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System Plan for California's Bay Area Regional Express Bus Service

Elizabeth Deakin, Manish Shirgaokar, Cornelius Nuworsoo, Aaron Golub, Jean Finney, Wingate Lew, Becky Frank, Chris Cherry, Nathan Higgins, Elihu Rubin, Thomas Valentin, Kamala Parks, Willa Ng, and Deborah Wong

Express buses operating on freeways and arterials are an important part of many metropolitan area transit services. A regional express bus system plan for the San Francisco, California, Bay Area is presented; network, station and stop, operations, and user issues are addressed. Previous work had focused on high-occupancy vehicles on freeways; the current work expands the vision of the system to address the door-to-door trip and service on arterials. Gaps in the high-occupancy-vehicle network, priority treatment strategies, access modes and connections, station and stop design, park-and-ride lots, and public and private access services were analyzed, and other user and operator concerns were addressed. The plan was developed through a partnership that included the state transportation agency, the metropolitan planning organization, local transportation sales tax and congestion management agencies, and transit operators, with university researchers providing technical support and facilitation of meetings. On-board surveys and consumer focus groups were conducted along with stakeholder interviews, field studies, design evaluations, and simulation modeling. The plan not only produced valuable information for future improvements but also helped develop a high level of cooperation and consensus among the participating agencies. Both methods used and lessons learned from the Bay Area experience should be useful to other metropolitan areas and transit operators.

Express bus services are an important element in strategies for improving urban mobility. Express buses offer customers a fast ride by offering limited-stop service to intermodal transfer points, work centers, and other major destinations and by making use of priority treatments to speed travel, including reserved lanes and ramps, signal preemption, ramp meter bypass, and fast ticketing options.

In the San Francisco, California, Bay Area, numerous express buses operate on the region's freeways and arterials, and the California Department of Transportation (Caltrans), the Metropolitan Transportation Commission (MTC), transportation tax agencies, and the region's transit operators work together to deliver these services. Caltrans owns and operates high-occupancy-vehicle (HOV) lanes on many of the region's freeways, as well as many of the park and ride lots served by express buses. Caltrans also owns several of the major

arterials in the region. MTC, the region's transportation planning agency, has planned and programmed additional HOV lanes and has proposed a number of coordinated express bus services and stations in key commute corridors. Several of the region's transportation sales tax agencies have provided funding for express bus services and facilities, including freeway and arterial priority treatments. With voter passage of Regional Measure 2 in 2004, additional funds are becoming available for new express bus services and for new HOV lanes on the region's freeways and arterials.

Although the existing and planned express bus facilities and services have clear individual benefits, this study was designed to put together a system plan—a plan addressing all elements of the system—for regional express service. Just as any system includes network links and nodes, means of access, operating rules, and flows on the network, the Bay Area express bus system plan addresses not only network links (routes, HOV lanes, priority treatments) and nodes (stations and stops, park and ride lots) but also the operating rules (schedule frequency and hours of operation, fares) and flows (passenger demand, passenger preferences). The system plan presents strategies for providing seamless, integrated service that respond to traveler needs and improve travel options, while helping to manage congestion, improve environmental performance, and support economic progress—regional objectives that are part of the justification for investments in express bus services.

Issues identified as part of the planning process and addressed in the plan include

- Bus users' concerns about the quality, reliability, and frequency of express bus services;
- Gaps in the HOV lane network on freeways;
- Delays on arterials;
- Crowded park and ride lots; and
- Feeder service needs and costs.

This study was funded by Caltrans and was carried out in a partnership with MTC, county-level transportation tax agencies and congestion management agencies, and 12 of the region's transit operators. Researchers at the University of California provided technical analysis, facilitated meetings, and prepared reports reflecting the consensus of the partners.

In addition to producing a system plan that could guide future detailed planning and design, programming, and investments, the study aimed to identify ways to increase the effectiveness and use of express bus facilities and services by developing an integrated regional plan—a system plan—for improvements. The study built on previous work sponsored by MTC that focused on freeway HOV lane

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use, but it went beyond the MTC study to consider arterial services, feeder services, park-and-ride, and other user and operator concerns. The system plan develops both specific project recommendations and recommendations for a process of ongoing cooperative planning and implementation among service providers.

RESEARCH APPROACH

The study presented here was conducted in three phases. In the first phase, the research team worked with the study partners to develop agreement on a definitions and policy framework. In addition, the research team

- Reviewed transit operators' current and proposed express bus services, as well as a major proposal for HOV lane extensions and new regional bus services developed by the MTC and Caltrans in an earlier study (1). As part of this review, team members also interviewed operators to discuss their investment priorities and service plans and met with congestion management agency and MTC staff to discuss financing issues and opportunities.
- Reviewed 2020 forecasts for express bus ridership and analyzed travel patterns and transit service quality elasticities to estimate demand for an integrated, improved freeway and arterial express bus network.
- Participated in public meetings designed to solicit broad community input on express bus issues and needs.
- Explored alternative ways that a regional express bus plan might be implemented.

The second phase of the study involved data collection and analysis to fill gaps in knowledge about user needs and concerns and operations alternatives. The research tasks, each documented in a working paper, included

- On-board surveys and ridership counts (1);
- Park-and-ride surveys and occupancy counts (2);
- Focus groups with express bus users and park-and-ride users (who travel both by bus and by carpool) and with car drivers in transit corridors (3);
- Study of access issues, including walk, bike, bus, and first and last mile shuttles (4);
- Case study simulation of signal timing options, queue jumpers, and so forth on arterials (5);
- Case study simulation of adding shoulder and median HOV lanes (I-580 case study) (6); and
- Identification of needed capital and operational improvements and first-cut cost estimates (7).

The study team worked closely with the study advisory group in each of these tasks, developing recommendations that had consensus support.

In the third phase, the research team identified six additional studies and demonstration projects that would proceed to implement the regional express bus plan.

DEFINITIONS AND POLICY FRAMEWORK

In this study, regional express bus service is defined as any limited-stop bus service that moves people quickly between Bay Area cities and communities. Study participants agreed that the regional express

bus system should include freeway flyers, bus rapid transit, and cross-town and Transbay limited-stop services ("limiteds"). Hence express buses may travel on freeways, on local arterials and streets, or on all three. Further, the partners agreed that the time required to get to the express bus service and the comfort and convenience of access, wait time, and transfers are all elements of the express bus system and are critical factors affecting demand. Hence the express bus system plan should address all aspects of door-to-door service, not just express bus facilities and services themselves.

The research team and partners worked together to develop a policy framework reflecting this definition of the express bus system, establishing standards and objectives for the key elements of the regional express bus system as follows:

- Express bus routes should serve all major centers and intermodal transfer points, including rail transit and interregional rail stops and stations and airports.
- Frequency and hours of operation should be matched to demand. In major corridors, headways of 15 min or less should be the standard.
- Midday and evening express bus services should be provided where work trip patterns or transit dependence data indicate a need for such services.
- Subscription services should be provided for specialized needs and should be considered for niche markets.
- The HOV lane network should be seamless; strategies to fill gaps in the HOV network should be developed.
- Buses should be given priority treatment wherever congestion would create delays, at freeway on-ramps and toll lanes, around intermodal stations, and at signalized intersections.
- Major stops (at transfer points or other major nodes) should have full services, including comfortable waiting areas with shelter, seating, lighting, real-time information, food and beverage services, news outlets, telephones, and toilets. Other stops should have, at minimum, bus shelters with adequate seating and weather protection for waiting passengers, covered passage ways for transfers, information kiosks, and lighting.
- Route and schedule information should be posted at all stops and be available over the Internet. Real-time information should be available at major stops.
- Maps and graphics should be provided to orient bus riders to the area around the station and the services available within walking distance, including local bus and shuttle connections, timed transfers to express bus services, and nearby facilities such as cafes and public restrooms.
- Point-to-point fare information should be provided, whether the trip requires one vehicle and operator or multiple vehicles or operators.
- Fares should be affordable and should be equitable considering costs of providing the service received.
- Security services should be provided for all stops and stations, including park-and-ride lots.
- Passenger count data from express bus services should be supplemented periodically with rider surveys designed to document origin-destination patterns, frequency of use, other travel choices available, and customer needs and perspectives.

On the basis of this framework, the research team assessed the status of the current system and plans for improvement and identified priority areas for the planning effort.

CURRENT AND PLANNED EXPRESS BUS SYSTEM

Nearly 6.8 million people resided in the nine-county San Francisco Bay Area in 2002, and nine outlying counties with considerable economic interaction with the Bay Area housed an additional 3 million residents. Growth in the Bay Area has been substantial, with six of the nine counties experiencing double-digit percentage increases in population in the last decade. Outlying counties also have experienced substantial growth, with all but one of the nine adding population faster than the state as a whole.

More than 3.5 million Bay Area residents were in the workforce in 2000—52% of the population. In the nine outlying counties, there were another 1.4 million workers. Although only about 70,000 of these latter workers commute to Bay Area employment, their numbers are increasing, especially for work trips to job centers at the fringe or the Bay Area. Some two-thirds of the workers begin their journeys between 6:00 and 9:00 a.m. Another 15% to 20% will leave for work between 9:00 a.m. and 4:00 p.m.

The region's large population and workforce, much of it commuting during peak periods, constitute a major market for public transportation. The Bay Area is served by more than 20 bus systems, four rail systems, two light rail systems, and four ferry services, as well as numerous paratransit services. According to federal and regional data sources, in 2000, nearly 1.2 million transit trips were made in the region, accounting for 5.6% of all trips made there. Almost half the transit trips were work trips, resulting in a 10.9% transit work trip mode share.

The transit agencies currently operate 141 express bus routes, including freeway flyers, rail feeder services operating express to BART and Caltrain stations, and cross-town limited-stop routes. Most express bus routes operate primarily to serve commuters and run only during the peak periods and in the peak direction. A small number of express routes operate all day, often paralleling local bus routes and providing a quicker option for long-distance travelers. In 2000, an estimated 138,000 trips were made each weekday on these services—about 12% of the region's total transit trips that year.

MTC, in partnership with Caltrans and the region's transit operators, has proposed additional investments in regional express bus services on nine freeway corridors that would operate in HOV lanes or with HOV priority treatments. Interregional express buses, serving very-long-distance trips (30 mi or more one way) to Bay Area job centers and intermodal transfer points (rail, air) from outlying counties, also would use HOV lanes in some corridors. Absent these major investments, growth in express bus ridership is forecast to increase by about 20,000 trips a day by 2020; with the investments proposed, regionwide express bus ridership would increase by about 34,000 rides per average weekday, a 9% increase over the 2020 base forecast.

However, of the 141 express routes currently operated, only 50 operate primarily on the freeway corridors that would be improved; the rest run entirely on arterials and local streets. Onboard surveys and ridership counts show that these latter services, which include heavily patronized cross-town urban services, carry substantially more riders than the freeway flyers, and they are likely to continue to do so for the next 20 years. Indeed, because of the popularity and effectiveness of these services, several transit operators are considering additional cross-town or cross-county limited-stop bus services and skip-stop rapid services. Upgrades of these services to Bus Rapid Transit (BRT) standards are being implemented or are proposed for key corridors in San Francisco, Santa Clara County, San

Mateo County, and in the East Bay. In addition, combined circulator-express feeder services to rail stations and ferry terminals are being expanded in some areas.

Express buses operating on arterials and local streets are important because despite the vast size and scale of the region, approximately half of Bay Area commuters are projected to travel fewer than 10 mi to work in 2020, just as they do today. Three-quarters of the commute trips will be less than 20 mi, and 90% will be less than 30 mi. Whereas median trip distances will grow region wide in the next 20 years, services that focus primarily on long trips will remain aimed at a small part of the market. Trip distance analysis shows a regional need for flexible express bus service that provides both medium- and long-distance travel options.

Demand for express bus services depends, like demand for transit in general, on a variety of factors, including the availability of competing modes and their performance, express bus availability and service levels, price, and individual and household factors—the fit between travel needs and the service offered. Considering both the freeway and the arterial express bus services as targets for improvement, the research team estimated that the total regionwide ridership increase could be nearly double the currently projected level, or 25% to 30% more than at present. For example, estimated elasticities of transit demand with respect to changes in access time, wait time, and transfer time suggest that ridership gains of 20% to 25% could be achieved. Additional increases could plausibly come from improvements in passenger comfort and convenience. In addition, new markets could be served with express buses.

Increases in ridership will be contingent on improved service levels on the arterials as well as the freeways. Cross-town limited-stop services are important alternatives not only for work trips but also trips to school, shopping, and a variety of other activities. However, buses cannot compete effectively with the auto if the buses are stuck in the same traffic as cars and face additional delays moving in and out of bus stops. Hence priority treatment is necessary for the buses to be able to offer faster service. Just as HOV lanes, bypass signals and lanes at ramps, and bus-only ramps are needed to make freeway flyer services operate competitively, wider stop spacing, signal preemption or signal priority treatment, bus-only lanes or queue jumper lanes at intersections, and bus bulbs and other boarding area design improvements are needed to speed bus operations on arterials.

Access to the express services is also a major consideration. Buses rarely can offer as direct a route as a personal vehicle, and access time and wait can be a significant disincentive unless stops are comfortable, convenient, and safe. Cross-town limited routes, rapids, and BRTs depend heavily on walk access to their services. Many express bus services depend on a combination of park-and-ride lots and feeder bus services for a substantial portion of their riders, with walk and drop-off important access modes in some locations. If these access modes are inconvenient, uncomfortable, or unsafe, they can deter express bus ridership regardless of how excellent the service offered by the express bus line may be.

Well-designed bus shelters and stations, equipped with real-time information systems and other amenities, also can encourage ridership by making the wait and transfer more pleasant for users. Timed transfers to and from other transit services (bus, rail, ferry) can reduce delay and uncertainty and make the journey more pleasant.

All these improvements are needed if express buses are to operate as an effective system, providing high-quality door-to-door services.

INFRASTRUCTURE AND OPERATIONS IMPROVEMENTS

The Bay Area operates

- 300 lane miles of HOV lanes on mainline freeways,
- 50 lane miles of HOV lanes on expressways,
- 13 lane miles of HOV or bus-only lanes on 16 arterials,
- Four bridge toll plazas with exclusive lanes for HOVs to pass without paying tolls,
- Four HOV freeway-to-freeway connectors,
- Two HOV-only freeway entry ramps, and
- 66 HOV bypass lanes at metered freeway entry ramps.

Recognizing the successful performance of express buses and their potential for helping to manage peak-period vehicle miles traveled, the Bay Area has planned new infrastructure to serve express buses, including an expanded freeway HOV lane system and new express bus terminals with parking and local bus connections. A voter-approved ballot measure, Regional Measure 2, provides funds for some of these new facilities as well as for additional express services in certain corridors. The improvements are being programmed in two phases, as funds permit; the first phase adds 71 lane mi of new freeway HOV lanes, a new freeway-to-freeway HOV connection, two new and two expanded direct access ramps, three major freeway express bus stations, and 12 minor express bus stations. The second phase will add an additional 87 lane mi of HOV lanes, five freeway-to-freeway HOV connection, five direct-access ramps, and six freeway express bus stations.

Considerable work remains to be done on some of these proposals, including locating the bus stations and, in many cases, obtaining land for them. Further, despite these planned investments, a number of missing links will remain in the region's HOV lane network. On state highways, the gaps include 109 freeway lane miles on 13 sections that are not yet congested, mostly at the fringe of the region; 106 lane mi of congested freeway on 14 sections and 39 lane mi of non-freeway routes where right-of-way limitations and potentially high construction costs have deterred HOV lane construction; and 23 lane mi where a bottleneck upstream or downstream would limit the effectiveness of an HOV lane. Some of these gaps are major sources of delay.

Transit operators have identified a number of additional investments that they believe would substantially improve operations. These include improved signal timing along arterials, bus priority treatments at major intersections, bus priority lanes and queue jumpers on congested arterial segments, traveler information systems, bus shelters, park-and-ride lot improvements, and sidewalk and pedestrian crossing improvements. These projects are for the most part low cost compared to HOV lane or transit station construction and can be highly cost-effective. For most of these improvements, it was found that the annualized cost per rider per year was less than \$2.

To explore ways to address the HOV gaps and to examine the effectiveness of arterial improvements, the research team conducted two simulations: one of HOV lane additions on a freeway segment and another of express bus improvements on arterials.

Simulating Alternative HOV Lane Designs on Freeway Segment

For the many freeways in the Bay Area that lack right-of-way for the addition of HOV lanes, alternative lane designs may offer a way

forward. Three possibilities are use of medians for the HOV lanes, use of shoulders for HOV lanes, and use of a narrower lane design to fit existing lanes plus an HOV lane into the existing right-of-way. California has used medians for HOV lanes and transit ways on some freeways; shoulder lanes and lanes that are narrower than standard have been implemented successfully in several states, including Washington, Minnesota, and Texas.

Determining the feasibility of alternative HOV lane designs would require site-by-site analysis, which was beyond the scope of this plan. To demonstrate a methodology for such analyses, the research team used data from a section of the I-580 freeway and used the Paramics simulation model to test alternative design and operation strategies (shoulder lane, median lane). The analysis showed the trade-offs involved in median versus shoulder lane designs under different traffic pattern scenarios and illustrated how simulations could be used relatively inexpensively to explore alternative design strategies and test alternative scenarios.

Two other strategies were identified for further study. One was to consider whether ITS technologies could make narrow lane operation safer. Another proposal was to reconsider whether taking a lane for HOV use might be acceptable in some locations, such as freeway sections within San Francisco.

Express Buses on Arterials

Some express buses operate entirely on arterials and local streets, but nearly all express buses operate on arterials some of the time, if only to reach park-and-ride lots and terminals. Consider that most HOV lanes offer time savings of 1 to 2 min per mile; this time savings could be wiped out by 1 to 2 min unnecessary delay at intersections along an arterial. Efficient signal timing and other spot improvements such as queue jumpers at critical intersections are typically low-cost strategies (e.g., signal timing usually costs no more than a few hundred dollars per signal per year) and are sound ways to protect the benefits of HOV lanes (in the Bay Area, a \$10 million per mile investment). For buses that operate entirely on arterials and local streets, these intersection improvements can be critical to success.

The research team used several traffic operations models to evaluate alternatives for improving bus performance, by using data from a major arterial, San Pablo Avenue, as the test case. The signal timing software TRANSYT-7F was used to analyze the benefits of coordinated signal timing and bus-weighted signal timing (passive priority) in comparison to individually timed signals with transit priority to offset schedule delays. Longer pedestrian crossing times were also tested. The Paramics microscopic traffic simulation modeling software was used to look at the effects of the alternative timing plans on the parallel freeway as well as on the arterial itself and to test the effects of bus queue jumpers created through minor widening and restriping for narrower lanes at congested intersections.

In this case, the research showed that simply coordinating signal timing produces significant benefits to transit and to general traffic compared to individually timed signals (15% reduction in delays) and that bus-weighted signal timing provides substantial gains to transit vehicles (4% to 7% better performance than optimized timing alone) and hence reduces person hours of delay with marginal detriment to overall traffic flow. Queue jumpers were beneficial in some intersections and ineffective in others, depending on the number of turning movements being made in the intersection. Although the results of such an exercise are case specific, the methodology demonstrated could be used to test the effects of the full set of signal timing and intersection improvements proposed by transit operators in the region.

INCREASING RIDERSHIP 1: EXPRESS BUS USER SURVEYS

Most transit operators in the region have not conducted on-board surveys for a number of years, so they had little information about their passengers, their door-to-door trips, or their preferences. To better understand the demand for express buses, this study surveyed passengers on 28 express bus routes operated by six transit agencies in four corridors. Freeway flyers, express bus to rail, and limited-stop buses operating on arterials were included in the route sample. Approximately 9,000 passengers were offered surveys, 5,477 surveys were accepted, and 3,354 surveys were returned, for a response rate of just under 37%.

Results revealed significant differences between services and passengers in different corridors and by time of day. As might be expected, peak-period express bus passengers made mostly work trips, whereas midday users made trips for various purposes and had lower employment rates and lower incomes. A less predictable finding was that the poorer passengers paid full cash fares more often and made more transfers than their wealthier counterparts. Further, although most of the bus routes serve park-and-ride lots, a surprising 50% of all riders walked from their homes to the bus in the morning, with morning walk access rates as high as 68% for some express bus lines. Most also walked from the express bus stop to their final destinations.

Users' key concerns, as reported in the survey responses, were wait times, waiting conditions, transfer times, schedule reliability, security, and safety; from the respondents' perspective, in-vehicle times were less in need of improvement. For many respondents, access needed improvement; those who walked did not always have crosswalks or sidewalks, and those who used feeder buses often complained that the frequency and schedule of service was inadequate. Other major concerns were the lack of security at park-and-ride lots, the lack of shelters and lighting at many stops and lots, poor information about bus arrival times, missed transfers, and delays at major intersections caused by traffic, poor signal timing, or no priority to buses. In contrast to operator assumptions that higher-amenity buses and faster onboard speeds were top priorities, the survey respondents did not rank these as major issues.

INCREASING RIDERSHIP 2: PARK-AND-RIDE SURVEYS

Occupancy counts made it clear that many of the region's park-and-ride lots were full to overflowing, but almost no information was available on who was using the lots or even whether those people carpooled or took transit from the lots. The research team designed and carried out the region's first large-scale detailed study of park-and-ride facilities and users. Thirty-eight major park-and-ride lots were surveyed with a form left on windshield with postage-paid envelopes; three BART station (rail) parking lots were also given a modified survey designed to assess why drivers chose not to use feeder buses to reach the station. A total of 1,289 surveys were received from the freeway park-and-ride lots (return rate of 37%), and 2,619 surveys were received from the BART lots (32% return.)

The surveys showed that almost all the parking users were commuters who used park-and-ride 4 or more days a week; at the freeway lots, half were transit users and the remainder organized and casual carpools. Most park-and-ride users lived within 15 min of the park-and-ride lot, drove there alone, and made very long trips to work, many more than 30 mi one way.

At freeway park-and-rides, almost all users park in the same lot each week, and if spaces are not available, they park in nearby neighborhoods or drive. Freeway park-and-ride users' number-one concern was for more parking spaces, since most found it frustrating to not find a space at their preferred lot. Respondents from the freeway lots also had concerns about the lack of lot security and lighting, poor cleanliness (litter, broken glass, pigeon droppings), and the absence of user amenities, such as shelters, toilets, newspaper boxes, and beverage outlets (vendors or machines). Many commented negatively about the lack of information on bus schedules and routes and the absence of any way to find out what was going on if a bus were late.

In contrast, BART riders, who do have security, lighting, maintenance, and user amenities available at the station or directly adjacent to it, had far fewer complaints; their main wish was for more parking. BART riders tend to use a different BART lot if their primary lot is full.

INCREASING RIDERSHIP 3: FINDINGS FROM FOCUS GROUPS

To further explore the viewpoints of express bus users and to find out more about those who choose to drive or carpool instead of take the bus, 13 focus groups were held with Bay Area commuters. The discussions were used to follow up on concerns raised in meetings with transit operators and at public outreach meetings, to supplement transit and park-and-ride user surveys, and to deepen the understanding of the commuter attitudes toward existing transportation options and possible improvements. Separate focus groups were held with transit users (seven groups), carpools (two groups), and drive-alone commuters (four groups) in different parts of the Bay Area. The 140 participants were recruited by using flyers handed out on board and at park-and-ride lots and were recruited from a FastTrak (toll tag) database (tag holders who had agreed to be invited to participate in meetings about transportation issues).

Focus group participants said that the most onerous aspects of regional express bus service were waits and transfers. Waits could be made more appealing by providing shelters, lighting, and other amenities; schedule adherence would help make waits more tolerable and make transfers work better. However, many of the participants believed that offering direct (one-bus) service to job centers in San Francisco, Oakland, Berkeley, and the South Bay would be even more appealing. Many participants were doubtful that timed transfers could be improved significantly; they pointed out that most transfers are already timed but are missed whenever a bus is delayed because of an accident on the freeway or delays on signalized arterials, for example. Real-time information systems appeared useful to the participants, but many cautioned that this would not overcome infrequent service or missed transfers.

Although focus group participants were unenthusiastic about transfers to and from other transit vehicles, a number of participants spoke favorably about mixed services that collect passengers at several neighborhood stops, then travel express to job centers. Others spoke favorably about employer and community shuttles that served the same function from key terminals.

Focus group members also wanted to see key parking lots expanded and revealed a willingness to pay \$1 to \$3 a day for a parking space in exchange for increased amenities, such as security and shelter. Few, however, were willing to move to one of the underutilized park-and-ride lots, pointing out that most of these lots are

too far away from their commute routes or are on the wrong side of the freeway (inbound direction in the morning with immediate off or on access is preferred). In addition, very few believed that a parking structure would be more desirable necessarily than surface parking, and some were uncomfortable with parking garages. Most would not be interested in a parking structure if they had to pay the full cost of parking (probably \$5 to \$8 a day, or more).

Drive-alone commuters included those who were indifferent to San Francisco's high parking costs, those who needed their cars during the day for business trips, and those who would rather park in San Francisco residential neighborhoods and move their cars every few hours to avoid a ticket than to take the bus services available to them—usually those bus services that require multiple transfers. Many of the drivers in all three categories reported that their transit options took several times longer than driving. The discussions also explored the appeal of casual carpooling, a significant competitor to transit and driving in many parts of the Bay Area. Most casual carpoolers have tried transit and found it wanting, especially when multiple transfers are needed to reach their destinations; many also enjoy the spontaneity and independence of the anonymous carpools that form at many park-and-ride lots. However, a large share of both driving and carpooling commuters would be willing to try express bus (or rail) service should it provide a comfortable, one-seat ride to employment centers for a reasonable price.

GETTING TO THE EXPRESS: BUS AND SHUTTLE ACCESS

The focus group participants drew the research team's attention to the importance of feeder services at both ends of the express bus trip. However, outside central business districts and a few high-density neighborhoods, transit operators typically provide only limited feeder bus service. The research team investigated shuttle programs that have been established to address this gap.

Bay Area employers and local governments have created more than 150 shuttle programs to provide or enhance feeder services in "first and last mile" markets. Three models for shuttle organization have been identified: the single-employer shuttle, the multiemployer–shopper–hotel shuttle or circulator, and the community shuttle. The first two types of shuttle largely started as traffic management requirements (developer exactions) but have come to be seen as employee benefits or business support strategies. The community program often has grown out of a multiemployer service, as the local government partnered to serve its own employees or to handle other community needs, such as senior transport or after-school transport.

Shuttle services use a variety of vehicles matched to market, from used buses to vans. Costs generally run \$50 to \$60 an hour—about the same as the least expensive conventional bus provider in the region and less than half the higher-cost providers' rates. Drivers often are unionized, but work rules are flexible and services are agile, responding to market shifts quickly. Relations with conventional transit often are positive, with the shuttles seen as providing valuable feeder services and supplementary services.

Major achievements include serving a collective total of 8 million riders a year and the attraction of substantial business support and funding. Ongoing challenges include coordination with transit agencies and other transportation providers, finding a stable source of costs and funding, especially if shuttle services are to expand, and finding strategies that work for the underserved first mile. Despite these challenges, the shuttles deserve ongoing attention as an important supplement and possible alternative to park-and-ride and feeder buses.

RECOMMENDATIONS

The planning effort has led to a series of recommendations:

- A broad definition of express bus services should be adopted, including cross-town limited and BRT services operating on arterials and local streets as well as freeway express buses; these latter services carry a large share of current and future passengers.
- Planning attention and funding must be given to door-to-door service, including access modes (walk, park-and-ride, feeder bus, shuttle) at both ends of the trip, travel conditions around stations and along arterials, and transfers.
- Gaps on the HOV network that will be hard to fill though conventional widening that adds a lane might be addressed through restriping for narrower lanes or through use of shoulder lanes and median lanes. Simulation software should be applied to test the performance of alternative designs and explore the effects of different traffic patterns. Gaps where there is no congestion should be studied for ways to implement HOV lanes (e.g., right-of-way preservation or advance acquisition) eventually, since most such gaps are in fast-growing areas.
- Express bus performance on arterials is critically important, and significant improvements can be made at relatively low cost by coordinating traffic signals, implementing bus-weighted (passive priority) signal timing, and adding queue jumper lanes for buses. Strategies for improving pedestrian crossing times also can be implemented, improving access. Traffic signal timing and simulation software should be used to test alternative operations strategies and identify the most cost-effective ones. Funds should be made available for these improvements.
- Limited or inadequate access (poor walking and biking conditions; inadequate and poorly maintained park-and-ride lots; infrequent feeder services; lack of shelter, lighting, and amenities at stops) are a major deterrent to express bus use and should be high priorities for expenditure. Many express bus users walk to their bus stops, and improvements in pedestrian facilities and waiting areas should be considered to be at least as important as park-and-ride facilities.
- Better information at stations, stops, and park-and-ride lots is desirable but will not compensate for poor access. Rather, information systems are an amenity that will be useful primarily for new or occasional users (not a big percentage of express bus users) and for unusual events (the occasional accident or breakdown that delays a bus, for example).
- Most express bus services focus on peak-period commuters, but at least in some corridors there is a demonstrated market for school trips.
- Park-and-ride lots should be expanded by redesigning layouts as a first, low-cost strategy. Maintenance and amenities should be added, and user fees should be evaluated as a way to pay for at least part of the improvements.
- Planning and implementation efforts should be mindful that most travelers prefer direct services and are skeptical about timed transfers. Where the market would support direct service, such service should be tested.
- Shuttles should be considered as an environmentally friendly alternative to park-and-ride lots and may cost less per ride. Shuttles also might be considered as a substitute for marginal feeder bus services. A program to more formally engage employers, local businesses, and cities in funding shuttles could be pursued.

Many of the recommendations for action could be funded with regional and state planning funds; state highway operations funds;

federal and state highway and transit funds programmed by MTC or Caltrans (depending on the facility and project type); federal, state, and regional transit funds; county transportation sales tax dollars; public-private partnership funding; or user fees. The key funding need is to include all elements of a high-quality system—networks, nodes, means of access, operations, user needs—into the funding package.

NEXT STEPS

The research team recommended six projects that would help Caltrans and its partners further refine and carry out portions of the regional express bus system plan.

Proposed Project 1. Arterial Operations and Context-Sensitive Design Improvements Along Express Bus Corridors

Transit operators in many parts of the region have identified delays at signals as one of the major frustrations in operating express buses. Even buses that operate primarily on freeways experience delays at signals as they go to and from terminals and park-and-ride lots. Many of the signal problems could be reduced or eliminated by better signal timing, by adding a left-turn phase, or by providing a queue jumper to allow buses to bypass congestion.

Along a transit corridor, putting together a package of signal upgrades, signal timing improvements, and minor capital improvement projects could greatly improve the on-time performance of transit services. User-friendly improvements to sidewalks, bus shelters and benches, landscaping, and pedestrian lighting may attract additional riders to express bus services. Context-sensitive design strategies could lead to new and more creative ways of managing vehicle and pedestrian traffic. Finally, even more riders likely would be attracted if traffic operations and streetscape improvements were combined with efforts to renovate and revitalize the land uses and activities along the corridor, as part of a community plan.

In this project, Caltrans would request proposals for demonstration projects and would work with successful applicants to develop a design plan for the demonstration corridor that would fulfill the overall objectives of the program: improved transit speed and reliability, improved pedestrian and transit user facilities, improved traffic operations, and street designs that respond to community concerns and support revitalization. Once a plan was developed and approved by all parties, the partnership members would apply for grants to develop and implement the corridor plan. Caltrans would also support the monitoring of both the planning process and a postimplementation corridor performance evaluation 1 to 3 years after implementation.

Proposed Project 2. Use of Innovative Lane Designs for HOV Operations

Plans are under way to add HOV lanes to close some of the gaps in the Bay Area's HOV lane network, but many other gaps are likely to persist, usually because right-of-way is not available or is prohibitively costly.

Several states, including, Texas, Washington, and Minnesota, have successfully added freeway lanes under such circumstances by

using a narrower lane than standard to fit an additional lane into available right-of-way (Texas) or by allowing HOV lane operations on shoulders or medians. These strategies require careful engineering analysis and operations testing and should be considered case by case. The work in the second phase of the study demonstrated some of the pros and cons of alternative lane designs in a simulation study, but it was not possible to simulate all possible candidate sites for added lanes, nor was the research team able to investigate the engineering feasibility of the alternatives.

Such detailed investigations could be carried out on other candidate locations and, if these investigations show that the lane additions would be feasible and acceptable, demonstration projects could test their utility, safety, comfort, and convenience. (Design exceptions might be needed to proceed.) Funding for the demonstration might come from Caltrans, MTC, or a county tax authority.

Proposed Project 3. Alternative Layouts and Parking Space Standards for Park-and-Ride Lots

Surveys of park-and-ride lots in the Bay Area found that many lots are at or close to official capacity, and many others are likely to reach capacity in the next 10 to 20 years. Many of the most popular park-and-ride lots are holding more cars than there are marked spaces, because drivers park along driveways and in other unmarked areas of the lots. Marking these spaces when they are safe would give both drivers and the lot operators a better sense of where it is acceptable to park and where it is not.

In many park-and-ride lots, the size of each space far exceeds the space requirements of most parked vehicles. The Caltrans space and aisle dimensions are larger than those recommended by many parking experts, including the Urban Land Institute, and are significantly larger than the space sizes required by a number of local agencies, such as Alameda County. Although large spaces are a convenience when land is not scarce and parking is not running short, the current situation would suggest that parking dimensions be revised downward. A smaller overall parking stall and aisle standard or a separation of large vehicles into a separate area are two possibilities. The adoption of this strategy would be inexpensive and in some lots could substantially increase parking capacity, allowing more people to use the express bus or a carpool from the lots. In addition, at some lots, bus access and egress are difficult; redesign of the lots could improve this, reducing bus run time and costs.

Starting with lots that are at or very near capacity, in this project planners and engineers reviewed layouts and developed alternative designs either by using a more modest stall and aisle dimension overall or by creating a separate area for large vehicles (SUVs, trucks, etc.). They then identified or developed alternative design standards, by working with a Caltrans-transit operator-other stakeholder working group. New parking layouts would then be developed by using the design standards tailored and applied as appropriate to the specific circumstances of each of the lots needing redesign. For example, the designs should facilitate bus access and egress, including relocation of driveways and aisles as needed. A demonstration project then would be carried out to test the effects of the alternative parking standards and layouts (e.g., test if any accidents are attributable to smaller spaces or if motorists voice complaints or praise the results). An evaluation would be carried out on 6-month and 1-year data, and decisions on whether to expand the use of alternative design standards would be made on the basis of the findings.

Proposed Project 4. Land and Right-of-Way Strategies for Park-and-Ride Lot and HOV Lane Expansion

A number of park-and-ride lots might be expanded and HOV gaps filled if land for their construction were available. In some cases, a reconfiguration of the lot or lane on state-owned land may be feasible. In other cases, other publicly owned land (e.g., held by a city or county) might be obtained, or privately held land might be purchased. Other possibilities include land swaps, long-term leases, shared parking, and joint development. An additional option suggested by a transit operator would be to use off-freeway right-of-way or surface street lanes paralleling freeway sections as bus priority lanes in sections where a freeway HOV lane cannot be accommodated.

A project to investigate these strategies and to recommend strategies for obtaining land for park-and-ride facilities (expansions or new lots) and for HOV lanes and ramps could examine the alternatives, investigate the legal issues and institutional arrangements needed, and recommend steps to obtain the needed land or land rights.

Proposed Project 5. Charges for Park-and-Ride Maintenance and Amenities

Park-and-ride survey respondents frequently complained about the poor upkeep and lack of amenities at most park-and-ride lots. These facilities have been provided free of charge, and state and local funds for maintenance have been difficult to secure. Some transit operators in the region are beginning to charge for park-and-ride, and in surveys and focus groups most park-and-ride users said they would be willing to pay a modest daily fee for maintenance and improvements (shelters, lighting, seating, toilets) at the lots. This project would carry out further studies of willingness to pay, identify candidate lots for pricing and improvements, and design, implement, monitor, and evaluate one or more demonstration projects testing the effects of pricing on consumer satisfaction with and use of the lots.

Proposed Project 6. Alternative Institutional Arrangements for Park-and-Ride Facilities Management

Many different agencies and organizations could effectively operate park-and-ride facilities. Although the Bay Area's park-and-ride lots are predominantly owned and operated by Caltrans, it may be appropriate to consider alternative arrangements for managing these

facilities. Other operators could be transit agencies, ridesharing agencies, congestion management agencies, local city or county public works departments, redevelopment authorities, private entities, or combinations of the above through public-private partnerships. Moving to alternative arrangements could be cost-effective for all concerned and could open new possibilities for improving the efficiency and effectiveness of the lots, such as stacked parking, shared parking, structured parking coordinated with adjacent land development, and flexible pricing (e.g., with or without a transit ticket, reserved space). This study would evaluate the legal, institutional, and operational issues involved in alternative institutional arrangements for park-and-ride facilities (which may vary by location or lot, as opportunities differ).

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