Framework for Testing Innovative Transportation Solutions

Case Study of CarLink, a Commuter Carsharing Program

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Transit accounts for just 2% of total travel in the United States. One reason for low ridership is limited access; many individuals either live or work too far from a transit station to make its use practical. In developing transit connectivity solutions, researchers often employ a range of study instruments, such as stated-preference surveys, focus groups, and pilot programs. To gain better understanding of response to one innovative transit solution, several research tools were applied, including a longitudinal survey, a field test, and a pilot program. The innovation examined was a commuter carsharing model, called CarLink, which linked short-term rental vehicles to transit and employment centers. Over several years, researchers explored user response to the CarLink concept, a field operational test (CarLink I), a pilot program (CarLink II), and a commercial operation (the pilot was turned over to Flexcar in summer 2002). This multistage approach provided an opportunity for researchers to learn and adapt as each phase progressed. In this paper, the authors outline the CarLink model, technology, and early lessons learned; describe CarLink II operational understanding; provide a synopsis of the pilot program transition; and offer recommendations for future model development.

Although public transportation use is growing in the United States, it still accounts for only 3% of total travel (*1*). In the San Francisco Bay Area, in California, where there is an extensive public transportation network, transit use is higher: in 2002, 12% of commuters used public transportation (*1*). Congestion, coupled with continuing air pollution, requires the examination of more demand-responsive alternatives. According to a nationwide report conducted in 2000, the San Francisco Bay Area averaged 92 h of delay per person per year during peak commute hours (*2*). Not surprisingly, transit access is a major impediment to use; transit capacity often exceeds the number of people living or working within walking distance—¼ mi or less—of a station. If existing access methods are augmented (ranging from traditional fixed-route to demand-responsive transit), more individuals could use transit. Increased transit access would assist in reducing congestion during peak travel periods, while also improving overall system efficiency.

Designing innovative solutions that increase transit access and ridership is challenging. This is especially true in the context of altering long-term travel behaviors, particularly use of single-occupancy vehicles. Furthermore, individuals are reluctant to try unfamiliar ideas, new technologies, or both. Understanding how to change long-held travel patterns is one of the greatest challenges transportation professionals face.

Many complex issues are associated with testing and implementing transportation innovations. Significant data about an innovation's impacts are typically needed to justify large-scale deployment costs. There are several methods for gathering these data, such as simulation modeling, stated-preference surveys, and controlled testing. As confirmed by CarLink I, much can be learned from testing a transportation innovation in a real-world setting (*3*). Field tests and pilot programs provide a framework for investigating complex relationships among system efficiency, user acceptance and impacts, economic viability, and other operational issues.

Usually, field tests operate for a predetermined length of time to evaluate a new concept or technology. In contrast, pilot programs can extend beyond this initial proof-of-concept phase by focusing on program sustainability. Whether one is instituting a new concept, technology, or regulatory framework, pilot programs can be beneficial to decision makers and participants. Pilots enable new ideas to be tested, modified, and assessed with limited financial risk and no ongoing obligation. At the same time, they can support program continuation and offer a cost-effective alternative to exploring transportation innovations.

From July 1, 2001, to June 30, 2002, a carsharing pilot program emphasizing transit and employer access—CarLink II—was deployed in the San Francisco Bay Area. Objectives of the pilot program included testing an advanced carsharing system, understanding user response, and testing long-term sustainability. This paper examines the CarLink technology, participant response, and lessons learned from the multistage initiative. First, there is a review of the CarLink model, technologies, and early lessons learned. Second, CarLink II operational findings are examined. Third, a synopsis of the pilot program transition to a permanent service is discussed. Finally, the conclusion covers opportunities for improving carsharing deployment initiatives, which are based on the findings.

CARLINK PROGRAM AND RESEARCH OVERVIEW

Between 1998 and 2003, researchers deployed a three-phase carsharing research program in the San Francisco Bay Area. It was CarLink, in conjunction with the California Department of Transportation (Caltrans), American Honda Motor Company, the Bay Area Rapid Transit (BART) District, Caltrain, and Lawrence Livermore National

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Transportation Research Record: Journal of the Transportation Research Board, No. 1927, Transportation Research Board of the National Academies, Washington, D.C., 2005, pp. 149–157.

Laboratory (LLNL). During the first phase, researchers conducted a longitudinal survey that examined CarLink concept response (*4*). During the second phase, researchers assessed CarLink I—a demonstration that examined user response and operations in a controlled setting. CarLink I was based at the Dublin–Pleasanton BART station and operated for 10 months during 1999 (*3*). In the final phase, researchers examined the CarLink II pilot program, which ran from July 1, 2001, through June 30, 2002, and was based at the California Avenue Caltrain station in Palo Alto. The research goals of this pilot project included testing advanced carsharing technologies, overall user response, and economic sustainability.

Broadly defined, carsharing allows a group of individuals to share a vehicle fleet and pay for use on the basis of time and miles traveled. The most common model is known as neighborhood carsharing, in which a few vehicles are deployed in several neighborhoods for easy access by members. Those vehicles are accessed from and returned to the same lot. CarLink tested a commuter carsharing model that provided vehicle access at home and work, as well as a transit linkage on either end of a commute. This section includes a brief overview of the CarLink model, differences between CarLink I and II, and program pricing.

Brief Overview of CarLink Model

Both CarLink I and II were based on the same commuter carsharing structure involving three sets of members: home-based users, work-based commuters, and day users. Both CarLink programs included a single, primary transit station that served as a vehicle transfer point for work-based commuters and home-based users who commuted via transit. CarLink provided a convenient transit linkage to and from home and work via a shared-use vehicle fleet. Households and employers also shared that same fleet for trip making on evenings and weekends, and throughout the workday.

During CarLink I, home-based users would drive their CarLink vehicles to a selected transit station each morning, park the cars in a designated CarLink space, and ride transit to work. Next, work-based commuters would arrive at the same station via train in the morning, pick up CarLink cars, and drive them to work, parking in designated CarLink spaces at their office. Throughout the day, day users could reserve CarLink vehicles for business and personal errands, returning the cars to a designated work lot after each trip. At the end of the workday, work-based commuters drove the CarLink vehicles back to the transit station and took the train for the remainder of their trips home. After home-based users—riding the train for the majority of their commute home—returned to the transit station, they would pick up CarLink vehicles and drive them home for personal use on evenings and weekends.

As mentioned, CarLink II is based on the same general model as for CarLink I. However, lessons gleaned from user feedback and recommendations from the CarLink I staff and project partners suggested several changes to improve the model and research focus. Overall, it was decided that more could be learned by adapting the model to a new setting and attempting to create a permanent enterprise. This section describes the CarLink II project components and how they differ from CarLink I (see Table 1).

CarLink Economics

Both CarLink I and II required members or their employers to pay for vehicle use. Lessons learned from carsharing programs in Japan informed this design decision. In Japan, programs lost participants when fees were implemented for services that had initially been provided for free (*5*). Thus, CarLink fees were required to test its economic value. For members, fees covered all operational and vehicle maintenance costs, including fuel and insurance.

The fee structure was determined by a literature review, focus groups, employer discussions, and estimates of operationing costs. The fee structure was below market value for both CarLink I and II, for this was a new concept, and users contributed to the research. Participants provided feedback on the program and technology, including participating in surveys, focus groups, and interviews.

As mentioned earlier, CarLink I and II consisted of three user groups: home-based users, work-based commuters, and day users. Home-based members paid a monthly fee for car use to commute to and from the station and on evenings and weekends. CarLink I home-based users paid $200/month, and CarLink II home-based users paid $300/month. The payment structure for CarLink I and II differed for the work-based commuter and day-use portions of the model. In CarLink I, employees paid a flat work-based commuter fee ($60/month/car) as well as usage fees ($1.50/h and $0.10/mi) for their personal CarLink vehicle use during the workday. Employers paid for work-related trips. As part of CarLink II, the model was adapted slightly. Under the new structure, employers paid a flat fee of $350/month per car, which covered both the work-based commuter and day-use components. Employers joined CarLink II to provide the service as an employee benefit. Potential benefits included the following:

- Promoting employee retention,
- Reducing office parking demand,
- Encouraging transit use, and
- Substituting a costly fleet with CarLink in some cases.

EARLY LESSONS LEARNED

The CarLink longitudinal survey and CarLink I field test were designed to test the commuter carsharing concept. Proof of the concept was the primary goal of CarLink I. Implemented as a demonstration, CarLink I ceased operations at the close of the research project in late 1999. In contrast, CarLink II was a pilot program designed to test integrated carsharing technology and long-term sustainability. Pilots allow for a more realistic evaluation of user response because members understand that the program may become permanent. For instance, a member might sell a car if he or she believes the program will continue. This section provides an overview of CarLink longitudinal survey findings and CarLink I field test results, which informed the design of CarLink II.

CarLink Longitudinal Survey

From June to October 1998, researchers collected response data on the CarLink concept from 302 individuals (representing 212 households) in the San Francisco Bay Area. Those attitudinal and belief data measured the change in response, which helped to explain the innovation adoption process. The survey consisted of an initial survey and three questionnaires that followed each of the informational media developed to explain the CarLink concept: an informational brochure; video; and interactive trial drive clinic with compressed natural gas (CNG) Honda Civics, smart cards, and a smart carsharing key management kiosk. An experimental group and a control group

TABLE 1 Differences Between CarLink I and CarLink II

Study Characteristic	Carlink I	Carlink II
Number of vehicles	12 vehicles.	19 vehicles.
Primary transit partner	BART District.	Caltrain.
Transit station location	Dublin–Pleasanton.	Palo Alto.
Vehicle type	Compressed natural gas Honda Civics.	Ultra-low-emission Honda Civics.
Home-based users	Up to 10 households pay $200 per month.	Up to 16 households pay $300 per month.
Work-based commuters	Up to 20 LLNL employees pay $60 per carpool ($30 each).	Up to 63 employees of businesses at Stanford Research Park (primarily), share CarLink vehicles to carpool to/from work. Businesses pay $350 per month per vehicle (a combined fee) for work-based commuter and day-use services (in contrast to employees paying for this service independently as in CarLink I).
Day users	Employees of LLNL pay $1.50 per hour and $.10 per mile.	Up to 28 employees of Stanford Research Park companies and other nearby businesses have access to vehicles for business and personal use. Employers pay $350 per vehicle per month to subscribe to the combined work-based commuter and day-use services.
Total users	54.	107.
Employer	One: LLNL.	Six: Several private companies at/nearby Stanford Research Park.
Technology	In-vehicle tracking, smart key kiosk at transit station, smart cards, manual key boxes at LLNL, and online scheduling system at LLNL.	In-vehicle tracking, automated data collection, smart key fob (or smart card) entry, PIN-based vehicle login, online reservations, and in-vehicle navigation system.
Program length	Field test designed for limited 10-month duration.	Pilot program with planned transition to ongoing carsharing service.
Research goals	Document demand for commuter carsharing service and gauge user satisfaction and needs.	Continued analysis of commuter carsharing (in a new setting) with greater statistical confidence (a greater sample size) and new emphasis on technology testing, its impact on cost reduction, and longer-term program sustainability.

were recruited for the study to evaluate informational media impacts on CarLink response. Communication objectives emphasized the disadvantages of current modes, advantages and disadvantages of carsharing, and how the CarLink system works.

Participating households, for both the longitudinal survey and the CarLink I field test, included four groups:

1. Current BART commuters,
2. Individuals who might use BART when carsharing becomes available,
3. People who do not usually take transit but could take it to work, and
4. Individuals who live in neighborhoods with substantial BART ridership.

These groups represented potential CarLink participants.

The final sample population consisted of 207 experimental participants (154 households) and 95 control group participants (58 households). A total of 488 individuals (both experimental and control) received the initial questionnaire. Throughout this study, there were 186 dropouts (58 did not return the first questionnaire, and 128 individuals dropped out after returning the second questionnaire). After the survey was completed, four focus groups were held in October 1998, to further gauge participant perceptions and overall concept response. The focus groups consisted of three experimental groups with a total of 28 participants and one control group session with 9 participants.

Researchers found that CarLink response was influenced by the amount and type of exposure to the concept, as predicted by social marketing and learning theories (*4*). Specifically, participants who only read the CarLink brochure lost interest over time (interest dropped from 45% at the time of the initial questionnaire to 33% during the final questionnaire), while nearly 78% of those who read the brochure, watched the CarLink video, and participated in the drive clinic reported that they would use CarLink as part of the final questionnaire. In fact, many indicated that they would be interested in joining the CarLink I field test (54% of the experimental group in contrast to 33% of the control) in the final questionnaire.

At the drive clinic, held in September 1998, participants used a smart card to access a CarLink vehicle and released the immobilizer, which blocked unauthorized users from starting the car. They took a test drive, accompanied by a researcher who documented their observations, questions, and concerns. The drive clinic offered participants a chance to see and try new technologies, as well as to interact with researchers. Each participant completed a 20-min exit interview on his or her response to the CarLink system and willingness to participate in such a service.

During the exit interview, over 90% of participants responded yes when asked if they would use CarLink. As a result of the clinic, there was a 21% increase in the yes response category. Because control group respondents did not participate in the clinic, there are no corresponding data for them. Thus, it appears that the drive clinic was an effective tool for increasing positive awareness of the concept. Nevertheless, the response appears to be overstated, for there was a 13% decrease (from the exit interview) in the experimental group's response during the final questionnaire.

The CarLink program built on the longitudinal survey in three ways. First, researchers included 32 longitudinal survey participants in the CarLink I field test (15% of the experimental population). Second, understanding about the value of multiple informational media was integrated into CarLink recruitment strategies. Finally, a trial offer was added to the CarLink II program, based on the drive clinic's success.

CarLink I

The CarLink I field test provided an exploratory test bed for this carsharing model. During the field test, many lessons were learned and success factors identified (*3*). Shortly after the CarLink longitudinal survey was completed, researchers contacted individuals who indicated that they would be interested in participating in the CarLink I field test. Individuals were able to enroll in CarLink I, if they had a match with one or more of the following requirements, including these:

1. Home-based commuter use—those who could use the Dublin–Pleasanton BART station to commute to work;
2. Work-based commuter use—individuals who work at LLNL and could commute via BART; and
3. Day use—those who work at LLNL.

Researchers were unable to enroll individuals who did not match one of these user groups. Given the restrictive participation requirements, a majority of interested individuals did not meet the program criteria. Interestingly, no one from the control group joined the field test. Thirty-two individuals, who requested to be contacted about field test participation, became members (15% of the total experimental population). These individuals (longitudinal survey participants) represent 60% of the field test population. Twenty additional individuals joined the field test (who did not participate in the longitudinal survey), primarily in the home-based user and work-based commuter categories.

The field test was deployed in the Dublin–Pleasanton region from January to November 1999. As part of the CarLink I evaluation, several participant feedback tools were employed, including questionnaires, household interviews, and focus groups. A high percentage of users agreed to participate in the study (73% response rate). The program enrolled 54 participants throughout the 10-month field test, with 38 active participants. Active participants drove the vehicles frequently, whereas inactive members did not use the CarLink vehicles, even though they enrolled in the program. The participant pool was limited due to the short project duration, startup delays, and limited CNG infrastructure (*3*).

The CarLink II pilot program built on six key operational lessons learned from CarLink I:

1. Streamlining technology. Several technology shortcomings (key management and vehicle tracking systems) contributed to delays and necessitated program modification. Technology should be integrated and customized to facilitate carsharing use. A standalone smart card approach should be developed and tested, in which fixed key box lots (typically sections of parking lots that have a key box in them) are not needed. In this way, participants could access vehicles with smart cards alone.
2. Limited CNG infrastructure. During CarLink I, two CNG issues constrained operations: a limited number of CNG refueling sites and slow CNG refueling pumps at LLNL. The CNG component of CarLink I restricted vehicle range and participation. Also, users did not refuel vehicles as frequently as agreed. Use of CNG vehicles in CarLink I distracted from the shared-use vehicle evaluation. In the future, this model should be tested with internal combustion engine vehicles and fuel cards.
3. Guaranteed parking. Guaranteed parking at the Dublin–Pleasanton BART station was a huge program incentive, because parking at that station filled up before 7 a.m. at the time of the project. In the future, carsharing programs should be sited at locations where parking is costly or limited, or both.
4. Vehicle cleanliness. During CarLink I, operations staff and participants cleaned and washed cars. Nevertheless, vehicle cleanliness continued to be a chronic issue for the program. There should be consideration of hiring a third party to clean vehicles more frequently.
5. Employer participation. Day-use participation in CarLink I was limited. In the future, there should be testing of an employer-focused carsharing service, with multiple companies located in a congested corridor where there are transit access and parking constraints.
6. Program duration. CarLink I was a limited demonstration project (10 months), which restricted understanding of user adoption and behavior because of its brief time frame. In the future, there should be deployment of CarLink as a pilot program with the potential to transition to an ongoing operation after the research phase ends.

CARLINK II USER AND OPERATIONAL UNDERSTANDING

During the CarLink I field test, the primary goal was narrowly defined: It was to study user response to the commuter carsharing concept. In CarLink II, the research goals were broadened to evaluate long-term program sustainability and to test integrated carsharing technology. The California Avenue Caltrain station in Palo Alto was selected as the CarLink II transit hub after evaluating a number of potential locations. The criteria for site selection were as follows:

1. Located near a congested corridor,
2. Significant number of commuters traveling to and from the station,

3. Concentration of employers near transit station (within 5 to 10 mi of station),
4. Supportive transit operator,
5. Limited bus or shuttle services,
6. Transit parking at capacity, and
7. Local governmental project support.

All sites evaluated for CarLink II had freeway congestion in both directions and commuters traveling to and from the transit hub. Other locations evaluated included Santa Clara and San Mateo Counties, San Jose, and the Dublin–Pleasanton area. On the basis of the foregoing criteria, Palo Alto was selected as the preferred location. The following section includes an overview of CarLink II user satisfaction and operational lessons learned.

CarLink II User Satisfaction

A total of 107 individuals participated in the CarLink II program: 16 home-based users, 28 day users, and 63 work-based commuters and day users. Of the participants, 53% were female, and 47% were male. Sixty-four respondents completed the final questionnaire (60% response rate). Respondents included 9 home-based users, 21 day users, and 34 work-based commuters.

Technology was a major aspect of CarLink II operations, for it facilitated user convenience, management tools, and program expansion. The CarLink II technology included an in-vehicle navigation system for trip routing, refueling cards for maximum flexibility, and reservation system for day use. Figure 1 provides user satisfaction data on four key program areas surveyed at the end of the pilot: (*a*) in-vehicle navigation system, (*b*) vehicle access, (*c*) refueling, and (*d*) reservation system. Following are details.

In-Vehicle Navigation System

This system allowed users to route their trips and receive visual and voice instruction. It was not a program requirement but an additional feature that provided convenience for some trips. Many did not use it regularly, because their trips from the train to home or work were identical each day. While 13% never used the system, more than 50% reported that the system was very satisfying or satisfying to use. It is interesting to note that system use increased during the second half of the pilot, particularly among home-based users.

Vehicle Access

"Vehicle access" is defined as unlocking the car with a key fob and logging into the CarLink II computerized system with a personal identification number (PIN), which released the ignition immobilizer and attributed trip activity to the user's ID number. Ninety-two percent of users were satisfied with vehicle access at the program's midpoint. By the end of the program, only 60% were satisfied or very satisfied, and more than 15% were dissatisfied with the system. Home-based users were the most frustrated by the length of time the fob took to unlock the vehicle (3 s), and they believed that the location of the smart key reader (rear windshield) was inconvenient if they were holding a child, groceries, and so on.

Refueling

CarLink II vehicles each included a fuel card and a PIN associated with each user. This system allowed individuals to refuel the cars at their convenience at local stations. Members were required to refuel a vehicle if the fuel level fell below ¼ tank, or a $10 fine was imposed. At the end of the pilot, 60% reported that they were very satisfied or satisfied with refueling, and only 7% were dissatisfied or very dissatisfied. Throughout the program, participants indicated that the vehicles were sufficiently fueled, although that was not always the case. Home-based users tended to fuel more frequently, because they used the cars more often and for longer trips. Users also indicated that incentives for individuals who frequently refueled the vehicles (e.g., coupons for free coffee, videos) would have provided more motivation for refueling consistently.

Reservation System

The reservation system allowed day users to reserve vehicles from any computer from 15 min to 1 month in advance of appointments. Typically, each employer set aside one vehicle that could not be reserved in advance, to provide a system buffer. Because the reservation and access systems did not provide a lockout component (preventing one member from taking a vehicle reserved by another), members were entirely using an honor system. A lockout system linked to the reservation system would have reduced unauthorized vehicle use.

At the end of the pilot, nearly 44% of respondents were satisfied, and approximately 10% were dissatisfied with the reservation system.

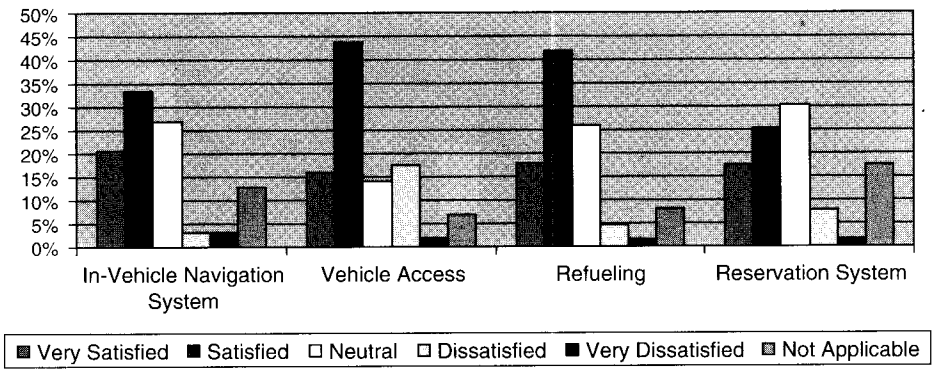

FIGURE 1 Satisfaction with CarLink II features, final results of survey.

However, during interim program interviews, 28% were dissatisfied with the system. That change likely reflects satisfaction with reservation system improvements made during the remainder of the program.

The primary reason for reservation system dissatisfaction was the lack of a lockout system—guaranteeing that a reserved vehicle would be waiting for the individual that requested it. Vehicle lockout was identified as an area for next generation technology development, for it was not addressed during the CarLink II pilot due to cost and time constraints.

Other reservation system concerns involved the overall reservation process and website format, including the following:

- Scrolling on the web page was difficult.
- There were too many steps involved in making a reservation.
- All cars should be available to reserve in advance (no unassigned vehicles).
- The clock on the reservation page was not always accurate.
- There was no way to inform the reservation system directly (e.g., automated phone interface) that a day-use trip was running longer than expected. Instead, users had to ask CarLink II staff to check the reservation's page and notify the next scheduled user.

Despite reservation difficulties, many participants who were vocal about that aspect seldom, if ever, experienced a problem. However, the perception that a reserved vehicle might not be available became so dominant that many saw it as their most critical CarLink II concern.

In addition to technology, it was found that CarLink II staff, transit costs, and member coordination were important elements to gauge user satisfaction. Figure 2 provides a summary of final questionnaire response to various program features.

CarLink Staff

A substantial amount of staff time was dedicated to responding to member issues. Of those who responded to the final questionnaire, 39% were very satisfied, and 45% were satisfied with the CarLink II staff. No respondents were dissatisfied or very dissatisfied. During the interim program interviews, participants also expressed satisfaction with CarLink II staff; 68% of those responding were very satisfied with CarLink II operations personnel. Members reported that CarLink II staff responded very quickly when problems arose and kept them well informed of relevant issues.

Transit Costs

Transit costs (primarily Caltrain) varied for individual members. All CarLink II member companies contributed to the transit fares of their employees. Findings through the final questionnaire were that 19% of respondents were very satisfied, 47% were satisfied, and only 5% were dissatisfied with their transit costs. Of the respondents, 10% answered that the transit costs were not applicable, because many day users carpooled, vanpooled, bicycled, or walked to work.

Member Coordination

CarLink II required all members to coordinate with one another to ensure that vehicles reached designated locations at required times (e.g., Caltrain during morning and afternoon commute peaks). In addition, work-based commuters carpooled from the train station to their employment location and back again. Initially, a significant effort went into schedule coordination by CarLink II staff. Approximately 8% of respondents were very satisfied, and 38% were satisfied with that process. Of the respondents, 35% were neutral, indicating that the majority of participants adjusted easily to schedule coordination. It is important to note that scheduling flexibility was accommodated with additional (or reserve) vehicles in the CarLink II fleet. While these vehicles were rarely used, they provided members with additional confidence that a vehicle would be available when needed, affording greater flexibility with arrival times, and resulting in reduced vehicle coordination by staff. In the pilot research phase, it was decided to provide those vehicles to accommodate growth and to understand the impact of additional cars on service flexibility. The maintenance and operation of additional fleet vehicles add to the overall cost of a carsharing program. To reduce costs after the transition to Flexcar—the private third-party operator—the number of reserve vehicles was reduced.

Lessons Learned from CarLink II Operations

Similar to the experience with CarLink I, numerous lessons were gleaned from CarLink II operations. CarLink participants were exposed to a number of new concepts and technologies simultaneously; thus, it is difficult to identify the interaction among the individual components. Issues ranging from parking to participant recruitment and retention are described in the following paragraphs.

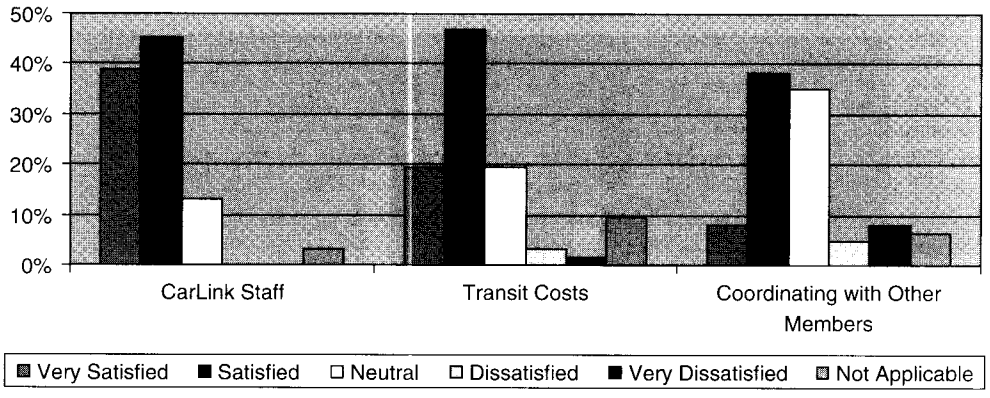

FIGURE 2 Satisfaction with other CarLink II features, final results of survey.

Parking Impacts

Because CarLink II was a pilot program, strong emphasis was placed on business membership, which could continue beyond the pilot phase. The Stanford Research Park (consisting of 150 companies, located between 1 and 5 mi of the California Avenue Caltrain station) viewed the carsharing service as an employee benefit. Building on a principal CarLink I success factor, there was emphasis on locations with limited parking during the CarLink II site selection process in early 2000. At that time, the parking lot at the California Avenue Caltrain station was close to 90% capacity. However, because of the subsequent economic downturn, lot utilization decreased to less than 60% by the end of CarLink II (July 2002). That change in parking had an impact on program recruitment, because guaranteed parking is a significant incentive to carsharing use, particularly when parking is oversubscribed. Thus, various economic forces can have a notable impact on carsharing adoption and appeal, particularly in a commuter carsharing program that emphasizes transit connectivity. With job loss and less congested roads, there was less demand for transit and carsharing in Palo Alto.

Economic Impacts

As mentioned, CarLink II site selection was conducted in Summer 2000. At that time, the California economy had just begun to experience an economic shift, but the extent of the decline was not yet apparent. Earlier, the strong economy had contributed to increased highway congestion, and many transit lots were approaching or exceeding capacity in the San Francisco Bay Area. Employers were anxious about employee retention, and Palo Alto was concerned about the impact of congestion on quality of life. At that time, there was no reason to believe that the economic strength of Silicon Valley would diminish enough to affect CarLink II's longer-term operation. Silicon Valley lost approximately 9% of its employment from the first quarter of 2001 to the second quarter of 2002 (the period of CarLink II operations) (*6*). That impact diminished user demand and willingness to pay during CarLink II, cost recovery, and long-term sustainability.

Integrated Carsharing Technology

Both CarLink I and II employed advanced carsharing technologies. In CarLink I, however, the two main technologies used were not integrated: (*a*) vehicle reservation and access technology and (*b*) radio frequency–based vehicle-tracking system. Several CarLink I technology shortcomings (e.g., user data transmission failure) contributed to delays and necessitated program modifications. It was recommended that carsharing technology be integrated (e.g., tracking, reservations, and billing), customized to facilitate vehicle access, and designed to serve multiple lot designs. Furthermore, the day-use reservation system was not integrated with the vehicle tracking system, meaning that real-time vehicle availability was not reflected on the reservation page. As part of involvement with CarLink II, American Honda Motor Company developed an integrated carsharing system that included the following:

- Vehicle access (smart key fobs);
- Internet-based reservation system; and
- Vehicle use and tracking (car location, vehicle miles traveled, fuel levels, user ID number, and time).

CarLink II also included a navigational system.

While the majority of participants were satisfied with the CarLink II technology, the following improvements were recommended, in order of importance:

- A lockout feature for reserved vehicles should be developed.
- The vehicle immobilizer should be integrated with the engine control unit to make this feature much more secure.
- The online reservation page should be modified to improve scrolling and reflect the correct time.
- The number of steps involved in making an online reservation should be reduced.
- A means to directly inform the reservation system that a trip is extending past the reserved time period should be developed (e.g., automated phone interface).
- Reserved cars that are unused should be converted to "available for use" automatically on the reservation page after a 10- to 15-min waiting period. Furthermore, users should be fined if they do not cancel a reservation in advance.
- The PIN entry screen process should be improved.
- The key fob door-release speed should be increased.

Participant Recruitment and Retention

Participant recruitment for a new transportation concept involves creativity and persistence. Engaging potential participants is challenging. Recruitment remains an ongoing effort because of member attrition (businesses and individuals), from changes in home, work, or employment circumstances.

During CarLink II, a wide variety of recruitment strategies were employed with varying levels of success, including: the CarLink II website, brochures and postcards, a video; flyers at stations and in Caltrain bills, flyers on trains, articles and advertisement in local papers, community meetings, carpool coordinator lists, a trial offer, Stanford Research Park management recommendations, e-mail at employment sites, and word-of-mouth. The most effective tools included the trial offer (as noted during the CarLink longitudinal survey), flyers on trains, recommendations from Stanford Research Park, word of mouth, and e-mail communication. The least effective methods included flyers in the Caltrain bill and at the stations, the carpool list, and the CarLink II video.

The Palo Alto location presented a challenge for home-based user recruitment. Two significant barriers were that (*a*) high levels of multiple car ownership are common in Palo Alto and (*b*) transit station parking was not limited throughout the pilot program. The most efficient mechanism for home-based user recruitment was the trial program, which allowed prospective users to try the system before committing to a monthly payment. The trial offer included 1 week of service for $25 (versus $300/month for full participation). More than 50% of the individuals who participated in the trial joined as regular members. Business recruitment was conducted by working with local community contacts (e.g., City of Palo Alto, Stanford Research Park Management, and a local ridesharing group). In addition, some employees who saw the CarLink vehicles in parking lots or flyers on the trains contacted CarLink II operations staff to learn more about the program. Once a business joined, its employees had access to the program at no additional cost. The employers were responsible for advertising the program to their staff and encouraging them to participate. Because employers paid a flat fee per car, it was in their interest to recruit as many employees as possible to

maximize investment benefits. In the next section, the 12-month CarLink II pilot transition is discussed.

PILOT TRANSITION

Starting on July 1, 2002, Flexcar–the private carsharing operator–began operating the former CarLink II pilot program. It was not possible to overlap personnel and operational protocols into a transitional phase, due to funding constraints. As a result, there were two Flexcar operational phases. The first phase, lasting 3 months, maintained the CarLink II format to provide member consistency and assessment time. During the second phase, Flexcar implemented a revised program approach and rates on the basis of an economic assessment. Changes included the following:

- Fee increases—employer rates doubled to $700/month per car; home-based user rates increased by $24.75/month to $324.75/month;
- Hourly rentals—$9/h and 10 free mi or $40/month with 5 free h and 50 mi;
- Fewer reserve (or unassigned) vehicles to reduce costs; and
- Restricted vehicle assignment and schedule adherence—vehicle must be returned to Caltrain at the same time each day, with no flexibility.

Initially, all work-based employers (four companies with a total of 10 cars) and six home-based users remained in the program after CarLink II ended (two home-based users pursued other options after CarLink II). During Flexcar's first phase, one company reduced its cars from five to three and provided employees with an option of a commuter subsidy or CarLink membership. About half of the work-based commuters and day users stayed with the program. However, two member companies left the program when Flexcar fees were raised.

Flexcar also established other programs to coincide with the CarLink II model (hourly rentals in a few neighborhoods, a foundation, and downtown parking lot). Of those programs, only one neighborhood lot proved successful. While Flexcar increased fees to cover vehicle and staffing costs, the program was still not viable. In July 2003, the Palo Alto Flexcar program ceased operations because of (*a*) a downturn in the economy, (*b*) inability to cover costs, and (*c*) member schedule fluctuations. Owing to the combination of these three factors, most employers did not perceive sufficient value in the service.

City CarShare, another carsharing provider, also entered the Palo Alto market at the completion of the CarLink II pilot. City CarShare initially placed two cars in a downtown Palo Alto lot, where Flexcar also later located two vehicles. Approximately two dozen members used the City CarShare cars at that site. In October 2003, City CarShare launched its Stanford University program. Students, faculty, and staff had access to two additional vehicles, which were placed in separate lots on the campus. One campus vehicle was removed in December 2003, and the second in September 2004. The City CarShare rates were the same for the Palo Alto program as for their San Francisco operations despite higher costs in that location. City CarShare closed its downtown Palo Alto operations in fall 2003, followed by a phased closure at Stanford University, which concluded in fall 2004, because those sites did not meet their business plan objectives and operational costs were higher in those locations (E. Dorbis, unpublished data, March 2005).

Stanford University has maintained an on-campus rental car program with Enterprise Rent-A-Car since 2001. Initially, Enterprise was located at an off-campus location until the completion of an on-campus parking structure. In June 2002, Enterprise moved its office into the new structure and was allotted 15 parking spaces to house the fleet. When City Carshare left Stanford in fall 2004, the university negotiated a new hourly rate option with Enterprise to augment the existing half-day and daily rates (K. Mathy, unpublished data, March 2005).

CONCLUSIONS

An important benefit of field tests and pilot programs is the systematic approach to designing, implementing, and analyzing the operational framework and user response. That information can serve as a foundation for future study (moving from a field test to a pilot phase), commercialization (transitioning to an ongoing program), or program modification. The phased research approach of CarLink I and II provided the ability to investigate differences and similarities between the two methodologies.

Field tests are especially useful to investigate (*a*) new concepts never tested and (*b*) specific attitudes or marketing strategies in a controlled environment. Furthermore, there is no commitment to future operation. Pilot programs generally follow the demonstration phase. Pilot programs are useful to investigate long-term sustainability and user response and to beta test commercial products (e.g., the CarLink II technology) in a real-world setting. They are typically more flexible in responding to market conditions.

Both field tests and pilot programs can assist in establishing public policy direction by putting innovative concepts into operation. While pilot programs are operating in the field, they can be used to show decision makers how a program can work and give them the opportunity to experience the idea firsthand, discuss it with participants, and assess results. Such experience is valuable to assist in the formation of realistic public policy initiatives that have a higher probability of success, given the understanding garnered. Costs can be controlled, and the feasibility of replicating the pilot in other locations can be assessed. Data collected during the research can assist in forming better policies that can yield intended outcomes.

The CarLink II pilot followed the CarLink I field test, which was preceded by a conceptual market survey (*4*). The process of investigating the commuter carsharing model through the conceptual, field test, pilot, and transition phases allowed researchers to gain a thorough understanding of how a project moves from concept to commercialization and what opportunities and obstacles it might face. Each phase has unique benefits, and the lessons learned during each stage inform program modification (e.g., technology), expansion (e.g., private-sector employers), and business strategies.

The CarLink program provided researchers an opportunity to evaluate operations, user response, and commercial potential over time. From the experience of the CarLink program, the authors recommend that a conceptual study of innovative ideas be conducted in advance of program design (e.g., focus groups and surveys) to assess potential demand, response, and willingness to pay. Furthermore, the authors argue that the field test phase be followed by a longer pilot phase (e.g., 2 years versus 1). Finally, the authors recommend that expert advice from a researcher involved in the field test and pilot design coincide with the transition to an ongoing operation (e.g., commercialization phase). Results from the CarLink II transition indicate that additional time to adapt the model and study its impacts would have been useful. A 12-month period is likely not long enough to achieve program sustainability, particularly during

an economic decline and when revenue shortfalls are projected during the pilot phase.

ACKNOWLEDGMENTS

The authors thank Caltrans, California Partners for Advance Transit and Highways (PATH), American Honda, Caltrain, BART, LLNL, Teletrac, and INVERS for their generous contributions to the CarLink program. The authors acknowledge Rachel Finson, Kamill Wipyewski, Amanda Eaken, Michael Paraiso, and Adam Cohen of California PATH for their assistance in preparing this paper. Thanks also go to Flexcar and City CarShare for their valuable assistance.

REFERENCES

1. 2001 National Household Travel Survey. U.S. Department of Transportation. nhts.ornl.gov/2001/index.shtml. Accessed May 30, 2003.
2. *Commute Profile 2002.* Rides for Bay Area Commuters, Inc., Oakland, Calif., Sept. 2002.
3. Shaheen, S., J. Wright, D. Dick, and L. Novick. *CarLink—A Smart Carsharing System Field Test Report.* UCD-ITS-RR-00-4. Institute of Transportation Studies, University of California, Davis, 2000.
4. Shaheen, S. *Dynamics in Behavioral Adaptation to a Transportation Innovation: A Case Study of CarLink—A Smart Carsharing System.* UCD-ITS-RR-99-16. Institute of Transportation Studies, University of California, Davis, 1999.
5. Fukuda, T., S. Kashima, and M. J. Barth. Evaluating Second Car System: Electric Vehicle-Sharing Experiment in Tama New Town District, Inagi City, Toyko. Presented at 82nd Annual Meeting of the Transportation Research Board, Washington, D.C., 2003.
6. *2003 Index of Silicon Valley.* Annual Report. Joint Venture: Silicon Valley Network, San Jose, Calif., 2003.