37-47

SPECIFICATION AND EVALUATION OF ALTERNATIVE FEEDER AND LOCAL TRANSIT SYSTEMS IN A SUBURBAN AREA

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This paper is based on research conducted in a suburban county in the San Francisco Bay area on the specification and evaluation of alternative transportation systems to serve as a feeder to the new San Francisco Bay Area Rapid Transit system and as local transit. Forty-five percent of the employed residents commute to jobs in central cities outside the study area and more than two-thirds of the area households own two or more private automobiles. Major conclusions are that conventional bus systems will not substitute for private automobile use by the general public and are not economically justified either as a rapid transit feeder system alone or as a combined feeder-local transit system. Costs greatly exceed combined user and community benefits. New forms of public transportation systems are required. Small, publicly owned, electrically powered automobiles appear feasible and economically justified. The conclusions of the study may be applicable to the broader problem of collection-distribution links to corridor public transportation systems and local public transit systems throughout metropolitan regions of the United States and suggest the possibility of major substitution for second and third private automobiles by publicly owned automobile systems. The method of approach used in the study demonstrates the critical significance of feedback between specifications and benefit-cost evaluation of alternative systems. Use of an innovative "successive approximation approach" identifies key variables at the earliest time in research.

• THE objective of the Contra Costa Transportation Needs Study was to analyze alternative transportation systems to serve as a feeder or collection link to the San Francisco Bay Area Rapid Transit (BART) corridor system and as a transit system to meet local travel demands for local trips. The context in which the analysis was conducted, the method of approach, and the major findings and conclusions should have relevance for public transportation systems in many metropolitan regions of the United States.

The BART corridor system is scheduled to begin operation in 1972. Service from five stations located in the central part of the county will be provided initially to Oakland, the second central city of the San Francisco metropolitan region. By late 1972 or early 1973, BART transbay service will be extended to San Francisco.

The central area of Contra Costa County (Fig. 1) is made up of approximately 15 communities that together have experienced an increase of more than 50 percent in total population between 1960 and 1970 and are expected to increase in population by another 50 percent by 1980. The residents of the study area have relatively high incomes—the median values of owner-occupied dwellings as reported in the 1970 Census of Housing are significantly above the average for the state for most of the communities located in the study area. Private automobile ownership data are not available yet from the 1970 Census of Population, but extrapolations from data for the period 1960 to 1965 indicate that about two-thirds of all households in the central area of the county currently have

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two or more private automobiles. About 45 percent of all employed residents commute by automobiles to jobs located outside the area, principally in San Francisco and Alameda counties. Although the number of jobs within the study area is projected to increase by nearly 100,000, the number of intercounty commuters, particularly to San Francisco and Oakland, is projected to increase from 71,000 in 1965 to 136,000 in 1980.

The intercounty commuter from the central area of the county must currently travel through the Caldecutt Tunnel of the Berkeley hills, which represents a severe bottleneck. It is estimated that BART will save the average commuter (to San Francisco) between 10 and 35 minutes one way from the five stations located in the study area of the county.

METHOD OF APPROACH

A new planning approach of successive approximations and sensitivity analysis was used in the Contra Costa County Transportation Needs Study. This technique has been applied previously (1, 2). The approach has three concepts: simultaneous consideration of all study elements, development of final results by a series of approximations, and emphasis on evaluation of alternative systems.

Simultaneous Consideration of All Study Elements

The four major work elements of the new planning approach are preparation of inputs, specification of alternative systems, evaluation of alternative systems, and specification of implementation programs.

Work was begun on all tasks simultaneously at an early stage in the project to get preliminary results at the earliest possible date. Within the first month of the project, there were first-approximation results on system specification and evaluation. Simultaneous consideration of key study elements permitted the use of significant feedback from early results in later system design, evaluation, and implementation recommendations. Beginning the system evaluation process in the early stages of the project permitted early identification of critical issues. Because of the evaluation feedback, the research team was able constantly to focus the work on the most promising areas.

The concept of simultaneous analysis is shown in Figure 2 and compared with the usual transportation planning approach. First-approximation treatment of all study elements focused attention on key relations and provided a basis for allocating research effort to maximize project output. For example, preliminary evaluation results indicated that conventional bus service could not be justified for Contra Costa County even with substantial increases in projected ridership levels. Therefore, preliminary research being conducted simultaneously to calibrate a refined feeder bus patronage model was stopped and the work effort redirected to other critical items.

Development of Final Results by a Series of Approximations

Companion to the principle of simultaneity in the study approach is the method of working by successive approximations. A complete first-approximation analysis of conventional bus alternatives was completed and presented to the project board of control within 2 months after the study began. The sensitivity of initial conclusions to projections and assumptions used in the first-approximation analysis was reviewed in additional approximation phases. Primary work effort was diverted to identification and evaluation of other transportation systems as it became certain that the first-approximation conclusions would not change with reasonable variations in the input variables. Significant insights were gained by working with approximation results, and these insights guided subsequent approximations into more fruitful areas of research.

Emphasis on Evaluation of Alternative Systems

More emphasis was placed on the evaluation of alternative transportation systems during the course of this study than is usually done. A benefit-cost approach was chosen for evaluation on the premise that a comparison of total social benefits with total social costs is the most relevant evaluation measure for comparing alternative transportation

systems. Alternative systems were evaluated by utilizing a broad definition of benefits and costs, which included identification of magnitude and incidence of community benefits and costs. Evaluation analysis was conducted simultaneously with other work elements from the beginning of the project. The early availability of evaluation results permitted the approximation analysis to be focused on the most meaningful areas, allowed for the refinement of the specification of alternative transportation systems, and contributed to the development of the major conclusions and recommendations of the study.

The benefit-cost evaluation methodology does not base its conclusions on the fiscal position of operators of transportation systems. The concept of benefits and cost is distinct from the relation between fare box revenues and operating costs. The relation between fare box revenues and operating costs does not give a basis for deciding whether to go ahead with a public transportation system or to choose among alternative systems. For example, on any particular trip, the fare represents the minimum number of benefits that the user thinks he will receive; otherwise he would not make the trip. On most trips, the actual benefits received by the user are in excess of the fares. Therefore, transit fares, in the first place, understate the number of real benefits that accrue to users of the transit system. In addition, transit fares do not reflect community benefits. For example, fares do not reflect any benefits that accrue to automobile users because of reduced congestion, or the savings from reduced parking requirements, or reduction in air and noise pollution. Therefore, the fact that fares collected by a transit system may fall short of operating costs is not sufficient reason to judge the public investment to be a poor one. However, if evaluation based on total social costs and benefits indicates that aggregate costs exceed aggregate benefits, then the public investment is not justified.

A second important aspect of the benefit-cost evaluation approach is the provision of information on the distribution of benefits and costs among various groups and jurisdictions affected by alternative transportation systems. This information aids decision-makers and the public both in choosing among alternative systems and in formulating ideas of how to finance the selected system.

ANALYSIS OF CONVENTIONAL BUS SYSTEMS

Four rounds of approximations were carried out in the complete analysis of conventional bus systems. A description of the principal features of each round will illustrate how the concepts previously discussed actually worked in the study.

First Round

The first round took about 4 weeks to complete and ended with a presentation of first-approximation results on all elements of the study—inputs, specification of alternatives, evaluation, and implementation. The principal tasks of the first round were development of estimates of BART patronage at each station in the study area, first specification of alternative feeder and local transit systems, and development of evaluation concepts and initial estimates of benefits and costs.

Estimates of BART patronage by station were developed from an analysis of the growth of employment and of commuting patterns among Contra Costa, Alameda, and San Francisco Counties. The first-approximation estimate was that there would be 12,000 daily one-way 7 a.m. to 9 a.m. work trips out of the study area on BART in 1980.

Four alternative levels of transit service (feeder and local) were specified and described in the first round. Initial estimates of system costs and of rider benefits from the feeder system were developed.

Second Round

The principal tasks of the second round were continued specification of alternative transit systems, development of patronage estimates for each alternative system, and evaluation of alternative systems.

Two significant feedbacks were discovered early in the second round, which allowed the research to be concentrated on more productive areas:

1. The initial estimates of patronage for the various systems showed that patronage did not expand as rapidly as did system costs. This fact combined with the early evaluation results meant that it was more likely that smaller systems would be economically justified as opposed to larger systems. Therefore, in the second round three additional minimum-sized systems were described and analyzed.
2. An initial benefit-cost evaluation of each system was completed in the second round. All systems had costs well in excess of benefits. On all systems, patronage would have had to double before benefits would have equaled costs.

The evaluation also brought out the distinction between the travel needs of the general public and the travel needs of limited-mobility groups (the elderly, young, and physically handicapped). On the basis of the results of the second round, a new component was added to the study. Research was begun to analyze alternative ways of providing public transportation service for limited-mobility groups. This analysis ended with the recommendations for the adoption of a dial-a-bus system.

Third Round

The principal task in the third round was a refinement of the benefit-cost evaluation of the most promising conventional transit system from the second round. All categories of benefits were reviewed to see whether the first evaluation had left out or undercounted significant benefits. The results of the third round were that the best conventional transit system had costs in excess of benefits.

Table 1 gives the results of the third round measurement of benefits. The feeder bus system benefits consist of savings in automobile ownership and operating costs to BART riders who use the feeder buses, savings due to the reduced number of parking spaces required at BART stations, reduction in cost of street improvements and congestion in the vicinity of BART stations because of diversion of BART riders to feeder buses from automobiles, and gains in income to commuters and reverse commuters which can legitimately be attributed to the feeder bus system. An aggregate feeder bus system benefit of $581,500 was estimated for this system. Total annual benefits for local-service work trip patrons was estimated at $232,500. The analysis of local-service work trips conformed to that used in the analysis of feeder bus benefits, except that, for each type of local-service work trip patron, benefits were estimated to be higher than those for the comparable feeder bus patron. Most of the upward adjustment of these benefits reflects the fact that local work trips would be of longer average length than the average trip from home to a BART station. Therefore, the average local work trip takes longer and accrues higher automobile operating costs than the typical trip to a BART station. In addition, the higher benefit levels estimated for elimination of an automobile reflected the belief that the car that would be eliminated would probably cost more than the car used solely for going to and from a BART station.

An estimate was made of benefits to users of the local transit service for nonwork trips (e.g., shopping, medical, and recreational). Those who make nonwork trips were considered as occasional users, and many of these users were judged to have no other transportation alternatives; hence, it was difficult to estimate the value of bus service for these users. Preliminary estimates were made to get an idea of the magnitude of benefits that would be needed to make any of the alternatives show more benefits than costs. Total annual nonwork user benefits were estimated at $360,000 based on a patronage projection of 360,000 annual round trips.

Estimates of community benefits from the local bus service component of the plan are given in Table 1. Benefits from reduced congestion due to the local bus service component would be very close to zero. Total ridership on the local service component represents only about 1 percent of the average daily total trips projected for the study area in 1980. With this low percentage of total trips diverted to buses (and considering the dispersed nature of origins and destinations in Contra Costa County), only a nominal reduction in congestion could be attributed to local bus service.

An estimate of $140,000 a year was made for the employment benefits that might arise from the introduction of local transit service. School bus operations of the various school districts were examined in detail to estimate the degree of school costs

Figure 1. Study area location.

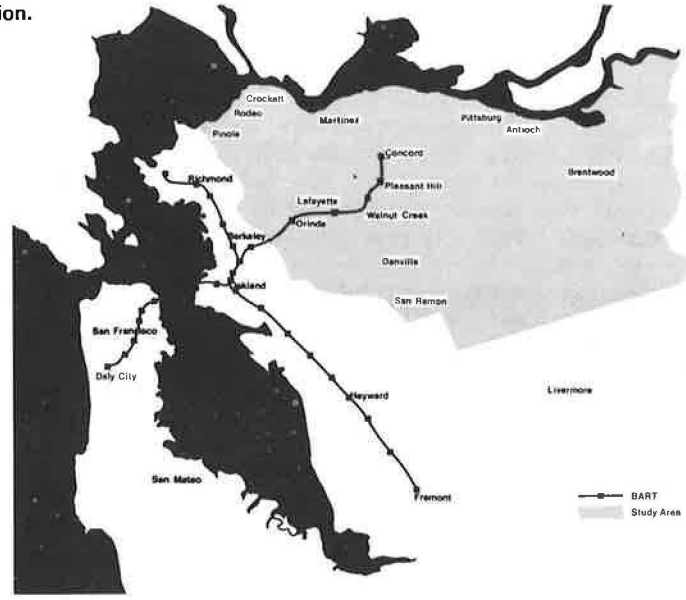
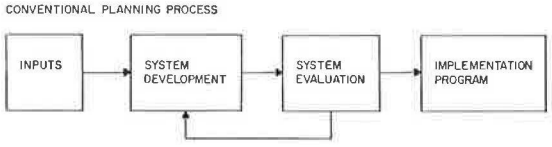


Figure 2. Alternative planning approaches.



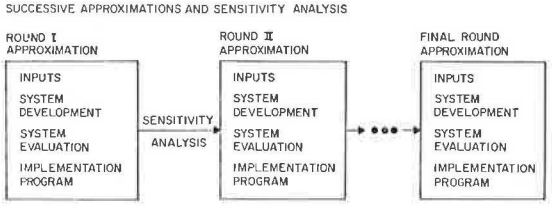


Table 1. Benefits of feeder and local transit systems.

	User Benefits		Community Benefits	
System	Source	Annual Benefit (dollars)	Source	Annual Benefit (dollars)
Feeder bus	Substitution for kiss-ride	230,000	Reduction in number of parking spaces	86,250
	Elimination of automobile	57,500	Reduction in congestion of stations and on roads to stations	165,000
	Elimination of automobile operating costs	11,500	Additional commuter income resulting from better job opportunities	50,000
	Loss from additional time in bus	(118,750)	Reverse commuter additional income from improved job	100,000
	Total benefit	180,250	Total benefit	401,250
Local transit	Elimination of automobile	139,500	Reduced parking requirements	30,000
	Elimination of automobile operating costs	93,000	Additional commuter income resulting from better job opportunities	140,000
	Elimination of ride to work	279,000	School transportation savings	80,000
	Loss from additional time in bus	(279,000)	Total benefit	250,000
	Occasional user	360,000		
	Total benefit	592,500		

Note: Total user benefits for both systems = $772,750; total community benefits for both systems = $651,250. Total annual benefits from all sources = $1,424,000; total cost = $2,000,000.

Table 2. PAS evaluation summary.

Type of Cost	Amount (millions of dollars)	Type of Benefit	Amount (millions of dollars)
Capital	19	Elimination of second automobile	27
Operating	10	Elimination of automobile operating expenses	10
Total	29	Parking spaces	2 to 4
		Total	39 to 41

Note: Net annual surplus of benefits = $10 to $12 million (1971 dollars). The following benefits were significant but not quantified: congestion savings, reduction in air pollution, and reduction in noise.

savings that might be realized by introducing a public transportation system in the study area. Even though school busing expenditures amount to more than $2 million, savings of only about $80,000 per year were estimated because of the public bus system. Higher operating costs for a public transit system; school transportation capacity, safety, routing, and related requirements; and coincidence of peak school and peak public transit passenger loads effectively preclude large-scale integration of school and public transportation services.

The final evaluation results show total annual benefits of $1.42 million and total annual costs of $2.00 million. It was concluded that, even with estimates of patronage and benefits that were judged high, total benefits would fall short of total costs for this bus plan and the other six alternative bus systems developed up to that point.

Fourth Round

Because of the broad ramifications and significance of the first- and second-approximation findings, it was decided to complete a final approximation of the planning and evaluation process, including refinements in specification of bus plans and the full evaluation. The objective was to check the conclusions of the earlier analyses from all points of view.

The final evaluation was conducted on two new bus plans—one a minimum plan with relatively low service standards typical of existing bus systems in suburban areas and the other a maximum plan with frequent peak-period feeder and local service. The bus plans were designed with two general criteria. The first general objective was to provide bus service within acceptable walking distance of as many households as possible so as to provide service to the greatest number of potential users in relation to the size of the system. The second general objective was to specifically orient routes to serve population subgroups with the greatest need for public transportation. These groups in central Contra Costa County consist of BART commuters in addition to so-called captive riders or persons with limited mobility who do not, or cannot, use an automobile.

Guided by the insights developed in the first three rounds, two new conventional bus systems were specified through refinements of the earlier systems. Routes, operating data, and service frequencies were refined on the basis of feedback from earlier rounds. The evaluation of these two additional alternatives did not change earlier conclusions. All nine of the conventional bus systems that were specified and evaluated had costs in excess of benefits.

The series of analyses conducted in these four rounds of bus system evaluation consistently demonstrate that conventional bus systems will fail in the suburban setting characteristic of Contra Costa County. The high proportion of families owning multiple cars, the high incomes, and the low land-use density all reduce the effectiveness of bus systems.

On the basis of these results, the study was continued along two lines. Analysis was undertaken to examine alternative ways of providing public transportation service for limited-mobility groups. In addition, effort was directed toward the question of alternative public transportation forms for the general public. This work led to analysis of the necessary attributes of a public transportation system to reduce automobile usage and to specification and evaluation of a public automobile system (PAS) for Contra Costa County to complement the BART corridor system.

MAJOR FINDINGS

The analyses of alternative feeder and local transit systems to complement the BART system in suburban Contra Costa County reveal several aspects of public transportation. Contra Costa is felt to be representative of many suburban areas in metropolitan regions of the nation. Therefore, the findings should have broad significance and application to many other urban areas.

General Public and Limited-Mobility Groups

In evaluating alternative feeder and local transit systems, it became apparent that two groups must be differentiated for rational analysis: persons and households who

have access to automobiles as a transportation alternative and persons with limited mobility who do not own or cannot operate private automobiles. Clearly, in suburban areas, the general public falls in the first category; the elderly, poor, handicapped, young, and nondrivers make up the primary limited-mobility group. In Contra Costa County, 97 percent of all households own at least one automobile and more than two-thirds of the households own two or more private automobiles. Although these statistics are higher than for the nation as a whole, the pattern of higher levels of automobile ownership in suburban areas is common in most metropolitan suburbs. The population composition in central cities is decidedly different, with the limited-mobility group representing a much larger share of the total population.

The combination of greater mobility and transportation alternatives for the general public in suburban areas means also that public transportation, to be effective, must be capable of competing with the private automobile for trips made by the general public. Limited-mobility groups, by definition, have fewer transportation alternatives and are, therefore, more dependent on public transit. Moreover, their residence locations, trip behavior, and transportation needs are distinct from those of the general public and demand special analyses. Most elderly persons do not make work trips; young people are typically in school until midafternoon and the origin-destination focuses of their trips do not coincide with those of the general public.

Finally, public transportation will have to attract the general public in order to have any significant impact on highway traffic and congestion. Without shifts to public transit by the general public, transit in suburban areas will not reduce the dominance of the private automobile.

Conventional Bus Systems in Suburban Areas

Because of dispersed, low-density land-use patterns and multiplicity of origin-destination trip combinations, conventional bus systems in suburban settings will not be widely used. Feeder systems to rapid transit, schedule limitations in the choice of trip times, relatively long access times or distances, and waiting times for bus service will preclude effective reduction in the use of the private automobile. Private automobiles will be the dominant feeder made to the corridor public transit system.

In order for public transportation to be of value to residents of an area, the routes and service must be conveniently accessible. Few people are willing to travel farther than ¼ mile to reach a bus stop. Indeed, evidence from many communities shows that most bus patrons travel less than three blocks to reach the bus. Densities between 4,000 and 10,000 persons per square mile are common in suburban portions of even large metropolitan regions. At these densities, bus routes spaced at ½- to 1-mile intervals on major arterial streets are not within acceptable distances of many residences. The most extensive of nine different bus route plans evaluated in Contra Costa County would allow bus routes to reach (within ¼ mile) only half of the residences. Even in communities where more extensive route coverage was provided, only about three-quarters of the residences were within ¼ mile of the bus routes.

Other typical suburban development patterns present additional difficulty in rendering conventional transit service. Curvilinear and noncontinuous streets, cul-de-sacs, and hillside residential development preclude effective service by public transportation. Thus, even with an extensive system of local bus routes, a high share of the residents would be beyond acceptable distances from the bus routes.

Only a very small percentage of residents who could reach the bus system would use it. The performance and cost savings to the individual—even at a very modest fare of 25 cents—would not be sufficient to induce large numbers to switch from private automobiles. The largest bus system tested for central Contra Costa County would attract only 23 percent of 1980 peak-period BART commuters. Only about 1 percent of the 1980 local trips within the central county was projected to be made on the largest conventional bus systems. High car-ownership levels, dispersed pattern of origin and destination travel, and the inability to meet automobile competition in terms of accessibility, flexibility, cost, and time are the principal reasons that public transportation in suburban areas cannot capture a significant share of total travel.

Benefits to the community at large through a reduced requirement for parking space, less traffic disruption in neighborhoods, and reduced congestion on the street network could be compelling reasons to support implementation of public transportation service. However, for these benefits to be realized, there must be measurable substitution of travel from private automobiles to the bus system. The low patronage for a conventional bus system in central Contra Costa County precludes significant impact on parking, noise, traffic, congestion, and air pollution. With only 1 percent of all trips projected to use the bus system, it is clear that community benefits would be minor.

Nine conventional bus systems were delineated and evaluated. The lowest cost of installing and operating a conventional system was approximately $0.80 per passenger trip. The capital and operating costs for each of the nine conventional bus systems exceeded the combined user and community savings in each case.

The initial plan alternative considered the creation of a BART feeder bus system only. Capital and operating costs for a feeder bus system would exceed savings to the user and community by a factor of 4 or more. Revenue from feeder service, based on 25-cent fares, would cover only about 15 percent of the total annual cost of providing this service. Combining BART feeder bus service with local bus service within central Contra Costa County would improve operating performance but still require nearly 70 percent of total cost to be met from general community sources. The cost per passenger for rendering public transportation service would exceed automobile costs by a factor of 2. Savings to those who use the bus system and to the community (reduced parking, noise, congestion, and pollution) would be significantly less than the annual operating and capital debt retirement cost for any of the transit systems. On purely economic grounds, conventional bus systems must be regarded as a poor public investment in a suburban area because costs are well in excess of savings to the public. If public transportation is to be rendered on social criteria apart from economic considerations, it can be demonstrated that alternative forms of transportation are more cost-effective than conventional bus systems.

Feeder and Local Transit Systems Evaluation and Corridor Evaluation

Analysis of the transit collection-distribution problem as a distinct entity has been very limited. Most analyses have focused on corridor systems. Typically, feeder and local transit services have been evaluated in conjunction with the corridor elements without explicit independent consideration of the feeder-local transit component on its own merits. Consequently, the feeder system frequently has been rationalized on the merits of the corridor system. This treatment has clearly masked the real feeder issues and the proper evaluation basis, particularly with regard to suburban areas. The Contra Costa County feeder and local transit evaluations demonstrate that patronage on the corridor system does not depend significantly on the existence of a feeder system and that private automobiles will perform most of the feeder function (collection to and from places of residence) but not the distribution function at nonhome trip ends in suburban areas. If inroads are to be made on the use of private automobiles and the negative external impacts of private automobile-dominant transportation systems, new forms of public transportation are needed to complement corridor systems such as BART.

The Corridor-Public Automobile System Concept

Based on the findings and conclusions concerning conventional bus systems, the identification, specification, and evaluation of alternative forms of public transportation systems became necessary. The emphasis was placed on those systems that would compete with the use of the private automobile and would meet the demands of the general public residing in central Contra Costa County for trips to BART stations and for local destinations.

Major studies of new public transportation systems conducted under the auspices of the Urban Mass Transportation Administration were reviewed, and further research was conducted to determine costs, adaptability, and feasibility of several systems for consideration in the suburban area of Contra Costa County. The corridor-PAS concept

was selected because its operational performance characteristics can compare favorably with the performance of the private automobile.

The corridor-PAS system has two components: frequent, high-performance public transportation service such as BART in major corridors of the metropolitan region and a publicly owned automobile system (PAS) consisting of a fleet of small, self-driven, electrically powered vehicles. Widely available in convenient stands throughout the urbanized area, the PAS fleet would provide collection and distribution service to the corridor systems and would accommodate short, local trips under 4 to 5 miles in length. The PAS would have five essential elements: public ownership; a large fleet of small, electrically powered vehicles; curbside stands and terminals widely distributed throughout the urban area where users would obtain or return a vehicle; a central computer information and control system to monitor vehicle and terminal use; and means for redistributing vehicles among the stands and terminal.

Public Ownership of PAS Vehicles

Public ownership of PAS vehicles would be necessary for three principal reasons:

1. Multiple use of PAS vehicles would be necessary to gain system economies. Therefore, the vehicles must be available for use by several travelers rather than sitting idle during the day; redistribution of vehicles to meet midday demand would be necessary.
2. A very large fleet would be required to achieve sufficient scale for the system to be widely used. The PAS vehicles would have to be available over a relatively large area and in sufficient locations and number to render confidence in the system and assurance of vehicle availability.
3. Perhaps most critical, the vehicles must be publicly owned in order to provide service from the corridor system to final destinations. The availability of PAS vehicles would allow individuals to use corridor systems and to get to many more locations than would be accessible without a PAS. In suburban areas, a system complementary to the corridor system is required to reach most destinations. The PAS would provide this critical link to the corridor system.

PAS Vehicles

Small, publicly owned, electrically-powered automobiles with room for two adults or one adult and two children would be used in the PAS. Later versions might have greater capacity. Vehicle prototypes have been developed for both electric and electric-hybrid PAS vehicles. PAS vehicles would be 9 ft in length or roughly about one-half the length of conventional automobiles. The vehicles would have interior space for both driver and passengers comparable to full-sized automobiles. Space for parcels would also be provided. A body shell of fiberglass or plastic cellular construction would be lightweight with high durability and attractive appearance. PAS vehicles would meet federal automotive safety standards and could operate on urban streets with mixed automobile traffic. Speed capability of the vehicles would be moderate (25 to 35 mph maximum) because operation would be intended for urban street conditions with restricted speed limits and short distance trips. PAS vehicles would not be allowed to use freeways or expressways. Moderate speed performance requirements are an important feature, considering the high-cost trade-offs between performance and capital and operating cost. Occupancy of the vehicle would be for short duration; therefore, interior appointments would not be elaborate. Controls and seating would be adjustable and suitable for a variety of different operators.

PAS Curb Stands and Terminals

The PAS vehicles would be available to users throughout the urban area at curb stands in neighborhoods and major terminals at key locations such as BART stations, shopping centers, and employment complexes. The curb stands would be constructed on public right-of-way, probably occupying the parking lane on residential streets. Curb stands typically would vary in size from 4 to 12 or more vehicles depending on

development density and expected trip demand. At BART stations, space for several hundred PAS vehicles might be necessary to accommodate peak demands.

Central Control and Information Subsystem of PAS

A centralized control and information subsystem would be required to perform several functions within the PAS. On-line monitoring of the curb stands and terminals for fleet inventory control, communications with the system attendants for redistribution operations, and accreditation of users as well as off-line billing operations are functions of the control information subsystem.

Sensors would be needed at each stand and terminal to report the number of vehicles and to detect vehicle check-out and check-in operations. Use of the PAS would be restricted to accredited drivers who would be billed on a time and mileage basis. The central information system would verify user accreditation and record information needed for customer billing during check-in and check-out procedures.

Because the control system would be essential for operation of the entire PAS, provisions for handling and/or recovering from all types of system failures would be necessary. Complete backup control systems might be required to ensure uninterrupted system operation.

Redistribution of PAS Vehicles

A key requirement of the PAS would be the capability to efficiently redistribute vehicles. Demand patterns would result in surplus vehicle accumulation at BART stations and employment centers in the morning. In order to achieve multiple use, these vehicles would have to be redistributed to PAS stands and terminals in accordance with anticipated demand patterns. In the evening, vehicles would be assembled at BART stations and job locations to serve returning commuters and local employees. An efficient and economical method to balance the supply and demand for vehicles throughout the system must be devised.

Economic Evaluation of Corridor-PAS Concept

An example was developed to illustrate how a PAS of 30,000 vehicles might operate in the central area of Contra Costa County. The example provides a basis for preliminary estimates of patronage, operating and capital costs, and a first-approximation economic evaluation of the PAS.

Evidence from the example case in Contra Costa County suggests that there is a strong economic justification for the implementation at the regional level of a full system of public rapid transit in major corridors combined with a PAS for feeder and local trips. Two key hypotheses of the corridor-PAS evaluation were as follows:

1. Many of the households with two or more automobiles would find a corridor-PAS system a convenient substitute for the second car. The capital and operating costs of the corridor-PAS system would be more than offset by reductions in the cost of the private automobile and its infrastructure (streets, highways, etc.) to county residents.
2. Benefits and costs associated with the corridor-PAS would be widely distributed among all county households. It was concluded that the corridor-PAS could substitute for the second car of many households because its performance characteristics in terms of scheduling flexibility, routing flexibility, accessibility, convenience, privacy, journey speed, and cost would be directly competitive with the private automobile for the majority of trips made by suburban households. In addition, community benefits resulting from reduced parking requirements, reduced congestion, and reduced noise and air pollution would accrue to all households. Evaluation results are summarized in Table 2.

IMPLICATIONS OF RESEARCH FINDINGS

There are three public transportation problems in metropolitan areas where these findings may be applicable. The collection problem per se (i.e., linking origins with public transportation corridor systems) will become increasingly important with the continued expansion of urban corridor systems like BART. Further research can

determine how broadly the conclusions of this study regarding the failure of conventional bus systems apply to other areas. Of prime interest is the relation of density of development to the benefit-cost evaluation of alternative systems.

Possibly a more significant implication of this research is the development of distribution systems to complement corridor systems at the destination end. Although people can drive from their homes to the rapid transit station (if buses are not justified), there is no such flexibility at the destination. Under what circumstances could a PAS function as a distribution system from the corridor? How much would the use and benefits of a corridor system expand if there were a good distribution system at the destination end? Now people can use corridor systems only if they are going to a restricted number of final destinations; otherwise, they cannot get to their final destination from the corridor system.

Beyond the context of corridor travel the implications of this research may be even larger. A concept like the PAS may open up the possibility of substitution for a substantial share of automobile travel by providing for local trips as well as links to the corridor. The PAS for local trips in combination with a public transportation corridor system for longer trips can do something that either alone cannot do. A corridor-PAS system can possibly serve the total travel needs of families, allowing them to get rid of at least second and third cars. What are the travel demands of families in terms of variety and length of trip? Under what circumstances could a PAS in conjunction with a public transportation corridor system satisfy the travel demands of a family sufficiently to allow them to get rid of a car? These are only some of the research questions that must be answered before the total implications and generality of the corridor-PAS concept become clear.

SUMMARY

Research on the corridor collection-distribution problem in a suburban setting has demonstrated serious question of the viability of conventional bus systems for either feeder or local transit functions. Although further evaluation is clearly needed to fully substantiate all elements of the PAS, the evidence developed in this project and earlier research work suggests that the concept should be pursued and that it merits far greater attention than it has been accorded to date.

The successive approximation approach and concept of evaluation as used in this study is a powerful analytic framework for transportation planners. By developing early evaluation feedback, the planner gains significant insight that can be used to improve the plan delineation process, and the project research effort can be sharply focused on those critical issues that affect final conclusions and recommendations.

REFERENCES

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