% had two cars, 1% had three cars and 6% had no car *(8, 9).* Since the husbands commute to work mainly by train, the chance of leaving car at home is high. Thus, other family members like wives and children can use the vehicle for their travel during the day. Also, a survey conducted with the dropped out users indicated more than 95% of them would rather prefer to use their own car than other transport mode as it is available at home. This could be one of the reasons why the number of Second Car users is less than the expectation. The studies done by European scholars, Harms et al., Shaheen, et al., and Car Cooperative Limited (Car Co-op), car sharing organization in Singapore indicated the very similar fundamental aspects. Car sharing will work well in these following contexts: 1) number of auto ownership is low, 2) car sharing service area should be located near shopping center and/or public transit, and 3) car sharing should provide the ability to connect to public transport / accessibility *(15, 16, 17, 18).* These significantly imply that if the supplier (i.e., car sharing organization: CSO) can provide accessible to products and services, car sharing system can be substituted or replace auto ownership. According to Car Cooperative Limited (Car Co-op), it was reported that car owners at Toh Yi were not interested in the scheme. The report also mentioned that one of the reasons for introducing car sharing system in Toh Yi area was because of the low car ownership rate (only 30.2% which is slightly lower than the national average of 31.1%) *(17).* The major reason of low car ownership rate is that due to land-scarcity in Singapore, and cars are largely unaffordable according to the imposition of restraints such as high taxes and vehicle quotas. This is one of the reasons why car sharing application in Singapore are successful.

- **The service area is less densely populated and has a less densely public transit system**

The SCS experiment appears to support the findings of Harms and others, which described in the “Emergence of a Nation-Wide Carsharing Co-operative in Switzerland,” that car sharing cannot be operated without a sufficiently dense and attractive public transport network. Harm et al. also indicate that in regions where such a network is at disposal, car sharing may establish itself as a complement for a largely public transport oriented mobility lifestyle *(15).* Foo Tuan Seik also explained that many Car Co-op users cited the reason that public transport and car sharing together were adequate substituted for private car ownership. An efficient public transport system, therefore, plays an important complementary role in attracting and maintaining membership *(18).* The opportunity cost of sacrificing the use of the privately owned car is lower when there is good public transport accessibility *(18).* As for Tama New Town, Inagi City area case, it is considered as a new developed residential area (Tama district was agricultural area, until the 1960s; Japan experienced the rapid economic growth forcing to expanded urbanization into the Tama district. Then the Metropolis of Tokyo decided to start constructed the new town in 1968. However, the construction was obstructed by law so called “the law of new house town ground development method,” making the new town became a mere dormitory town and did not have a typical city function. There were no large-scale commercial facilities and the population has not increased because of this inconvenience. In 1986, the law was revised to aim at improving the city functions. As a result, some commercial facilities, cultural center and welfare facilities have been constructed recently) *(1, 2).* The public facilities like hospital, post office, recreational centers and shopping centers were scattered over a wide area with infrequent and inefficient public transports to serve between them. Therefore accessibility to these places requires the use of private transport. As a result, these contribute significantly to a negative impact on the attractiveness of shared-use vehicles in Tama New Town.

- **Walking distance versus time value**

Allan describes the typical walking gait of a normal healthy adult would be about 6 km per hour (i.e. 1.67 meter/second). In unimpeded conditions, this would allow a range of 6 km in an hour; 3 km in 30 minutes; 2 km in 20 minutes; 1 km in 10 minutes; 500 m. in 5 minutes; 100 m in one minute. However, a walker’s speed for a person of average fitness would wane as fatigue begins to set in. Also adverse weather conditions, such as heat or rain, may compromise walking performance *(19).* In comparison with Japan, as a local non-motorized transport modal choice, walking makes reasonable sense in many Australian urban environments for distances up to 2 km (20 minutes) whereas walking distance even less than 500 meters for Japanese is considered far and time consuming to walk. Time is more valuable for Japanese to spend for leisure activities either at home or outdoor than walk even under the fine weather condition (no heat or rain) to get to the station despite it is good exercise. More than 35 percent of dropped out users answered they were willing to walk to the station within 50 meters radius from their residence. However, it can be assumed that regardless of proximity to the station as long as users have their own car at home and can use at disposal, the chance of selecting shared-use vehicles as another mode is relatively low, unless it is free of charge.

- **System complication**

Before using the system, each new user had to attend an orientation and learn how to operate the system and how to use the EV. This was done to eliminate possible misuse of the vehicle. For example, training was provided on making a reservation, using the IC (integrated circuit) card to unlock and lock the car, starting the engine, plugging and unplugging the inductive battery charger each time they return the car, performing cleaning when the car interior is dirty, and using hand-free phone to communicate with operation center for the case of emergency. The Second Car System, like many EV-sharing in Japan, equipped electric vehicles with ITS and other advanced technologies like GPS and car navigation systems. Deploying these technological devices have significantly contributed to receiving useful information for designing/managing and improving future experiments such as real time traffic and en-route driver information, located position of vehicle while being rented and measuring vehicle miles traveled (VMT). The data collected from the experiment suggest that the unique features of the EVs, including ITS and other advanced technologies like GPS and car navigation system, seem to be more attractive and challenging to men than women. Women seem to like a system that is much simpler to operate. In addition, users who stopped using the system stated that their participation in the program was mainly due to environmental concern, particularly when the vehicles were free of charge. Therefore, using new technology may sometimes not imply the system is the overwhelming attractive feature to users.

- **Fee readjustment period**

When the number of users drastically dropped after the fees were charged, organizers readjusted the package (fee). This readjustment resulted in a modest increase from 20 to 35 partcipants. Some were users from the first phase, some were users during the midpoint of the experiment, and some were recruited after adjusting the fee. There were 3 packages users could select: (1) Package A consisted of Yen 3000 monthly charge and Yen 100 per 15 minutes time charge, (2) Package B consisted of Yen 1000 monthly charge and Yen 200 per 15 minutes time charge, and (3) Package C consisted of Yen 6000 monthly charge with no time charge.

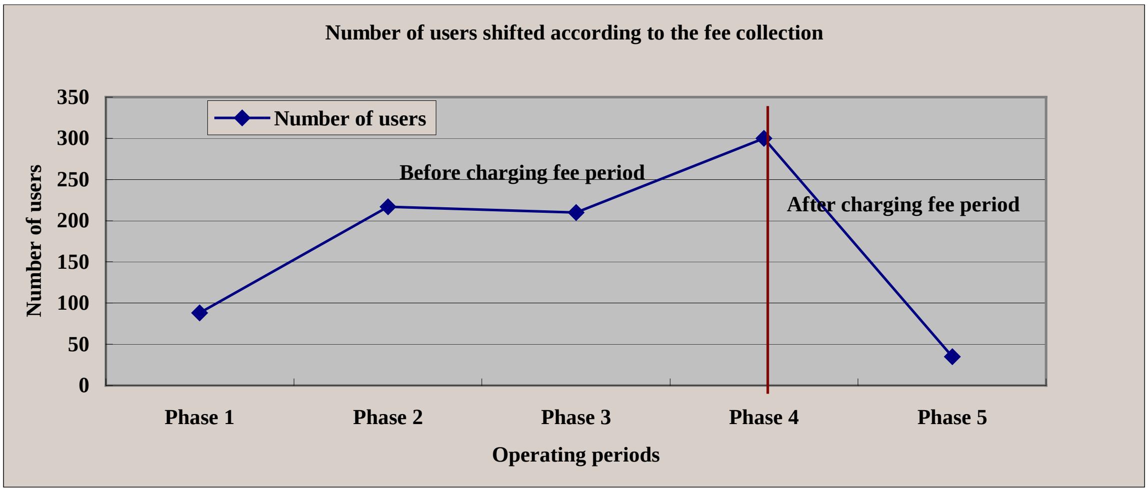

FIGURE 9 Number of users shifted according to the fee collection

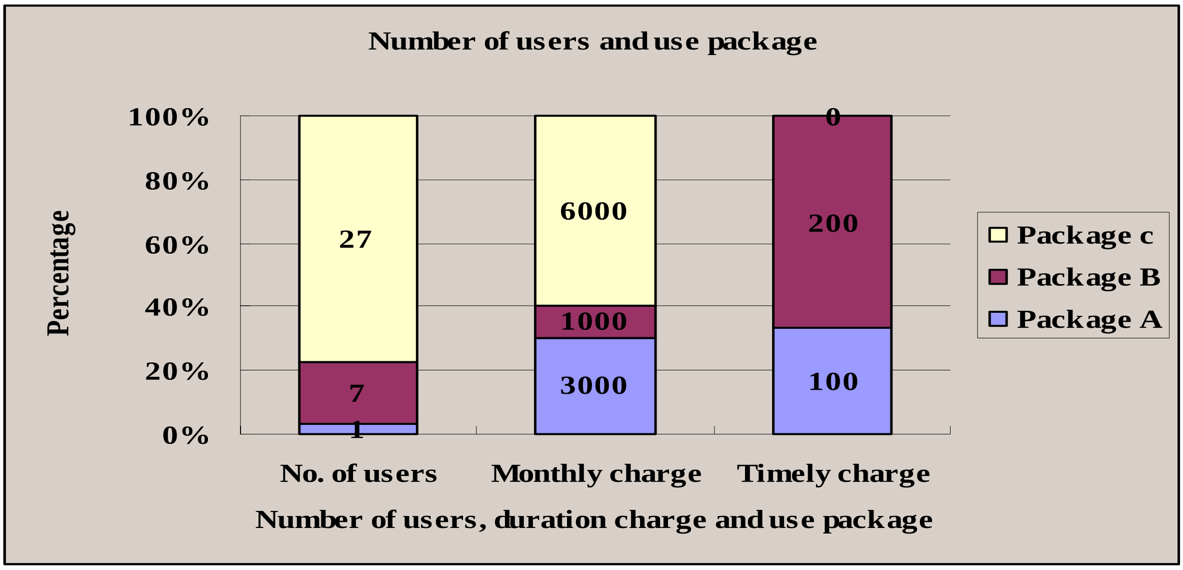

FIGURE 10 Number of users and use packages

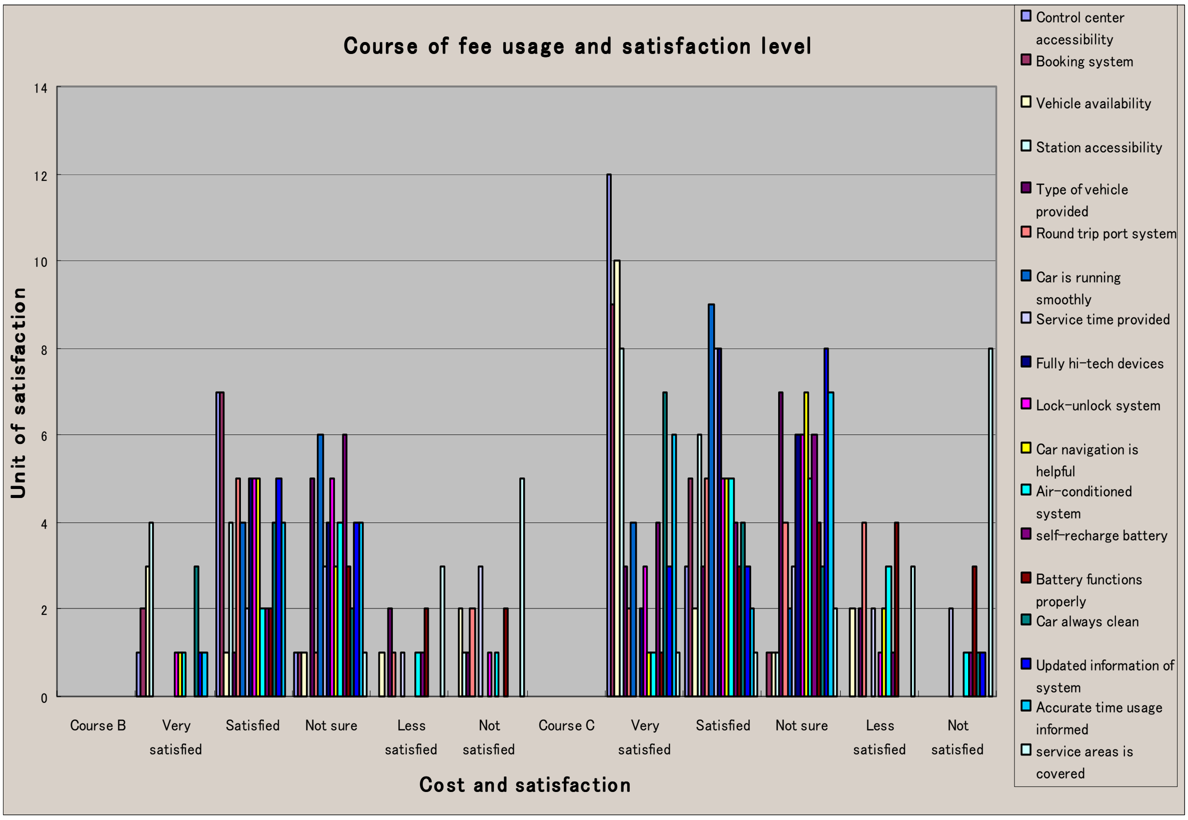

FIGURE 11 Level of satisfaction and fee /usepackage

Figure 10 shows the relationship between the number of users and usage of packages. It appears that users prefer package C. However, this information came to light one month before the project ended. The result shows that most of the users were very satisfied with: 1) operation control center accessibility, 2) vehicle availability, 3) booking system, 4) station accessibility, and 5) car cleanliness. The vehicle state-of-condition such car running smoothly and quietly, and hi-tech devices in vehicle was satisfied. There was strongly requested to extend the project since some were already starting to sell their own cars. Some demanded to expand the service areas. The most dissatisfactory service was the second car service areas were not adequately covered. Figure 11 indicates level of satisfaction of each function in the system with fee usage.

The convenience, security, symbolic status, and easy accessible of private vehicle which brings live-in comfort still plays a very significant role in human desire and society. Despite the fact that electric vehicle sharing is a sustainable transportation mode that helps support livable cities, there are still a few numbers of people concerned about car sharing. Many European scholars and Shaheen et al. indicate one of the factors that led to the success of car sharing organizations is a highly environmental consciousness among users *(16)*. This may be true but it used to be another alternative choice to select using mode rather than cost of usage per se. Therefore, the promotion of environmental awareness among the public should be done through the use of shared-used vehicle system. The Second Car System was relatively successful in terms of gaining data in two aspects: SCS operational management and user travel pattern and user travel behavior. These data are essential to determine what system function in SCS has to be developed or improved upon for future SCS operations.

Conclusion and Future Work

Many EV-sharing experiments have been implemented in Japan to evaluate the feasibility of commercializing such a system. However, none of them has yet come up with satisfactory commercial viability. Most experiments such as Eco-Park and Ride in Ebina City, Public Car System in Kyoto, Car-Sharing in Yakushima, except City Car System project in Yokohama, are terminated due possibly to budget limitation and insufficient recruitment of users to compensate monthly operating cost of the system. Also, most of car sharing projects have experienced in the decline of users after fees were imposed. The Second Car System (SCS) field trial in Tama New Town had a similar experience. However, the fact that SCS ended the experiment in February, 2002, does not imply the failure in operation but only unable to persist holding the project according to the termination of financial support. The stakeholders such as Mobility agencies, telecommunication organizations were reluctant to continue supporting the experiment as they claimed the project had very little number of users. Therefore, it was too soon to draw a conclusion whether the project was commercialized viable.

Nevertheless, the Tama New Town case had a high probability of recruiting more participants if the project was prolonged. As was seen that after fees were adjusted, the number of users gradually increased. Despite lower than expected use of the system, particularly after fees were imposed, results from a public hearing carried out one month before the project end indicated that most users were greatly satisfied with the service. There was a strong support to extend the trial period as some users have already started selling their own car. Some suggested to expand the service areas to enhance the attractiveness of the system.

Deploying ITS technologies with electric vehicle sharing to facilitate operation allowed operation center to receive real time information while vehicles were being rented and also allowed both the operation center and users to communicate through in-vehicle/mobile communication system effectively. The experiment shows that the EV-sharing with ITS systems performed properly and efficiently. Advanced technological systems can be one of the marketing strategies that lead to successfully attracting people to become members of the system. This perception did not pan out with the Second Car System, particularly with the users that dropped out. It can be said that since the major number of users are housewives, their interests and appreciations of acquiring these technological devices was rather low in comparison with male users. However, this situation can be improved by simplifying and reducing some functions that are less necessary. It was also suggested to create a simple and understandable sign in the vehicle so that users feel more comfortable when using the equipment without fearing of damaging the system. The experiment gained a significant amount of valuable information and experience for EV-sharing with ITS application, which can help contribute significantly to future trials. Specific elements may include: 1) setting proper condition and readjusting fare appropriately; 2) demonstration of cost effective operational methods based in cooperation with local government and the public; 3) redesign of the center-management system; 4) improvement of car sharing system and development of low-cost in-vehicle System; 5.) informing the availability of vehicles for other users; and 6) informing real time traffic information, vehicle miles of travel, and en-route driver information.

Despite issues of vehicle ownership and public transit having a strong influence on shared-use vehicles, the system was very attractive to those who do not own cars and those who have a car but is not available when needed.

Also, special attention should be paid on the drastic drop of users after fees were imposed. The SCS project proved the importance of charging users from the beginning. The drastic drop in the number of users entailed the policy implication for future experiments that fees should be charged at the time the service begins so that the cost of using the vehicle is more realistic to users and, therefore, will not distort users decision making. It should also be discussed or studied more about women travel behavior. As the number of female drivers increase every year in Japan, the tendency of becoming a public transport feeder like car sharing can be made practical. As far as safety and comfort are concerned, women travel preferences tend to be focused on relatively short distances with many stops on the way home (picking up children, going shopping, etc.). Women, as a mother and/or wife, may spend money carefully on any purchase, particularly, if they think it is cost effective. Car sharing is another alternative modal choice that can fulfill this niche.

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