Impact of the Bay Area Rapid Transit System on the San Francisco Metropolitan Region

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FOREWORD

The Bay Area Rapid Transit system will soon commence operation. It is the first new rail rapid transit system to be constructed in the United States since the Cleveland system was built after World War II. It will afford a unique opportunity to study both the system itself and its influence on the economic, social, and ecological development of the San Francisco Bay Area.

Members of the Highway Research Board's Committee on Passenger Transportation Economics were concerned that there had been no major effort to develop a comprehensive research program to determine the economic and social consequences that the Bay Area Rapid Transit system will have. A number of other cities within the United States and throughout the world are considering the development of new urban transit systems, and the experience to be gained from the San Francisco system will be of value not only to the San Francisco Bay Area but also to other cities in their assessment of the values and costs of such a system.

Therefore, the Highway Research Board's Committees on Passenger Transportation Economics and Socio-Economic Aspects of Highways decided to promote a conference to stimulate interest in researching the impacts of the rapid transit system on the San Francisco metropolitan region. The Joint Program on Urban Transportation Study at the University of California, Berkeley, agreed to cosponsor the workshop conference, and from February 9 to 11, 1970, approximately 65 persons from government, industry, and universities met on the campus of the University of California, Berkeley. The purpose of the conference was to recommend research necessary to evaluate the impact of the rapid transit system. The first day's activities included the presentation of a description of the system and presentation of formal papers on considerations related to impacts. The second day the conference was divided into 4 panel workshops to discuss the following aspects of impact research: land use impact, impacts on travel volumes and traffic flow characteristics by all modes, impacts on social and environmental characteristics, and impacts on economics of the region and transportation. On the final day, each panel chairman presented a summary of his panel's discussions, and this was followed by a general discussion by the conferees.

This Special Report contains the conference proceedings that include the formal papers, a summary of the panel reports, and the general discussion by the participants. It is hoped that federal, state, and local governmental agencies, and perhaps industry, will encourage research through providing adequate research funds and that universities and other research agencies will be encouraged by the conference to develop detailed research project statements.

The conferees represented only themselves in their professional capacities and not their agencies. Likewise, the findings and recommendations of the panel workshops and the conference are those of the conferees and are not presented as those of the Highway Research Board.

CONTENTS

TRANSPORTATION AND THE URBAN ENVIRONMENT

W. N. Carey, Jr., Executive Director, Highway Research Board

In behalf of the Highway Research Board, I welcome you to this conference to design a research project statement on the impact of the Bay Area Rapid Transit (BART) system for the San Francisco metropolitan region. If there is any question as to why the Highway Research Board is participating in a conference related to rail transit, there are at least 3 answers. First, HRB is interested in and involved with transportation research, and this conference was considered necessary to outline a well-designed large research program. The interactions and interfaces of rail with highway and with the socioeconomic environment of the area, of course, make it impossible to isolate BART and undesirable to try. Second, HRB has been for many years deeply involved with public transit. In fact, its bylaws call for attention to "highway and urban transportation systems." Some 20 committees of the Board are directly concerned and many others are peripherally involved. At the 49th Annual Meeting of the Board in January 1970, some 10 to 15 percent of the programmed material related directly to public transportation. Third, more than 300 highway impact studies have been made, and their successes and failures should certainly be used as inputs to the development of techniques for this program.

A revolution is occurring in transportation planning, and this conference is a visible example of it. Next January the Highway Research Board will celebrate its 50th Anniversary. During the past half century transportation has made its most significant technological advances and perhaps has had the greatest impact on society of any of the technological developments of several centuries. A close competitor would be communications. The space program is glamorous, but it has not had nearly the impact on society that the development of the motor vehicle has. Because of this tremendous impact, especially on urban structure and life styles, transportation is being currently blamed for many of the ills of cities. We will all readily admit that it is a primary factor in pollution and that urban congestion is deplorable from many points of view. I think, though, that I speak for many transportation planners and administrators when I say that I am unwilling to be defensive about highways and other transportation systems. Although these systems do create problems, many of them serious, society cannot survive without them.

Ten years ago, Dean Boelter of UCLA told us at the National Academy of Sciences Woods Hole Transportation Conference that the movement of people and goods must be approached from a total system point of view. Planners now fully recognize that we can no longer give sole priority to a particular project or to a single transportation mode. In an urban area, of course, we need balance among the modes. It is naive to believe, however, that in balancing a transportation system we will substantially reverse current patterns of freight and people movement. Highway engineers have for some time recognized that highways must fit into the total environment and that they are needed to satisfy public demands for individual transportation. They recognize that highway transportation is a service industry responding to public demands and that social considerations rather than technological considerations will in great measure dictate the future development of highway networks.

For these reasons, transportation systems planners must be wary lest they design systems that will satisfy planning criteria and hardware concepts but that may frustrate public desires. Social and economic considerations warrant the upgrading of urban transit systems, and I think we all hope that Congress will appropriate sufficient funds on a long-term commitment basis to see this vital upgrading achieved. The $3.1 billion approved by the Senate is a good start, and we hope the House will agree. It

is not realistic to believe, however, that high-capacity urban transit systems can be employed to replace the automobile and truck in urban areas. Corridor density, economic constraints, and transit limitations related to less than instantaneous demand response and low flexibility must be considered in the creation of new transit systems. In addition, problems of congestion in the city involve not only peak-hour commuter loading but also movement of freight and commodities in the city.

In trying to resolve urban transportation problems, perhaps we have been too concerned with hardware and not concerned enough with the problem of the basic relationship between transportation and the environment. During the first third of this century, our primary objective was the development of a minimum level of access. In the second third of the century, our primary concern has been on upgrading transportation systems to meet a tremendous increase in demand for travel and for reduction in travel times.

Advances in transportation technology have enabled the public to better satisfy its desire for greater mobility. Rail systems permitted the development of high-density corridors extending outward from central business districts of cities. People could live at considerable distances from their work and enjoy the amenities of less dense living and yet not increase their travel time to and from work. The automobile provided similar opportunities with additional elements of greater mobility and flexibility. It also made possible point-to-point delivery of persons and goods. There can be little doubt that transportation systems have helped shape the structure of cities. In fact, it is my belief that, in urban areas where land as a natural resource is not the controlling factor, accessibility is the key determinant of land use.

We are here to try to determine ways for assessing the impact of a new transportation system on the social and economic environment and on the ecology of the area through which it passes and on the larger region that it influences. BART is the first totally new rail system whose impacts we may evaluate, and I am sure these impacts will influence decisions regarding future installations in other cities, nationally and perhaps worldwide. In your deliberations, I hope you will keep in mind that perhaps we need to reevaluate criteria for determining transportation needs. Perhaps transportation planners should place less emphasis on developing systems to meet forecast demand based on existing travel patterns. Perhaps we should put more emphasis on using transportation systems to influence land use and the structuring of cities so as to shape our common life.

Henry David Thoreau, a century ago, asked the question, "Do men ride on railroads, or do railroads ride on men?" Should technology serve us, or we serve it? Our cities should be a reflection of our social consciousness. As you design a research project statement, I hope you will include the BART system's impacts not only on the economic and social elements but also on the people in the Bay Area, their life style and their living and working environment.

BAY AREA RAPID TRANSIT

B.R. Stokes, Bay Area Rapid Transit District, San Francisco

Bay Area Rapid Transit is a 75-mile, dual-rail, rapid transit network with high-speed electric trains serving 33 regional stations in 15 communities. The service area of the Bay Area Rapid Transit District (BARTD) comprises the counties of Alameda, Contra Costa, and San Francisco, whose voters in 1962 passed a $792 million bond issue to build and operate a rapid transit system. The system's lightweight vehicles (250 are now in production at the Rohr Corporation plant near San Diego) will be capable of top speeds of 80 mph and operating speeds of 50 mph, including station stops. Each car, and BARTD eventually will have 450 such vehicles, will accommodate 72 passengers in upholstered seats and will feature carpeted floors, automatic air conditioning, a specially designed reading light, and wide windows.

Power to propel BART trains will be 1,000 volts of direct current, supplied to the vehicles from a trackside third rail. The 1,000-volt power system will permit an acceleration and deceleration rate of 3 mph/sec and, with stations spaced an average 2½ miles apart, will allow the 50-mph operating speed, more than twice that of existing systems.

BART cars, by contract specification not to exceed 56,000 lb in total empty weight, will travel over continuous-welded rail. The rail is delivered in 1,480-ft lengths, Thermit-welded on site, and then attached to either concrete ties or solid concrete roadbed. Elastomeric pads between track and fastener are used to further reduce sound.

In order to ensure high operating speeds and eliminate sway, BART tracks are spaced 5 ft 6 in. apart instead of the conventional 4 ft 8½ in. BART travelers will travel atop 25 miles of architect-designed aerial structures, through another 25 miles of subway, and another 25 miles of surface track, the hard-rock Berkeley Hills Tunnel and the Trans-Bay Tube. The tube extends for 3.6 miles between the cities of Oakland and San Francisco. It is made up of 57 individual tube sections, each fabricated at a San Francisco shipyard, concrete-lined, and floated into position over a trench dredged across the floor of the Bay. Delicately lowered into position, each section was connected to its mate, made watertight, and the process repeated until the crossing was made. Currently, track and electrification contracts are in force in the tube, and, when operational, the tube will permit BART trains to travel between downtown Oakland and downtown San Francisco in 9 minutes. This $180-million project is being financed by the state through surplus bridge tolls.

A $26-million automatic train control system, now installed at the Lake Merritt Station in Oakland, will be responsible for the starting, stopping, speed levels, door movements, and proper spacing of trains. The computer, linked to wayside and in-station signaling equipment, can make as many as 6,000 command decisions every half second for the control of as many as 105 trains on the network at any one time.

A highly sophisticated fare vending and collection system is also being installed throughout the stations. Based on the stored-fare principle, this system allows tickets to be purchased for any amount ranging from 25 cents to $20; the amount paid is magnetically encoded on the back of the ticket. The BART user triggers a turnstile at the start of his trip, identifies himself as to point of entry, and repeats the process as he leaves the system. At this point, the turnstile automatically subtracts the necessary money for miles traveled and visibly imprints on the ticket the remaining value. Equipment involved in this $5-million contract includes vending and collection machinery, money changers, add-fare equipment, and a station agent's reader to assist ticket users.

Twelve architectural firms, supported by 9 landscape architects, are at work on stations and their parking lots. These facilities range from low-profile surface stations in Orinda and South Hayward to varicolored concrete structures in El Cerrito and the bright tiles and expanses of glass at Hayward. Subway station design runs the gamut from complex, 3-level transportation centers beneath Market Street in San Francisco to simple clear-span stations beneath Shattuck Avenue in Berkeley and Mission Street in San Francisco. Parking lots at suburban stations range in capacity from 1,500 cars to 450 cars. We are engaged currently in a study to allow BART patrons free use of the lots, while charging the non-BART user.

We have been fortunate in reaching agreements with other agencies within our service area that permit BART to adjoin railroad rights-of-way for some 20 miles and to share common transportation corridors with the California Division of Highways. One agreement with the Division of Highways involves 3½ miles of the new Grove-Shafter Freeway in Oakland. BART lines and 2 of its stations lie in the median of the Grove-Shafter: MacArthur Station bridges 40th Street, and Rockridge Station is at the intersection of College and Shafter Avenues in North Oakland. In Contra Costa County, 2 BART stations and 7 miles of transit line occupy the median of a widened and relocated Cal-24 extending from Orinda to Walnut Creek. A third highway-BART agreement permits tracks to run alongside the Southern Freeway in San Francisco for nearly 5 miles and alongside a not-yet-completed freeway in Southern Almeda County for another 5 miles. BART's working arrangement with the Division of Highways has proved so successful that the District recently asked the California Transportation Agency to provide an extra 10 ft in the median of a highway reconstruction project in eastern Contra Costa County for use by BART when service is extended to that area.

Currently, the total construction program is more than 65 percent complete. We have 3,200 workers engaged in 53 separate contracts throughout the system and earning a weekly payroll in excess of $1 million. Engineering design is more than 95 percent complete, and the property acquisition program, a $93-million undertaking in itself involving 3,600 parcels, is 98 percent complete. Subway station excavation in San Francisco is virtually complete, and street restoration should be well along within the next few months. Excavation is complete for the 2 Broadway stations in Oakland, and the street has been restored. The same can be said of Central Berkeley, where the station shell now awaits the architectural finish contract.

The most dramatic example of the District's construction progress can be found in southern Alameda County, where some 17 miles of aerial line and 6 stations are nearly complete. Stations in San Leandro and Hayward are 95 percent complete, and line contracts are now in force for Union City and Fremont. Completed aerial structures stretch for more than 6 miles in the cities of Albany and El Cerrito, and very shortly the BART board is expected to award station construction and finish contracts for El Cerrito.

BART was fortunate in receiving a $447,000 federal urban beautification grant to carry out a 2.7-mile linear park alongside and beneath aerial structures in Albany and El Cerrito, complete with grassy play areas, wide walkways, a variety of street and shade trees, lighting, and benches. We now are in the process of applying for federal matching funds so that similar landscaping treatments can be carried out along other segments of the network.

We have determined that the full cost of the 75-mile system will be $1.38 billion. A rough breakdown shows that $792 million from general obligation bonds approved by voters in 1962, $180 million from surplus bridge tolls for the Trans-Bay Tube, $78 million from revenue bonds for the purchase of rolling stock, $114 million from federal demonstration and capital construction grants, and $150 million from a half-cent increase in the sales tax (from 5 to 5½ cents) commencing in April 1970. Until April 8, 1969, that $150 million represented a deficit the District had been faced with for some 3 years. The Governor then signed into law Senate Bill 2, erasing the deficit, and permitting the District to proceed on a definite construction and operations schedule.

The first step was to place an order for 250 cars of the eventual fleet of 450. This move was impossible until Senate Bill 2 was signed because the cost of the cars was to be borne through revenue bonds, and no investment house would even consider

revenue bonds sold by a project that had a good chance of not being completed. The next step, based on car delivery dates, was to establish operating schedules. The first 10 prototype cars will be delivered to the District in August 1970, and will be extensively tested for a full year on the southern Alameda County line.

Then, in the fall of 1971 we expect to commence revenue operations from Fremont to MacArthur Station in North Oakland. Within weeks, we will bring in the Concord-to-MacArthur segment and then the Richmond-Berkeley line. By mid-1972, we expect to have the full system in operation, with trans-Bay service into San Francisco and out to Daly City.

We expect commute times to be slashed by as much as one-half to two-thirds with BART. Our people-carrying capacity is 30,000 seated passengers per hour on a single line in one direction. We are convinced that when the Bay Area resident is offered a choice in his mode of travel he will choose BART, a mode that is fast, convenient, and reliable.

IMPACT OF THE BART SYSTEM ON METROPOLITAN LAND USES

Britton Harris, University of Pennsylvania

Although there will be many other opportunities at this conference to discuss the general framework for transportation planning and evaluation, I shall, as a framework for my own remarks, make a brief attempt at the same thing.

Quite clearly, transportation is an intermediary service whose effectiveness depends on the larger context in which it is embedded and its influence on the social purposes that it aims to serve. In general, these purposes have to do with interaction of the type that is necessary for both production and consumption. The transportation of goods and the transportation of people form 2 different aspects of both production and consumption, but I will disregard the transportation of goods at this point, for 2 basic reasons. First, the evaluation of the BART system does not involve the transportation of goods except very indirectly and, second, in any case, the transportation of people is far more costly and more important for the welfare of the community.

The movement of people in production and consumption leads into a system of interaction in which the various aspects are inextricably interlinked. By way of example, consider the journey to work. Superficially, this journey is necessary to assemble the factors of production and consequently to produce. In basic concept, and in some land use models, however, we can regard this as a trip from work to home, and thus as a trip that is made for the purposes of consumption of housing. This view is not at all unrealistic in the sense that improved transportation systems may lead people to make longer work trips in order to enjoy better housing. The same illustration, therefore, also suggests that lowering total transportation cost is not a good direct measure of the efficacy of the system because such a measure underestimates the benefits of increased choice that accompany an improvement.

In this context and with some additional thought, we can therefore distinguish a number of levels of the impacts of transportation systems on the welfare of a region. In the first instance, we have the level of convenience, safety, and cost to the collective users of the transportation system. This is a conventional standard by which transportation performance is measured, and it is by no means an insignificant one. At a second level, we have the impact of the transportation system on the choices available to both residents and businesses regarding consumption and production in the metropolitan area. The exercise of these choices inevitably leads to changes in the land use pattern, and consequently we look to these changes for one type of measurement of this effect. A third type of impact has to do with the influence of the transportation system on the environment through noise, air pollution, vibration, and neighborhood disruption. A fourth type of influence arises because of the impact of transportation arrangements on the total efficiency and amenity of the metropolitan region, which in turn leads to acceleration or deceleration of the growth of the region in competition with other regions with different transport arrangements. Finally, a fifth consideration cuts across all of these and comprises the considerations of equity with respect to all of the impacts on impoverished and minority groups within the population. Quite clearly, given the present social goals for metropolitan planning, our view of each of these impacts must be substantially disaggregated by contrast with many past analytical approaches. This disaggregation will enable us to compare the status of many different groups of the population under transportation alternatives.

This paper is concerned principally with the second level of measurements. That is to say, we are concerned with the impact of a transportation system on the choices available to the population of the metropolitan region with respect to production and consumption. We expect to be able to track the use of these choices directly through changes in travel patterns, which I will not discuss, and slightly less directly through

the impact of these choices on the development of land uses. At the same time, a study of the development of land uses will lay a basis for a much richer and more complete evaluation of the impacts of a new transportation system.

The remainder of this discussion raises more problems than it answers. This is intentional because the paper is being presented to a conference that aims to develop methods and concepts. I do not wish to presume to anticipate the very great contribution that we expect to get from the participants in the conference. If, therefore, anything that follows seems too dogmatic or strongly opinionated, it may be taken as an effort to stimulate a reaction and a discussion.

In the framework of this introduction, the problem of dealing with the land use and related impacts of the BART system may be divided into 3 very broad categories. There is the simple problem of collecting and perhaps processing relevant information. There is a problem of interpreting or digesting that information. And there is the problem of evaluating the picture that emerges from this interpretation. It will perhaps be beyond the scope of any studies undertaken to make a final or even an interim evaluation of the BART system. Nevertheless, we must include evaluation in our scheme in order to structure our thinking. We might better, therefore, reverse the order of steps and say that we must decide how the performance of a system will be evaluated in order to decide what performance characteristics need to be measured for the total system (that is, total metropolitan living arrangements); and in order to construct these indicators of performance, we must determine what data will have to be collected. Quite obviously, these various considerations interact, and we cannot propose to make evaluations or construct indexes of performance where the costs of data collection or data processing are exorbitant or where the reliability of the only available measures is very low indeed.

In spite of the fact that I am generally unsympathetic to the idea of saying "Our first step will be to take an inventory of the situation," I will nevertheless start with a brief canvass of the data situation because of the priority that must be given to considerations of evaluation and interpretation.

Over the past 10 years, very substantial strides have been taken in the development of urban metropolitan data systems—at least in principle. We now know a great deal more about the nature of the data requirements for analyzing metropolitan systems, about the availability of data and the costs of acquiring it, and about the potential methods for managing data files. Unfortunately, this knowledge and the available computer technology that could be used to implement it have not yet given rise to any substantial data banks. We are thus all familiar with the fact that in most respects the initiation of a large-scale transportation study (such as was conducted in the Bay Area in the mid-sixties) is the principal occasion on which comprehensive and large-scale data bases become accumulated. For comparative impact studies of the type that we will be discussing here, data bases that have to do with the distribution of activities are important, and important at more than one date. Because I happen to believe that such data bases will be needed for a wide variety of planning purposes over a long period of time, I am not bashful about suggesting the basic content of such a data base, or about reviewing certain necessities in terms of the acquisition of information.

Basic population information is available by census tracts for any metropolitan area for years evenly divisible by ten. There is some anticipation that the coming decade will see the inauguration of a quinquennial census, with data being collected in 1975. The 1970 Census will be highly accessible and will contain a wealth of detailed cross-tabulations that were not available in previous decades. For this reason, it is, in my view, the pivotal data element for an evaluation of the BART system. If, however, a 1975 census is not taken, a number of serious problems about securing comparative data could permit conclusions to be drawn in the immediately foreseeable future. Because a large number of the effects of the BART system will in effect be long run, it is not entirely unreasonable to say that the first really complete evaluation will have to be made at the time of the next really complete federal census, be it 1975 or 1980.

At the same time that we need to know about the location of population on a basis that comprehends the social and economic characteristics of that population, we also need to know something about the distribution of employment. The fine-scale distribution of

employment in a metropolitan area is not the object of any ordinary ongoing federal census activity. The periodic publication of County Business Patterns gives employment at the finest possible SIC detail, but not at the necessary levels of area detail. The sporadic Census of Business and Manufacturing is not complete in its coverage and not very small-scale in detail. The best complete data file for the San Francisco region was compiled by the Bay Area Transportation Study Commission, and unfortunately this does not correspond in date with any comprehensive survey of the distribution of population except as is reflected in the BATSC origin-destination survey. There are 2 alternatives with respect to the long-term distribution of industry by category and by small areas. One is to rely on the feasibility of turning the Census of Population inside out. This depends in the first instance on proper coding of the location of place of work and in the second instance on resources for tabulation. These issues should receive detailed local attention. There are still other difficulties in relation to the coding both of the location and of the industry that may or may not prove to be insurmountable, given the way in which census data are collected. The second approach is to initiate periodic and repeated retabulations of the State Bureau of Employment Security records. In this case multiple establishments reporting from a single employer have to be disaggregated, and many other adjustments have to be made. In my view, however, this is the method of choice, because conceivably standardized procedures can be set up and undertaken at regular intervals, say annually or biennially, to the substantial advantage of local planning, including transportation planning.

A third basic element of a land use data base consists of some kind of classified tabulation, currently updated, of land and structures. Except for things such as bay fill, land is essentially a constant quantity, although the subdivision of parcels creates record-keeping difficulties. Structures in place are also constant quantities except that it would be nice to have a record of the condition of the buildings, which changes over time. A recording of these data is currently not feasible unless code enforcement is being very vigorously pursued in most municipalities, and records are accessible and translatable into a form for machine processing. The real issue, therefore, becomes the updating of structure files for new construction and demolitions, preferably given some base year data. For residential structures, the Census will provide a benchmark of a sort; for nonresidential structures, it is conceivable that the BATSC files could be employed. Because new construction and demolitions are ordinarily governed by permits, a permit file can with some qualifications be used to update a structure file. Because the news that we have about the impact of BART on the San Francisco economy is already stressing the amount of construction that has taken place, obviously any valuation scheme will be somewhat sensitive to the tabulation of these variables. A scheme for dealing with them either from local records or on the basis of sampling with periodic universe surveys will have to be devised.

One of the most difficult aspects of metropolitan data for purposes like those presently in hand is the issue of valuation of land and structures. Residential structures, with the land on which they stand, are usually valued more or less reliably by their owners in the census or implicitly by the report of the rental value of their occupiers. Data of this type do not exist for commercial activities because in most cases the rental or owner valuation of nonresidential buildings is not available. A major data processing activity might have access to assessment records, but it is well known that many problems arise regarding the interpretation of these records. The levels of the assessment in general, the unevenness of the assessment, and the tendency for assessments to lag behind current market prices are but a few of the issues involved. Nevertheless, I cannot see any easy way to evaluate the impacts of a large-scale transportation change without understanding the impact on values as well as on volumes of construction and occupancy.

We may now set the question of data temporarily to one side and take a look at questions that have to do with the interpretation of the data. Insofar as possible, I hope to hold the question of interpretation slightly separate from the question of evaluation. There are a number of issues of interpretation, and I will try to take them up one at a time.

In the first instance, I do not think that it would be wise in general to undertake any partial interpretation, whether based on partial data or not. For example, if we had data about the volume of construction of commercial space around the BART subway stops, we would, I think, find it necessary to attempt to evaluate the vacancy, abandonment, and decline in economic value (or at least the observed changes) among similar properties located elsewhere within the metropolitan region. The question that is relevant here is whether the change in the transportation system is in fact changing property values or only redistributing them. It also seems likely that the changes in commercial values and in residential values might be expected to move in opposite directions. That is, if a new transportation system such as BART facilitates the concentration of commercial activity and the dispersion of residential activity, then the prices of centralized commercial land would be higher than those ordinarily expected and the prices of peripheral land might be on the average higher. Nothing could necessarily be said about the totality of land values.

The discussion in the preceding paragraph has of necessity referred to some set of comparative values having to do with what would "otherwise" have happened. The necessity for this comparison raises 2 additional issues of interpretation of major importance. The difficulty of providing a standard of comparison for measured events is undoubtedly the most vexing problem in the whole evaluation procedure.

One approach to the problem of comparisons would be to select one or more control cities in which major transportation innovations are not immediately anticipated. Such a metropolis should be approximately the same size and industrial composition as San Francisco and should have a prospect of enjoying approximately the same growth rate. The types of candidates that might be considered probably include Seattle, Denver, the Twin Cities, Houston, and Phoenix. It would be desirable in the control city to collect much of the same information as would be used in evaluating the impacts of the BART system, on both a before-and-after basis. This suggests among other considerations, therefore, that we would have to take into account the local capabilities for data collection and data management in making this selection. Such a control city should in any case either be conducting a large-scale transportation study or have a very lively multipurpose regional planning agency.

The problem of using a control city is of course expensive and chancy. It is chancy in the sense that there may indeed be peculiar features of San Francisco that cannot be captured in any other city, and also in the sense that if only one control is selected its basic developmental motivations may diverge from those of San Francisco in the next decade. As a hedge against the unreliability of control methods as a basis for interpretation, it is therefore important to develop projection methods that provide a more or less self-contained basis for comparison. Two fundamentally diverse approaches to this problem may be considered.

At the simplest level, and in any event, the impact study should attempt to make trend projections, probably based on BATSC data and on the 1970 Census and extended into the 1980 decade, perhaps in 5-year increments. Similar trend projections may have been undertaken by BATSC and by other planning agencies in the region, but in order to provide a basis for evaluating impacts, they now have to be redone on the assumption that the BART system is nonexistent.

A general difficulty having to do with projection systems of any kind is whether a divergence from the projection signalizes a failure of the system or a basic and unanticipated change in the total environment. This problem is endemic to transportation studies and cannot be evaded with respect to the evaluation of the BART system. It poses a major problem of research strategy that I believe should be discussed at this conference but on which I am not prepared to make any detailed advance statements.

In this connection, however, I would recommend that a part of the BART evaluation study go back to the original preliminary surveys justifying the project as they were made in the middle and late 1950's. These studies should be examined in minute detail from the point of view of their reliability as predictive and projective systems, and the final output should be a 3- or 4-way comparison. One element would be an independently projected Bay Area status without BART. Another would be an actual measurement of the regional situation with BART. A third would be the projection made by the consultants of the region with BART, and a possible fourth would be any projections made at

the same time without BART. This comparison, it seems to me, is essential for the ultimate improvement of the transportation planning process, because there is some reason to believe that the actual performance of the BART system will diverge somewhat from the projections made by the consulting engineers. Such divergence, if it exists, may be a weakness in the transportation planning process and should in any case be subject to careful scrutiny and possible future correction.

This discussion then introduces the second and related issue with respect to the attitude of this impact study toward projections. It is perfectly clear that a trend projection of past developments that does not assume the existence of the BART system is probably simpler than a reliable projection of what will indeed happen under the BART system. I think it should be a matter of discussion for this conference whether the impact study should involve itself in projecting a future for the region with the BART system. This would be an exceedingly valuable exercise in view of the 15 years or so of experience in land use modeling since the original projections were made, and it is an opportunity that will not occur frequently in terms of the mass of data and the extent of technical capability that ought to be assembled for the evaluation of the system. It is not, however, strictly necessary for an evaluation of the impact of BART. It is necessary only for some type of evaluation of the capability of transportation and land use modeling methods.

In spite of the relative low priority that I give this type of projection, I think that one rather telling point can be made about a comparison between transportation forward planning methods and transportation impact evaluation methods. It is probably fairly obvious that no very good evaluation of the BART impacts can be made without, as I have discussed earlier, measuring changes in property valuations. The question therefore arises, if land values are important in an ex post evaluation of transportation impacts, are they not equally important in an ex ante evaluation? If the answer is yes, we must acknowledge that very few land use projection models enable us to predict land values under alternative assumptions as to transportation systems. It might be wise in the course of this study briefly to explore issues of this type.

I turn now very briefly to the question of the evaluation of impacts. This question, as I have suggested, will probably arise at a much later date in the study, and the actual evaluation will be undertaken largely outside the impact study on the basis of its interpreted results. The study staff, however, will want to be able to make selected evaluations on its own account and, at the same time, will wish to be sure that the proper information has been provided to the evaluators and decision-makers of the region and elsewhere. It is quite certain that large numbers of people all over the United States, and indeed all over the world, are watching the outcome of the BART experiment with considerable interest. They will not be entirely satisfied with figures regarding ridership, schedules, and financial performance. Indeed, it is assumed in advance that, on the basis of overall financial accounting, BART will not be self-liquidating and that the benefits that will accrue to the residents, businesses, and land owners of the Bay Area fully justify their assuming most of the capital costs of the system. The evaluation of land use impacts is therefore a nontrivial aspect of the total impact study.

I think there are 2 or 3 different ways of looking at valuation that may be of use in the discussion of methods for interpretation and data collection as they will certainly be undertaken in the impact study and with respect to the valuation itself. These questions essentially have to do with the worth of a land use plan to the users of the plan and the relation of these impacts to broader social goals. There will also be a residual problem of separating the impacts of transportation per se from possible coordinated land use planning efforts.

Even though the property valuation changes that take place partly as a result of transportation changes are important, they are not the final measure of the impact of transportation on land uses. In this respect they are analogous to transportation costs that are not the final measure of the efficacy of a transportation system. The direct impact of land use changes fall differentially on 3 general classes of entities—households, businesses, and land owners. The social goals that we will discuss have to do with other impacts that are valued by the community but that are not measured by their effects on these 3 groups of people.

As far as households are concerned, it is probably feasible to make global estimates of the utilities that they derive as the result of land use and transportation patterns combined. These utilities have a limited set of components. First, households may receive more or less housing benefits in the form of space, amenity, and quality of shelter. Second, they may obtain more or less advantages of accessibility to opportunity within the region, considered quite separately from the costs that they incur in interaction. Third, under any given set of arrangements, their transportation and living costs will be determined in relation to their income, leaving a certain level of purchasing power for all other expenses. In general, and with an exception to be noted later, the costs of these other expenses are not very much influenced by housing and transportation arrangements.

The expenses of businesses are influenced by transportation and land use arrangements in ways that are somewhat difficult to estimate and that may not be easy to evaluate in an impact study. These expenses, however, can be translated into impacts on the resident population in the following ways without raising many difficult issues of evaluating business interests. First, if transportation and land use arrangemnts make it cheaper or more expensive to provide goods, services, and amenities to the resident population, their purchasing power will increase or decrease for the subset of nonlocational goods that they purchased locally. Much of the costs of most purchased commodities are determined, however, outside the metropolitan region. Second, if local land and transportation arrangements affect the costs of export industries or of service industries supplying export industries, their competitive positions in the United States and world economy will be influenced. Two types of adjustment are possible. Low costs may stimulate growth and high costs may discourage it; equally likely, it seems to me, is the probability of a wage adjustment in the export industries. In this case, households are directly affected. It seems unlikely, however, that the bulk of these economic effects can be very well estimated in an impact study of the type we are discussing, and approximate methods will have to be sought.

The impact of particular plans on land owners will be reflected directly in the values of their properties. How this is to be translated into social welfare functions is a problem on which I am not presently prepared to take a stand. In general, there seems to be a view that, for purposes of getting things done, an anticipation of profits will make some groups of real estate owners vigorously vocal but that, for long-run evaluations, their interests are speculative and do not reflect real income and should therefore be disregarded. Some further discussion of this topic might be useful.

There are obviously a certain number of major social objectives that cannot be measured by the present impact on individual entities such as households, businesses, and land owners. One of these is the preservation of the environment, both at present in terms of the protection from pollution and in the future in terms of a much broader scale of conservation. Many conservation goals must be pursued through the use of the police power rather than through the impact of transportation systems like BART and are hence excluded from present consideration. Public open space and recreational facilities that are related to conservation are only one of the many public services whose supply and enjoyment is strongly influenced by the transportation and land use system. Some review should probably be reserved for the adequacy of these public supply systems in view of the increasing relative importance of public goods in American consumption. A most important social goal in terms of opportunities for choice has in part been taken care of by our previous discussion of accessibility, but it may very well be that the community as a whole may wish to place a higher importance on accessibility to employment, recreation, and other goods than the individual does, so that these possess a value higher than that reflected in individual utility functions. There are many parallels in the community insistence on adequate levels of health and education for the general population, even without regard for the preferences and utility functions of the consumers of these services.

The final and quite possibly overriding social goal in present American planning is equity. I do not here presume to make any definition of this difficult concept nor to suggest how it can be reconciled with many other social goals with which it may to some extent conflict. It is quite possible, however, to assert that transportation and land

use arrangements will have differential impacts on many different ethnic, social, and economic groups, and that currently, insofar as possible, there is a strong tendency to attempt to respect the interests of those groups. A sound evaluative scheme will therefore demand evidence as to these impacts, and this means that transportation and land use measurements and predictions must be as disaggregated as possible on these various dimensions.

Looking back over what I have written, I think that there is ample room for much detailed and specific discussion of topics that I have purposely slighted or inadvertently omitted altogether. I share what I think is the feeling that the BART experiment is of major importance in urban transportation planning and that its effects must be carefully weighed in relation to a potential of many billions of dollars of expenditure that may be either properly directed or misdirected. The program of study that I have laid out is intrinsically ambitious and would ultimately, in conjunction with other topics discussed elsewhere at this conference, entail very large expenditures. But if my assumptions about the importance of a proper evaluation of BART are correct, even expenditures of tens of millions of dollars, properly directed, would not be amiss. I hope that we will be able on the basis of our discussions to make some contribution, first, toward keeping these expenditures within bounds but, second, toward giving them proper direction and ensuring the adequacy of the results.

SOCIAL AND ENVIRONMENTAL IMPACTS OF THE BART SYSTEM: NEEDED RESEARCH

Donald L. Foley, Douglass B. Lee, and Donald Appleyard,
University of California, Berkeley

The social impacts of BART is not a separate topic from, say, economic impacts or land use impacts but rather a different set of viewpoints for looking at many of the same phenomena. As we spell out these viewpoints, it will be clear that they particularly adhere to the central questions: Who gets served by BART? Hence, who benefits? Who is not served by BART? Hence who, indeed, bears the costs? Note that the viewpoints we propose start with all of the residents (and visitors) in the Bay Area and examine how BART impinges on them, their lives, and their desires to carry out various activities.

An important viewpoint influencing our approach to needed research is that the study of nonusers and infrequent or irregular users of BART is as important as the study of regular or heavy users of the system. A pivotal question is, What are the blockages to use (or to greater use) of BART? Also, What are discrepancies between the use that was envisioned by the designers of BART and the use that is actually being made of BART? Interestingly, such questions have various connotations: theoretical, public policy, and pragmatic—the last, perhaps, virtually akin to market research. They zero in on the importance of understanding why potential service is not used rather than of emphasizing the characteristics of trips that are made on the system (1).

Perhaps an even more central viewpoint providing a theme for our approach stresses the differentials in the relative use made of BART by different categories of persons in the Bay Area—categories judged to be socially significant. We would argue—and we develop this point further later—that, in terms of social impact of BART, understanding these differentials in usage may be more important than concentrating on aggregated, total, or average measures of usage. We suggest that it may be particularly important to know whether the relatively greater use is by the socially advantaged or by the socially disadvantaged segments of the population. Other differentials are also of very great importance, and we sense that these differentials are not commonly ferreted out and stressed as social impacts in the typical transportation study. It is also evident that BART will inevitably have very wide-reaching impacts on countless nonusers, or more accurately, on persons in their nonuser roles who also may or may not be users of the system.

We shall now expand these main points, and we shall then suggest examples of possible research that would seem promising. Our interest is in encouraging research that will monitor the early and evolving operations of BART in the spirit of providing inputs for possible policy and administrative modifications in the system. There is little point to research for research's sake; we urgently need research that will further the improvement of service to BART's users and potential users.

DISTRIBUTIONAL IMPACTS OF BART

A focus on differential usage or impact paves the way for analysis of the actual distributional impacts of BART and for possible review of public policy setting forth intended distributional impacts (2). These types of questions follow:

1. What benefits do persons in various social categories receive from BART? Usage, perhaps preferably expressed as a rate of use, i.e., actual users as numerator and potential users as denominator, is one direct measure. There are other less direct measures, e.g., store owners, employers, or property owners may receive benefits, often indirect.

2. What costs are borne by persons in these various categories? These may be direct monetary costs, taxation, or user charges; or they may be social costs borne by those who are relocated or adversely affected by the proximity of the BART route.
3. What is or should be the public policy regarding the direct or indirect distributional effects of BART? With changing times, we are witnessing possible shifts in the public priorities as to the social categories of persons to be served. We can readily envisage further shifts in the future. Such public policy deserves to be openly aired. If subsidies are intended, are they getting through to those for whom they were intended? Or do the benefits flow, rather, to those who do not need to be subsidized?

The social categories employed will have to be carefully thought out, and heuristic criteria employed in their selection. If emphasis is to be placed on disadvantaged persons, categories must be employed that offer operational definitions of disadvantage. Examples of social categories of persons are age and sex, income, occupation, place of residence, homeowner or renter, employment, place of work, student or nonstudent, ethnic status (whether member of minority group), automobile accessibility, and other special conditions affecting or limiting access to transportation facilities. Characteristically, the most significant social categories may represent combinations or cross classifications of these categories (e.g., persons of older age and low income; persons of low income and of ethnic minority and, possibly, residing in a ghetto district of a central city). Other categories, perhaps relating more properly to the trip than to the person taking the trip, include usual trip length, degree of familiarity with the BART system, and times of day when trips are usually made. Such breakdowns aid in differentiating types of users and trips.

IMPACTS ON USERS AND NONUSERS

Certainly a major dichotomy is between user and nonuser of the BART system. This is viewed as a distinction between social roles. A particular person may conceivably occupy both roles, e.g., as periodic rider on the system and as homeowner or store manager in locations near the system.

User

All individuals are potentially users of the system. Some may never actually use the system but remain potential users, and the concern of impact research is then with why they do not use it. Some may be essentially excluded from the start as being outside the range of the system, but they may, nonetheless, occasionally use BART. Other individuals may use the system for certain purposes, e.g., for recreation trips only or for work trips only. Others may be heavy users who make trips for multiple purposes. Thus, actual usage is distributed in some way over the population, and the zero-users are simply at one end. Rates of usage and changes in rates or levels of usage include as backdrop or base all individuals or, more precisely, all individuals of the social category being examined. Within the user category are the following:

1. Captive or dependent users who have no alternative access to an automobile; i.e., there is no automobile in the household, an automobile but needed and used by other members, no license to drive, physical infirmity. Demand by such users may in part be latent, for, not having ready access to transportation, they may have grown accustomed to not using transportation.
2. Marginal users and nonusers who would be gained or lost by the system depending on marginal changes in the system or possible changes in users' resources or situation. Marginality may involve different parameters: price and ability to pay, speed and time constraints, comfort, and the like. Much may depend on the feeder systems at one or both ends of the BART trip.
3. Optional users who have access to an automobile or other transit mode but may select BART some or most of the time. This may be selective by type of trip, e.g., only for the trip to work.

Nonuser

Virtually all individuals are affected by the BART system quite apart from being actual or potential riders on BART trains. We suggest some of the following types of nonusers:

1. Property owner whose property may gain or lose in value or be otherwise affected and who must pay property taxes for support of BART.
2. Resident whose home or neighborhood is affected by proximity to a BART line.
3. Person in business, manufacturing, or service activity in which the activity is affected by proximity to a BART line.
4. Persons in or moving about the city for whom the physical presence of BART lines, stations, trains, and equipment constitute a part of the urban environment.

SUBSTITUTION AND INCOME EFFECTS

Conceptually, impacts on the activity patterns of users can be separated into 2 kinds.

1. Substitution—changes that result in substituting BART, because BART offers a relative price change, for some other transportation activity, such as decreasing automobile usage and increasing transit usage, or some nontransportation activity, such as using BART to attend games at Candlestick Park and having fewer backyard barbeques.
2. Income effect—changes that result in increased personal resources to spend and consequently lead to more activity; e.g., using BART leaves people with more time or money that becomes available for other things. This could lead to (a) new trips on BART neither previously possible nor thought of; (b) new opportunities that increase total income and lead to increased use of transit or transportation in general; and (c) new nontransportation activities generated as a result of increased actual budget or increased residual budget because BART has made the transportation budget smaller.

POSSIBLE STUDY DESIGNS TO BE CONSIDERED

We now suggest ideas for research on the social impact of BART. These vary, proposal by proposal, in relative balance as between substantive focus and methodology. Greater stress is placed on methodology by the first three than by the remaining ten. Some of the proposals toward the end of the list verge toward rather precise topics and might be absorbed into larger projects.

1. In-depth longitudinal study of persons representing both user and nonuser blocs and representing a range of social characteristics. If possible, a before-and-after design would have advantages. A comparison of informants who do use BART with those who rely entirely on the automobile would also be desirable. This study would seek to make a comparative assessment of the many ways in which the quality of people's urban life is affected by the BART system. There have been many claims for and against transit systems. In the Bay Area we will have a chance to compare transit and automobile systems that are in equally good condition. Such a study could, over time, focus on the changing life space of a system user, his evolving activity patterns, his perception of the system, and his attitudes toward the system. Main emphasis could be on the transit system, but attention would need to be paid in a comparative sense to users of the highway system. The study should determine whether the new transit system expands the life space of most inhabitants or whether it contracts it. How are the travel patterns affected? Do people travel farther and more often? For what purposes do they travel, other than commuting? Is transit used on weekends? Does using transit force users into more rigid and routine patterns? Or into greater flexibility in travel patterns? How does its impact on persons of lower income compare with that on more affluent users? How do users and nonusers learn about the system? What are their images of the system? Does use of the transit system affect users' comprehension of the larger city? (There is some evidence that transit travelers find it difficult to piece together a ready comprehension of the larger city.) What will travelers see as the effective environment of the transit system? Will they be more concerned with vehicular design or with stations? Where will the points of high attention and vulnerability to

failure be from the users' viewpoints (3)? Will BART travelers come into more or less contact with members of other social groups, with accidents, and with the natural environment than those who travel by automobile?

2. Sample survey of all households, perhaps with a sample design featuring oversampling of certain disadvantaged households, aiming to reach actual and potential users of transit. The main spirit of such a survey might probe why BART is not used, if that is the case, or how BART works out in use, if in fact the informant does use it. If BART is not used, what are the blockages that seem to stand between potential users and effective use? Questioning should be directed not only at trips made by other modes of transportation but also at trips that the informant would like to be able to make but finds he cannot. A careful investigation into the types of people who use and do not use BART could be very useful. Apart from the usual social categories of class, income, and the like mentioned earlier, determinations by survey means of general environmental dispositions might show whether, for example, urban or rural dispositions or security seekers were the more frequent users of the system (4).

Because good survey research is expensive, it would be desirable to tie such a survey with other ongoing surveys to take advantage of sample designs already developed. Perhaps this could be through the Regional Transportation Planning Committee, or perhaps through an organization like the Survey Research Center, which is on this campus, that is seeking to develop a continuing Bay Area sample survey. In addition to a single broad survey, a continuing series of interviews through a panel approach would have clear advantages. Such a panel might approach the spirit of study 1, already suggested, or it might emphasize the repeated use of similar questions so as to monitor reactions over time. The character and completeness of the system, including the ties with feeder lines, would be expected to evolve gradually, people's knowledge of the system will grow with time, and use of the system may grow or change.

3. Longitudinal studies featuring statistical indicators and empirical data on trips. These may range from macro-analytic to micro-analytic. Macro-analytic studies could follow BART statistics through time and compare them with other indicators to determine, for example, to what extent demand follows supply and vice versa, or how relative shares of usage among user groups shift over time. Micro-analytic studies might follow individuals through the system from the time they leave their places of origin until they reach their destinations. Comparable trips by other travel modes may also be studied to see where BART's advantages and disadvantages are with respect to client groups. These studies may show where feeder systems are unsatisfactory, where particularly irritating or uncomfortable events may occur such as excessive waiting time and real or imagined opportunities for crime, and where individuals fail to receive efficient service from the system either because of their own ignorance or because of weaknesses in the system.

4. A study of reverse commuting and of trips in directions other than the main inward commuting trips to the main centers of San Francisco and Oakland. Particular emphasis could be directed to the problems of getting to destinations beyond ready walking distance from outer BART stations where regular inward commuters can park or to which they can be driven. How do outward-trip passengers get service in suburban low-density districts? There are land-use impact aspects of such a study as well. The original rationale for the BART system was to foster the development of strong, compact centers near those BART stations deliberately located in these centers. A very large question is whether this is occurring and whether an appreciable number of destinations are thus brought within ready walking distance or otherwise conveniently available.

5. A study of the service provided for persons in low-income households. How effectively does BART serve low-income residents and, particularly, the residents of ghetto districts? According to Kain and Meyer (5):

> Many proposed new systems, such as the BART system in San Francisco and the transit extensions in Boston, will provide only nominal benefits for the poor In fact, it is probable that both systems will have a highly regressive impact They are to be subsidized out of the property tax, which is heavily regressive, and virtually all of the benefits will accrue to high-income, long-

distance commuters traveling between high-income suburbs and central employment centers. They will do practically nothing to improve accessibility between centrally located ghettos and suburban employment centers.

This undoubtedly also opens up the whole question of the services provided by the main local transit systems. It is unreasonable to assume that BART, as an intercity express system, will by itself rectify inherent weaknesses in local systems. But it is important to see how the total transit system is used and viewed by low-income residents. Either this study or a separate study should also focus on older persons, many of whom are also struggling to get along on very low incomes. How do they make out in their travel? How does the transit system work for them? What blockages remain to satisfactory service through reliance on transit?

We recognize that related to the questions of services for low-income households and questions of subsidy are questions relating to the various forms that subsidy or redistribution can take. Redistribution may be brought about by the form of tax support employed or by the character of the fare structure. Service for lower income persons, if judged politically desirable, raises significant questions as to the manner in which this is accomplished and the character of the accounting. To what degree is it reasonable to expect that BART will itself provide subsidies? To what degree should BART be maintained on a basis of breaking even financially and the subsidies come to the lower income population through forms of income maintenance, negative income tax, or other devices? We do not know or suggest the answer; research is needed to resolve this question. But we are convinced that, by whatever appropriate means, good service to lower income persons should be a public concern with a very high priority.

6. A study of the ties between BART and feeder transit systems. [The degree of coordination that will be achieved is yet to be determined. Selected proposals are presented in a northern California transit demonstration project (6).] Clearly, this is implicit in other studies being proposed. A specific focus on this topic might encourage, and take advantage of, deliberate experiments that should be conducted cooperatively by BART and others of the transit systems. Such experiments could then be carefully observed and reported. These experiments could take a variety of forms: fares and transfer privileges, ticket taking, scheduling and routing of feeder buses, and internal physical arrangements of terminals or transfer points. A study of the effectiveness of the information output might also be possible. Suppose a person travels on BART for some distance and needs to get on to the right bus or buses on leaving the BART train. How is he informed about the larger system beyond BART? How does he know which BART stop he might best use? How is he told the possible connections that he can make at each BART stop? Take the opposite situation. How does a person some distance from the BART line know how best to get to a BART station? How does he know for sure that he should, in fact, be heading to a BART station? (See also study 10.)

7. A study of BART terminals and their operation. Here observational studies could be helpful. What do people do? How do they get along? What problems do they have? How do they obtain information or directions? Observations, questioning, or other methods must be used to determine whether people find their waiting period and their use of the terminal pleasant experiences. It will be important to know, conversely, what the unpleasant features may be. How safe do they find or think the terminal to be? How clean? How convenient is the access to shops and other services that may logically be associated with terminals? (This will probably take us, in most cases, to the outer development adjacent to or near the terminal.)

How well does the terminal work as a point of transfer? Various permutations of the transfer matrix can be conceived. How do signs and information-output devices work? What do the terminals communicate through their architecture, maintenance, or the social symbolism of the tone and mix of persons likely to be waiting or present? In what ways do terminals provide important social-status clues as to the nature of the system's clientele? The large number of terminals in the system offer marvelous opportunities for comparative studies. The objectives and predictions of those architects, engineers, and designers as to how the terminals would be used can serve as an important backdrop; these could then be reexamined in the light of subsequent studies of actual use.

8. The direct effects of the BART system on the natural ecology of the Bay Area. Within the next few years, a comprehensive survey of the Bay Area's natural environment will likely be mounted. The direct and indirect effects of the BART system on the natural environment—on flooding, landslides, vegetation, wildlife, climate, pollution patterns, and visual amenity of the surrounding country—could be monitored. So, too, could the environmental effects of the development that is bound to occur around BART terminals. If any stations are located in fragile natural environments, these effects could be serious.

9. The careful study of various features associated with actual use of BART. We have in mind such features as flexibility in taking or altering trips, accommodations for groups traveling together or for persons carrying packages, and personal conduct and helpfulness of BART personnel. Automobile use coupled with walking provides very great flexibility. We need to understand how BART and the associated transit systems score in offering equivalent flexibility. Can people make out reasonably well in embarking on trips impulsively or casually (rather than deliberately waiting for scheduled vehicles)? Can people make unanticipated stops or alter their intended trip pattern? Can they conveniently and economically break their overall trip into several legs rather than a simple to-and-from pair of trip legs? Clearly, these questions touch on a number of features of the transit system: its overall completeness, its fare patterns, its interchange points, and its frequency and reliability of service.

The automobile accommodates groups of persons with a considerable sense of privacy; it is like a moving room. How do pairs or groups of riders get accommodated on transit vehicles? Is there some semblance of privacy for conversation, hand-holding, or pleasant association? Are compartments possible? An advantage? A danger? (We think of the compartments of European-type trains, for example.) How do people handle packages, suitcases, briefcases, toolboxes, or other bulky items on BART trains? Many of these are, of course, the very items that are so conveniently carried by private automobile. What do people do with their time while traveling on BART? Is time used more productively in a BART train than in a private automobile? What are the psychological gains or losses as compared with driving or riding as a passenger in an automobile? Are there advantages to transit riding that compensate for the possible satisfaction that the driver of an automobile can have in his sense of mastery and of decision?

10. A focused study of the information materials and symbols employed by BART. These include signs, maps, schedules, direction markers, instructions about fare payment, and the like. This study should include all the symbols employed in communicating how the system works and how people find their way around in the system. What images of the overall system layout and its connections with feeder systems are provided? What images of the metropolitan area or of large sections? Can the system be reasonably self-explanatory and essentially foolproof? Or does it depend heavily on explanations by persons? What, too, of the interpersonal contacts between system users and representatives of BART? Are personal representatives available to provide information or reassurance? (One thinks of the countless times airport users take advantage of strategically placed airline representatives to ask questions that the sophisticated and accustomed user may think quite unneeded.) Indeed, in a very highly bureaucratized urban world, BART may appear to be just another bureaucracy: unresponsive, relentlessly impersonal, coldly uncaring. How can the traveler be encouraged to think that there can be some responsiveness to complaints or suggestions? How can the traveler receive some reassurance about a direction that he thought he knew but about which he was not certain? We hear that older people, even though still driving, may hesitate to venture onto a complex metropolitan freeway system. Is it possible that they might hesitate to venture onto BART?

The single act by the London underground system of providing a highly simplified and diagrammatic route contributed immeasurably to an imageable understanding of how to find one's way around London. Reassurance that one knew how to proceed was buttressed by the provision of large diagrams within the cars on which one could trace one's position according to the stops, also well marked. Are there corresponding, simplifying diagrammatic maps of the BART system and clear supplementary diagrams of the other transit systems? Are there attractive guidebooks that show users how they can get to the downtown air terminal, the city hall, the art museum, the sports stadium?

11. A study of the connections between BART and major transportation terminals such as airports, out-of-town bus depots, railroad stations, heliports, and ship or ferry terminals. Here we suggest the study of the connections between the internal Bay Area transit system (BART plus integrated transit systems) and various other systems for long-distance or intermetropolitan travel. Airport and heliport usage comprises special but highly significant trip destinations and origins that deserve full study. The potentials for alleviating parking problems at the airports and for providing convenient, fast service, especially for persons who do not necessarily know the ins and outs of the freeway system, are great. The service must provide assurance of reliable service, including service at off hours; the person arriving at the airport could expect service round-the-clock.

12. The study of trips for other than work, shopping, or school. This could include uses made of BART for getting to leisure-time activities—sporting events, cultural affairs, or places to be visited. Weekend and holiday usage might be especially studied. Such analysis would help to determine the ways in which BART succeeds, or fails to succeed, in providing convenient transportation for other than workday, peak-hour usage. A variant of such study would be to determine the degree to which traveling by BART trains might be undertaken partly for the trip as such. Certainly, people go out riding in an automobile partly or wholly for the ride, perhaps combining stops but possibly making stops that were selected after being under way rather than as predetermined destinations. Would BART provide any of this function? This would be an interesting test of the pleasantness of the ride. (One may note that London buses may be taken because of the marvelous views they provide; but one would seldom take the underground, while it is traveling underground, just for the ride.) Will it prove disappointing to some travelers or tourists that the trans-Bay trip is below the Bay? What will prove to be the most scenic parts of the system to take for the ride?

13. A study of the designers of the system. Finally we propose a study of the attitudes and perceptions of the engineers, the architects, the landscape architects, the planners, and the other professionals responsible for developing the BART system as it has emerged. The point would be to identify their perceptions of the system to be provided, the future users, and the environment. It would be important to learn how they went about predicting user behavior and how they proceeded to simulate the future system in their design planning. It would be possible to assess the accuracy of these predictions by means of post-construction and operating comparisons; this could be an extremely useful aid to the designers of future systems. Little is known of the psychological makeup and disposition of environmental decision-makers, yet the one thing that emerges from the few studies to date is that their perceptions of the environment differ from those of the ultimate users (7).

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ON STUDYING THE IMPACT OF RAPID TRANSIT IN THE SAN FRANCISCO BAY AREA

Richard M. Zettel, Institute of Transportation and Traffic Engineering,
University of California, Berkeley

Worldwide transport interest centers on the San Francisco Bay Area. At a capital cost of almost $1.5 billion, a decade of major transit improvements, including a new 75-mile rail rapid transit system, will be in full operation by the end of 1972. There is much speculation about what this considerable investment will accomplish. As I understand it, the purpose of this conference is to develop ways and means for studying, in depth and impartially, the total consequences of these transit developments in the Bay Area. This is no easy assignment. The conference plan, for workshop purposes, is to divide the question of impact of the Bay Area Rapid Transit into 4 subject areas:

1. Impact on land use;
2. Impact on travel volumes and flows;
3. Impact on social and environmental characteristics (query: Should these be separate areas of study?); and
4. Impact on the economics of various transport systems and economic and industrial life of the region (query: Should these be separate areas of study?).

Later, I will deal briefly with each of the designated subject areas (though not in the order listed); however, I intend to concentrate primary attention on the second item, which seems most fundamental, at least in the early years of BART operation. If there is no great effect on traffic volumes and flows, there can scarcely be large impact in other areas of concern.

I might observe that this list of study group assignments does not explicitly cover certain subjects that need to be considered. For example, the question of direct costs is not specifically mentioned. The first and most immediately measurable impact of BART and its partners-in-service is the substantial transfer of funds from individuals to the transit operators through fares, taxes, and tolls. The advent of BART and the attendant emergence of planning and operational problems, both within the transit industry and among transit and other modes, may trigger latent forces that will have a far-reaching impact on political machinery. Thus, in drawing up a possible research program, perhaps we should include the impact of BART on political institutions.

These thoughts suggest the dangers of separating impact research into neat compartments for study. Because all impacts are interrelated in some degree, our objective should be appraisal of the magnitude and distribution of the total consequences of BART, both positive and negative. If for operational reasons the research effort must be divided into manageable packages, then provision for overall correlation and evaluation of the results is all the more important.

My basic purpose is to raise questions that need to be thought through. Some of them may seem trivial or even frivolous to an audience of this sophistication. But they need to be asked, for they are kinds of questions that will continue to be debated heatedly in the press and in the legislative halls.

THE BAY AREA SITUATION

It may be of use to the workshops as well as to later impact researchers to set forth a few characteristics of the San Francisco Bay Area, in general, and BART, in particular, that have a bearing on impact research problems. This understanding is particularly important in order to forestall unwarranted transfer of research results to other areas, a practice all too common in transportation circles.

I take it that we are attempting to find ways to appraise a real-world case. We are not dealing with a hypothetical situation or mathematical abstractions. Real trains are going to carry real people over real tracks from real residences to real places of employment and other activities. And all of this is going to happen in a diverse, dynamic, and in some respects unique metroplitan area that will be continuously adjusting over time to many social and economic forces, only one of which will be the advent of a 75-mile rail system in 3 of the 9 Bay Area counties and with a potential service area of approximately one-half the Bay Area population.

The Bay Area

The Bay Area now has nearly 5 million people and 2 million jobs dispersed over 7,000 square miles of land and divided by large barriers of water and mountains. Yet the San Francisco-Oakland complex has one of the most concentrated urban core developments of any large metropolitan area and also many low-density suburbs. Diversity is extreme and must be reckoned with in development of the total urban transportation system. Santa Clara County (not served by BART), fastest growing and almost certain to be most populous, is in many respects more like Los Angeles than San Francisco itself. On the other hand, "the city" (little more than 40 of 7,000 square miles) is something of a Manhattan of the Pacific, having little likeness to other western cities and having a unique political structure that leads some to call it a duchy and others to suggest that it be fenced off as a state historical monument.

The overall shape of the Bay Area's development owes much to the presence of the Bay and the mountains. Physical features constrain a narrow bay plain, which, for a distance of about 100 miles, now contains bands of virtually uninterrupted urban development on either side of the Bay. These corridors fix the direction and location of the major streams of urban travel at the central core of the region and strongly influence the circulation of persons and goods toward the developing periphery. Topography has served to constrain a large part of the growth along existing and predictable paths.

Outside the core, the bay plain is characterized by linear pockets of industrial activity along the bay front. In the rest of the region, the pattern has become one of suburban development in a number of subcenters joined by urbanized corridors of land. In the largely undeveloped hinterlands, cities are generally small and self-contained.

Transportation Characteristics

The transportation system that has developed, and is in current development and planning, follows the corridor configuration dictated by the region's natural features. The Bay itself is a formidable barrier requiring that traffic be funneled to major crossings for east-west travel and north-south travel (on the west side) leading to heavy volumes in narrow confines that appear, on the surface, to lend themselves readily to transit movements.

An inspection of transport networks elsewhere suggests the Bay Area's uniqueness. Regions such as Boston and Washington, D. C., have a wheel-and-spokes pattern in their transport systems. Chicago has radial spokes superimposed on a grid of freeways. Los Angeles has primarily a grid pattern. None of these resembles the San Francisco region, where many of the principal routes run doughnut-shaped around the Bay, and crossings of the doughnut hole are spread farther apart than they would have been over land. The particular Bay Area pattern tends to concentrate major travel flows in main corridors and to emphasize "gateway" transportation needs and problems.

It is significant that the 75-mile rail rapid transit system now abuilding is designed to serve this pattern. Essentially, it intercepts 4 gateways—in the East Bay from the north, east, and south and in the West Bay from the south. The 4 arms of the system follow major corridors already served by freeways, and the Bay is crossed at the point of heaviest traffic concentration. The system is primarily serving built-up areas. According to one estimate, 87 percent of expected patronage in 1975 will be destined for existing employment centers (downtown San Francisco, Oakland, and Berkeley), and 86 percent of the riders will come from already built-up residential areas.

This, then, appears not to be the planners' dream. It appears not to be a system that would shape the area into a radically new pattern of urban development, but rather one that would tend to maintain the status quo within the 3 counties and for half the population of the Bay Area served. According to Simpson and Curtin:

> BART will be a different transit service on the two sides of the Bay, just as the attitudes and aspirations of these communities are different In San Francisco, it will be a fast trunkline to downtown, in Berkeley and Oakland, an alternate to traffic congestion on the Bay Bridge to San Francisco; and in Fremont and Concord, a realty catalyst .

The Voter's Decision

The rail rapid transit system that will be in full operation by the end of 1972 was brought into being by a vote of the people in 1962 through approval of a general obligation issue amounting to $792 million that, together with interest, is to be paid entirely from taxes on property within the 3 counties. Other financing, including federal aid, bridge tolls, and retail sales taxes, will raise the total capital cost to about $1.3 billion, none of which is expected—nor ever was intended—to be paid by users of the system directly. It is hoped, however, that expenses of maintenance and operation and capital costs of rolling stock can be met from fare-box revenues.

The subsidy to BART, approved by the voters with foreknowledge, will be substantial. In effect, it was decided that the direct benefits of the system to its potential users would not be sufficient to induce them to meet the full costs of the system. Justification for the subsidy will have to be found in other beneficial impacts of the system. One of the objectives of the programs developed in this conference might well be to ascertain, if possible, whether gains to the community as a whole in terms of transport service, economy, ecology, land use patterns, and social values warranted the total investment.

BART's Promises

Obviously, the voters held great expectations. Before the Bay Area Rapid Transit District was formed, they were told that an interurban rapid transit system "integrated with the programmed arterial highway network, is not only the best but the least-cost solution to the region's total land development and transportation problem." Also, "that without rapid transit the region will ultimately pay many times its cost in additional hours of travel time, in the additional cost of trucking goods over highways congested by automobiles, in diminished revenues from property depreciated by congestion or swallowed by automobile facilities, and in the premium costs of urban freeways and parking garages." And, "the development of nucleated centers and subcenters is possible only if these are served by a high capacity transportation system integrating freeways and rapid transit. To depend on highways alone is inevitably to choose the alternative of dispersion."

Just before the election, the benefits of BART were listed for the voters in BARTD's Composite Report, as follows:

1. It would aid future growth by (a) maintaining and encouraging concentration of business and industry and lessening sprawl, (b) improving living and working conditions, (c) preserving and increasing property values, and (d) permitting more economic use of land.
2. It would benefit state and local governments by (a) reducing the need for highway funds in the central cities and releasing them for suburban areas, (b) containing urban sprawl thereby lessening costs of public services, (c) protecting and increasing public revenues by inducing greater economic growth, and (d) reducing usurpation of tax and job-producing lands by highway facilities.
3. It would benefit families and individuals in the 3 counties by (a) increasing mobility and job potentials of users, (b) providing transportation for those without automobiles, and (c) expanding social, educational, and recreational opportunities.

In concluding the piece on benefits, the consultant said:

> With the great growth of population, employment, and travel which lies ahead for the Bay Area, the influence of rapid transit in establishing efficient travel patterns—and the system's large reserve capacity to absorb growing volumes of traffic in the foreseeable future—would make rapid transit an invaluable tool for aiding the area's economic growth, and for creating conditions for a high standard of metropolitan living.

But despite the assertions, few of the promised benefits could then be quantified; the question now is whether studies of impact after the system is in operation can be devised to successfully measure gains and costs.

Since BART has been abuilding, additional claims have been made. For example, in 1968 it was stated that "the advent of BART has triggered a building boom exceeding all voter expectations." Again, "The advent of BART will inexorably and positively broaden and create new choices in employment, housing, recreation and education." In 1969 a report entitled "BARTD and the Ghettos" pointed out that 24 of the BART stations "effectively and dramatically serve designated poverty areas." It was noted also that "the Bay Area can expect a three-county rapid transit system which virtually eliminates student dependence on the automobile."

There is something rather refreshing in the last report that may have considerable bearing on the impact of BART. Instead of blunt assertions of automatic, inevitable benefits of BART, there is recognition that BART's impacts will depend in some circumstances on conscious policy action. It is noted:

> Precisely how well the political and economic leaders of the Area will use the BART lines and stations for the benefit of the blue-collar and white-collar workers alike is not a known fact It is a matter of speculation. It can also be a matter of disillusionment if opportunities are ignored . . Effective use of BART and surface transit for social purposes will require a regional point of view in the routing of public transit lines More significantly, a unified attack on the problems of unemployment could result in new industries and businesses being established near BART stations . . Creating job training of specialized education centers near BART stations is yet another challenge that can be met realistically by regional leadership

These are interesting thoughts regarding impact; not that BART will inexorably cause something to happen, but rather that BART's existence may stimulate Bay Area leadership to cause things to happen.

This recital of some of the hopes held within the Bay Area regarding benefits that will accrue because of BART suggests kinds of questions that need to be dealt with in impact research.

INTEREST IN BART IMPACTS

Interest in BART's potential impacts extends far beyond the Bay Area. The Oakland Tribune recently observed: "From Moscow to New York, urban planners and transportation experts will be watching BART's progress. These persons have also dreamed of trains and sophisticated equipment capable of doing the things BART has promised the residents of Alameda, Contra Costa and San Francisco counties. . . . Once the trains carry passengers, urban planners will begin taking notice."

A National Concern

Simpson and Curtin stated: "Nationally, BART is a billion dollar experiment to determine whether the highest and best application of transit can lure commuters out of automobiles." It should be an experiment to do more than this. It should help us to appraise the total impact of a considerable infusion of transit investment on urban life. We need to ascertain, if we can, whether hoped-for benefits actually materialize, how they are distributed, and how they compare with total costs and their incidence.

The BART area owes something to the nation; nowhere else to my knowledge has the federal government invested over $100 million for a total new and admittedly experimental

system. If it is to be useful to others, however, impact research will have to be carefully done. The characteristics of the Bay Area and the circumstances of BART's operations will have to be constantly recorded so that inferences regarding BART impacts will not be casually and mindlessly transferred to other urban areas.

Bay Area Concerns

Impact research is much more than an "after the fact" study as far as the Bay Area is concerned. Grave questions remain as to future extensions of BART, not only within the 3-county area but to other counties of the Bay Area. There are difficult decisions to make regarding other transport facilities, most importantly freeways and bay crossings. Already there is considerable sentiment for delaying a southern trans-Bay crossing (now in active design) until the full impact of BART is known. How to know and evaluate this impact, even when the system is in operation, is going to require more rigorous analysis than most people imagine.

The controversy currently raging over the southern crossing dramatically suggests the extent of confusion presently prevailing in the Bay Area. It also suggests the possibility that public actions may be taken to ensure that BART's impact on traffic will be greater than it otherwise might be. Policy desisions of this kind should be monitored and explained if a frank appraisal of BART's impact is to be presented. One might think we would now have more consensus concerning BART than we have. If we do not have full understanding of potential impacts on land use, on social and environmental characteristics, and on economic development, at least we should have reasonable agreement on probable usage during the early years of operation.

Actually, a number of travel studies have been made. Prior to voter approval of the system, patronage estimates were prepared and disseminated. The Northern California Transit Demonstration Project, jointly sponsored by the 3 agencies with federal aid and conducted by Simpson and Curtin, prepared estimates of daily transit trips on BART, A. C. Transit (A. C.) and the San Francisco Municipal Railway (Muni) for 1975. More recently the Bay Area Transportation Study Commission completed its report that included estimations of transit patronage for 1980 and 1990. These estimates are all based on quite similar techniques of transport analysis, including the modal-split procedure. The differences in results are not large enough to be of great significance in analysis of broad issues. The fact is that none of the results is accepted by some who have high hopes for rapid transit's impact in the Bay Area.

The Simpson and Curtin report, for example, estimates that the 3 transit agencies will carry 673,000 adult transit trips per average weekday in 1975. This about 26 percent more trips than were carried by transit in 1965—a considerable increase but not so significant when compared with a 20 percent increase in population in the area served by the 3 systems. In all research on BART impact, it must be remembered that the area served already has transit service that might have continued to grow in the absence of BART. BART's main source of patronage will be riders who have been diverted from other transit systems.

BART's patronage is estimated to be 241,000 adult passengers per day in 1975, but transit ridership on the other 2 systems is expected to decline by about 103,000. The greatest impact is expected to be on Bay Bridge traffic; BART and A. C. together are estimated to carry about 75,000 adult passengers per day in 1975 as compared with 42,000 carried by buses in 1965, an increase of 81 percent. BART is expected to divert 21,000 trans-Bay automobile person trips to transit in 1975. In terms of peak-hour, peak-direction usage, this transit diversion is estimated to be the equivalent of 3,200 automobiles and a number of buses—roughly 2 lanes of highway capacity.

These are significant numbers, but they hardly suggest a staggering impact on traffic flows or an enormous rearrangement of urban living patterns. If we make extreme assumptions (a) that transit usage would not increase between 1965 and 1975 without BART and (b) that all trans-Bay and East Bay adult transit trips by BART estimated to be diverted from automobiles would be journeys to and from work, about 21,000 workers, out of a work force of nearly a million, in the area served by BART in the two east Bay counties would be involved in 1975. When figures like these, inflated

though they may be, are scattered over the 3 East Bay arms of BART in an area that is growing rapidly, it should be no surprise that many observers do not expect miracles from BART.

Estimates of this kind based on present techniques of traffic analysis, however, are rejected in many quarters. BARTD's general manager generally dismisses them as based on mathematical models that fail to reflect the true drawing power of the BART system. Mayor Alioto of San Francisco is now reported to be in favor of delay of the southern crossing and is quoted as follows: "Rather than taking a wild guess at whether the new crossing will be needed, we should wait to see the effect of BART before going ahead." In contrast, State Senator Lewis F. Sherman, presumably a supporter of another trans-Bay crossing for motor vehicles, is reported to have said: "Opposition to the Southern Crossing is based upon mere speculation that there will be a mass shift from autos to trains of the Bay Area Rapid Transit System."

It is ironic that only now—some 8 years after the matter was before the electorate—the question of BART's potential patronage is being seriously debated in public. If the issues cannot be resolved now—and I suspect they cannot—perhaps well-conceived impact research will provide a basis for improving and imparting confidence in transportation analyses in the future, particularly as it pertains to the modal-choice problem.

Impact Research and Transportation Planning

In the study of BART's impact, there will be other things to look for that may be useful in reappraisal of techniques of transportation analysis and planning. In fact, certain assumptions made in the BATSC reports (and I believe this to be true of other major urban transport studies) tend to deny the very possibility of certain kinds of impacts resulting from the operation of BART.

First, estimates of regional growth of population and employment were prepared without regard to levels of urban transport service that would be available. Possible transportation deficiencies were not regarded as a restraint on growth. Second, locational models assumed accessibility to all places of potential development for residence and employment. Third, future person trips were generated based on estimated changes in socioeconomic characteristics of households but without regard to nature and quality of the transport services offered and were distributed between production and attraction areas using a hypothetical network that might meet potential demands. Moreover, the modeling techniques made no provision for impacts resulting from disequilibriums inevitably arising during the course of unavoidably providing transport improvements sequentially.

These were heroic assumptions based on the thought that the transportation system is to serve, not to shape, the area and its travel habits. In effect, however, they asserted (a) that regional growth will not be affected at all by BART, (b) that location of activities as to the region as a whole will not be affected to any major extent, and (c) that person trip generation and distribution will be the same, regardless of the mix of highway and transit facilities or the order in which they are provided.

I should hasten to note that BATSC's analytical mechanisms were developed so that alternative assumptions regarding land use and transportation patterns could be tested. The "controlled trends plan," reported to the legislature as an initial exercise, reflected a continuation of current trends and policies that, of course, could be modified by policy intervention. It was emphasized that there existed neither a general regional plan nor any statement of comprehensive regional goals to which transportation plans might be fitted. Moreover, the BATSC findings were not represented as the plan for the Bay Area but as a development guide. Much attention was given to the need for a continuing transportation planning process that, in fact, is now being carried forward under a new organization that has taken over BATSC data and analytical capability.

The point to be stressed here is that the continuing transportation study and planning process can make a major contribution to impact research through its data base and processing and analytical capabilities. At the same time, however, effective impact research may lead to more realistic assumptions and improved techniques of urban transportation analysis and planning. In a broad sense, an impact study might be approached as an exercise in transportation planning and analysis after the fact.

Difficulties of Impact Research—An Overview

As in all studies of urban phenomena and human behavior in the real world, meaningful results of impact analysis will not come easy. None of the economist's "other things" will stay equal. Cause and effect may run in circles. Different impacts, if they can be identified and measured at all, will be manifested over different periods of time.

One possibility is that BART's impact may run through cycles. After its initial impact, which may be less than many expect of it, there may be some disillusionment with transit and renewal of interest in highway development. But this could run its course, and attention could again be turned to effective utilization of the very substantial reserve capacity that will probably exist in the BART system. Some observers believe this ability of BART to expand operations in its service area without change in its basic plant may be its greatest asset over the long run.

A number of possible research techniques should be explored. The first that comes to mind are before-and-after studies. But, how long before, how long after? For example, BART has been cited as a "major catalyst" for a downtown commercial building boom that is taking place in San Francisco. Whether BART is cause or effect, it would be ironic if the building boom tapered off after BART began operations, not because of BART but because the BART impact had been anticipated before its operation. But the larger question is whether BART in any way caused the boom; or, on the contrary, did foresighted business leaders, seeing the need for expansion of their facilities, cause BART to come into being? Whichever way it was, would an extension of BART in other directions, say, down the peninsula, result in or be accompanied by another building boom of similar proportions? Or have Bank of America, Pacific Gas and Electric, and other major developers anticipated their needs for a considerable time in the future? Consider here that their needs are not generated by regional demands but may be statewide, nationwide, or even worldwide in origin.

Before-and-after research might be partially misleading even in the matter of traffic diversion. Have a significant number of people already anticipated the advent of BART's operations and chosen their residential or job locations accordingly, and are they commuting via bus or automobile until such time as BART offers service? If so, impacts on travel flows and land use will have been exerted before BART.

What are the difficulties of impact-area versus control-area research? How does one establish comparable areas where the critical variable is the existence or nonexistence of rapid transit? To be considered also is the possibility that the control area is affected by development in the impact area. For example, in the Bay Area a significant BART impact in the East Bay in regard to the attraction of residents and jobs might have adverse repercussions on the West Bay Peninsula.

Can we conduct realistic "with or without" research? Should we consider how other transportation facilities and services might have developed had the 3 counties not made the commitment to BART? For example, the Simpson and Curtin report estimates a loss of 103,000 riders on A. C. and Muni between 1965 and 1975 and ridership on BART of 241,000 for a gain of 138,000 transit patrons. But if A. C. and Muni had simply increased ridership proportional to the increase in population, their ridership in 1975 would have been 642,000, only 31,000 less than the estimated daily patronage of these systems plus BART. What the numbers say is that while population increases 20 percent transit ridership increases 26 percent, some of which will be caused by multiple use of transit for a single trip.

What is the net impact of BART? The words, "what might have been," said to be the saddest words of all, may also be the most unresearchable. A bell cannot be unrung; the commitment of resources to BART cannot be disregarded. Insofar as 3 counties of the Bay Area are concerned, the capital cost of BART is sunk (raising questions to be discussed later), and this fact is bound to have an impact on policy decisions—those that have been made in recent years, those that are currently being made, those that will be made in the future when BART is in operation. The decisions may be economically sound and politically rational, but they must be ferreted out and dealt with if we are to understand the true impact of BART.

SPECIFIC CONSEQUENCES

Impact on Traffic Volumes and Flows

I noted earlier that BART's impact on traffic volumes and flows seems to me to be the starting point for impact research. Only if there is significant impact here will there likely be major impacts on the economies of other transport modes, on land uses and values, and on environmental and social characteristics.

Changes in volumes and flows should be comparatively easy to identify and measure. Moreover, well-structured research in this area may provide considerable insight into other consequences of the BART operation. If this is to be done successfully, provision should be made to include in data surveys of trip-makers the kinds of information that will be useful in appraisal of impacts on land use and social and environmental conditions. Even if separate analysis is feasible, data collection should be comprehensive.

As a starter, I think we would want to get much information about BART riders. We would want to know the origins, destinations, and purposes of their trips. We would want socioeconomic information about their households: incomes, occupations, automobile availability, family composition, household type. We would want historical data, too: whether the trips in question were made prior to BART and by what mode; whether residences or job locations, or both, had been changed and the specific nature of the changes; whether BART was a factor in making decisions regarding such changes.

At the same time we would want to know much about those who continue to use highways for urban travel purposes, especially journey-to-work trips. We probably would want to separate the highway users into 2 classes. In one group would be those who continue to use highways even though BART seems to offer them a reasonable alternative as evidenced by comparison with those who actually use BART. What we would like to understand is the basis of behavior among the so-called choice users—those who choose to use BART even though they might use automobiles and those who use highways even though they could use BART.

The second group of highway users to be studied consists of those who travel within the BART service area and even follow corridors and go through gateways served by BART but who do not use it. For one reason or another, perhaps because their actual origins or destinations are not conveniently served, BART offers no reasonable alternative. This group of users needs to be clearly identified and its basic requirements explained. Far too often the casual observer, seeing striking contrasts between congested freeways and unused transit capacity (which will be especially obvious in the Bay Area), will conclude that only the perversity of the motorist stands in the way of greater transit usage that will contribute to quality of life. What is overlooked is the inherent flexibility of the automobile over the length of the journey to which users have become habituated and to which they have adapted their life styles.

We will need to keep all of this in the perspective of total travel demands, neither to denigrate transit nor to extol freeways but to understand the overall picture. Unless we completely miss our guesses, automobile travel will continue to dominate the total urban travel scene. In the 3-county BART area, transit accounted for about 9.3 percent of all person trips produced in 1965 (19.6 percent in San Francisco and 4.6 percent in Alameda and Contra Costa Counties combined). According to BATSC estimates, transit will account for a lesser percentage of total person trips in 1990 than 1965 (8.6 percent in the 3-county area), notwithstanding a 50 percent increase in transit trip production. But we should acknowledge that comparisons of total daily trips standing alone no more reflect the importance of transit than do peak-hour trip comparisons alone reflect the full value of highways. Both must be considered.

It is generally conceded that transit's large contribution to solution of the total urban transportation problem will be found in its peak-period patronage, provided largely by commuters who account for only about 1 out of 5 daily trips. Already A. C. Transit is carrying about half the persons that travel across the Bay Bridge at peak hours; BART will do better and therein will lie its value. However, a word of caution is in order here lest there be disillusionment through superficial analysis of BART's impact on

peak-hour congestion. There is an established tendency for traffic peaks to spread over time as congestion increases and to compress as congestion eases with a resulting sharpening of the peak. It could easily happen that, as BART relieves the bridge of some vehicular traffic, highway travelers will adjust to the new situation so that peak-period congestion will seem as great as before even though compressed into a shorter time span. Even if this happens, however, the peak users will have benefited because they will have chosen times of travel more nearly in accord with their desires. This point might easily be overlooked in casual observation or superficial study of BART's impact on traffic volumes and flows.

Impact on Economics of Urban Transport Facilities

Much support for BART stems from the hope that its operations will minimize the total costs of urban transportation, both by providing a less costly alternative to the automobile and by directly reducing the costs of the remaining highway travel. The extent of any cost reduction will be related, of course, to BART's success in attracting patronage through the immediate diversion of traffic and perhaps over time by rearrangement of land uses in a manner that will reduce demands for highway service and encourage use of transit.

Highway Facilities—Savings in cost of highway transport may be manifested in 2 ways. For those who continue to use highways, congestion costs would be reduced by diversion of motor vehicle traffic to BART. This argument was persuasively used to justify the allocation of motor vehicle tolls on the Bay Bridge to the construction of BART's trans-Bay underwater tube. Both monetary and other costs might be reduced by lessening congestion. As to the former, highway users would have resources to spend for other things or for more travel. Most of these savings, however, would probably accrue through greater comfort and convenience and through time savings, which not only are difficult to quantify but never show up in disposable income. If indeed demands for highway travel are reduced significantly, it follows that the need for highway facilities should be reduced concomitantly and, in turn, the burden of highway-use charges should be lessened. Much point was made of this possibility when BART was presented for public approval. The controversy involving the need for the southern crossing is an immediate case in point.

From the transit viewpoint, there is a rather paradoxical note in the potential impact of BART on highway travel costs; if the costs of highway transport are reduced or the benefits enhanced, the relative attractiveness of the transit service is thereby diminished. It is common knowledge that many people in the Bay Area regard rapid transit as something for "the other fellow." They see it mainly as a means for improving the quality of their own highway travel. An additional possibility is that, if there is a significant diversion of highway travel, the overall quality of urban transportation will be so improved that the total volume of travel will increase with the result that diverted highway travel is offset in some degree by induced travel—travel that would not have taken place in the absence of the transit improvements. This gnawing little possibility might be stored away conveniently for academic research on BART impacts were it not for the fact that counteraction might be taken to discourage any tendency for highway travel to increase. This could be accomplished by increasing motor vehicle taxes or tolls, or even more easily by simply refusing to permit improvement of any potentially competitive highway facilities. Until very recently, any possible hostility between highway and transit supporters has been rather easily camouflaged by the comfortable shibboleth that both highway and transit facilities are needed, which will happily complement each other once that indefinable something called balanced transportation has been achieved. We may be approaching a moment of truth.

It is foolish to deny that an improvement of highway facilities in corridors served by BART is likely to have an adverse impact on BART's patronage and its revenues. The more congested the highways, the fewer the additions to highway capacity, the better it will be for BART. On the other hand, to allow the costs of highway congestion to continue or to build up simply because BART exists can scarcely be regarded as rational economics.

The hard question is not whether a highway improvement adversely affects BART but whether the benefits of improvement outweigh the costs, including the costs of an adverse impact on BART. From the public viewpoint the matter of incidence of benefits and costs (who gains and who loses) both within and among highway users, transit users, and other groups and individuals in nonuser roles is important. In particular, consideration should be given to highway uses for which transit offers a decidedly inferior alternative (many of the nearly 80 percent of trips that are not work trips) or no real alternative at all (goods movement and person trips whose origins and destinations are far removed from transit facilities).

Transit Facilities—Once a decision has been made to subsidize transit service, there is little that conventional economics can tell us about the value of the service. We can, of course, call up some popular bromides: overriding social considerations, cleaner air, lesser external costs, more desirable land use patterns, happier living conditions, and higher quality of life. We have little, however, that we can measure by any standard and even less that we can translate into monetary terms. It is hoped that this conference can suggest ways to get a grip on some of the these matters, so that our impact research will lend objectivity to what otherwise will be purely subjective judgments jelled in the political arena.

Whatever the benefits of improved transit services are judged to be, they must be set off against direct costs. Leaving aside subsidies for the moment, we might note that Simpson and Curtin estimated transit revenues (costs to the users) of the 3 public systems to be about $72 million in 1975 (under their assumptions regarding potential patronage and optimal fare structures) as compared with revenues of $33 million in 1965. Thus, direct transit costs to riders will increase almost 120 percent as compared with a 26 percent increase in the number of trips taken by passengers. Although they will be different and better, the trips will each cost substantially more. Economic reasoning tells us that the benefits to users will equal or exceed these direct costs because the riders are willing and able to pay the fares. It is still worth noting that disposable income of this magnitude is being transferred to the transit operators. The assertion usually is that those riders who will have been diverted from automobiles will experience direct cost savings, but even this matter will deserve careful study.

The substantial transfer of resources to transit through taxes and tolls will also deserve careful study. For example, the Simpson and Curtin report forecasts operating deficits in 1975 of $5 million for A. C. Transit and $7 million for the San Francisco Municipal Railway, a total of $12 million. The hope is still held that BART will be able to meet its expenses and costs of its rolling stock from its fares; but, the capital costs of the fixed system will all come from external sources—property taxes, sales taxes, bridge tolls, and federal aids, some of which will have been "prepaid."

I have not attempted in this paper to prepare careful estimates of annual cost, but it might be noted that service of general obligation bonds in 1975 were estimated to require about $40 million, which should now be increased because of higher interest rates. An early estimate of annual costs of $42 million for BART alone would now be considerably higher because of inflation, higher interest costs, and additional nonrevenue financing that has been arranged. Something approaching $100 million might be regarded as a rough approximation of annual capital costs. For the 3 systems, the amounts of subsidy will exceed the amounts paid by the riders.

One of BART's immediate impacts will be its effect on the operations of the existing transit systems. It is anticipated that Greyhound Bus Lines, which serves parts of East Bay not served by A. C. Transit, will discontinue operations and will be happy to do so. Not so with other systems. They will continue to operate, but their roles will be changed. It is estimated that nearly two-thirds of all trips to and from the BART system will take place on the present surface lines, A. C. and Muni, thus involving troublesome transfers and problems of fare structure and collection. Many patrons now paying one fare for a transit trip will find themselves making transfers between systems and paying two or more fares, one to A. C. or Muni and one to BART.

A. C. Transit will be expected to so adjust its operations that it will contribute to the success of BART. On the one hand, it will be expected to provide optimal feeder service to BART stations; on the other hand, it will be expected to discontinue operations

where they are in direct competition with BART. A. C. Transit is estimated to carry 57,000 adult passengers per day in 1975 as compared with 125,000 in 1965, a reduction of more than half, notwithstanding the growth of the area. There is an estimated reduction of 38,000 riders in the East Bay (over 40 percent) and about 30,000 in trans-Bay operations (almost 90 percent). Moreover, A. C. operations in the East Bay will carry more than half of the passengers to or from a BART station, according to the Simpson and Curtin estimates. Financial problems will arise, and A. C. Transit will lose its profitable lines and assume an increasing number of deficit-ridden feeder operations.

The real question is whether operation of the 2 systems can be optimized under separate managements. Will each attempt to minimize its own deficit or maximize its revenues to the detriment of the other? Unfortunately, the boundaries of the 2 public districts are not conterminous, and the difference in constituencies may aggravate the difficulties. Quite obviously those who live and pay taxes in both districts will want the kind of optimization of the combined systems that minimizes the combined tax bite. But what of those who live outside the A. C. Transit district? Their concern with BART's welfare may not be so magnanimous as to include A. C. Transit. The institutional difficulties are of sufficient gravity to have led already to suggestions for a merger of the systems. For example, Mayor Wallace Johnson of Berkeley, on the recent occasion of resigning from the BARTD directorate, stated.

> The realities are that . A.C. Transit is financially dependent upon its profitable transbay runs to offset its unprofitable East Bay service. .BART's operational success is based on taking over 90 per cent of A.C Transit's transbay patronage . (It is) time for the Legislature to force a merger of BART and A C Transit which could economically serve the citizenry.

The Muni picture is also murky. It is estimated that the Muni will lose almost 30,000 adult passengers per day between 1965 and 1975, even though it will pick up transfers to and from BART. However, the impact of this loss is not nearly as great as that of A. C. It is estimated that Muni will still carry about 353,000 adult passengers per day in 1975, which—not at all incidentally in connection with impact studies—is about 10 percent more daily passengers than BART and A. C. together are expected to carry.

The Simpson and Curtin report, however, based its estimates on the heroic assumption that Muni would have a rapid transit system as well as a surface system by 1975. It was estimated, in fact, that 199,000 of Muni's 353,000 passengers in 1975 would be on its own rapid transit. The recommended rapid transit network would include 3 new rail rapid transit lines (in addition to BART's line to Daly City) as well as new express bus services on freeways. Costs would range from $310 to $400 million. The plain fact is that the proposed rapid transit system will not be in operation in 1975, and perhaps not even started. The Muni is struggling even now merely to replace its obsolete equipment and to provide cars that can operate on its level of the Market Street subway furnished by BART.

Digressing slightly, I might note that difficulties in financing the Muni will have a direct bearing on the financial feasibility of extending BART to the northern and southern peninsulas. San Francisco is already destined to bear a substantial continuing property tax burden for support of the initial BART system. If and when a rapid Muni is built, an additional burden will be imposed. San Franciscans will not be kindly disposed to share any part of the cost of extending BART into either Marin or San Mateo Counties, even though somewhat ironically these counties have the largest share of resident workers commuting into San Francisco. It will be even more difficult to engender support in the East Bay for sharing in costs of any BART extensions emanating from San Francisco to West Bay communities.

There is need for some kind of regional intervention. Two of the rail rapid transit lines recommended for the Muni reach toward San Francisco's northern and southern neighbors. It would be a sad circumstance, indeed, if Muni rapid were instituted but institutional barriers stood in the way of full exploitation of potential opportunities for

extended transit service, particularly in the Marin corridor. But this is a future problem. During the early years of BART operations, it is safe to conclude there will be no Muni rapid service of any kind. I have found no data on the effects of not having the Muni rapid—either as to the impact of BART operations on Muni's patronage or as to Muni's impact on BART operations without its own rapid transit component.

As to our own area of concern—overall impact of BART—the ramifications are broader. For example, a considerably improved Muni service might hold or encourage residents to stay within the city (and exert other influences on land use); in the absence of such improvements, they might locate elsewhere, perhaps influenced by the availability of BART. Clearly, policy actions or inactions may have much to do with the nature of BART's impacts, both in the short and long run. Repugnant though the idea is, an unimproved Muni could be to BART's advantage as an independent agency, just as unimproved highways might be. The question is whether BART's interest necessarily coincides with the interest of the community-at-large; and if it does not, how differences are to be resolved.

Regarding the economics of BART's own operations, the significant fact is that costs of the fixed plan are sunk. Even in a strict economic construction, only the variable costs of operating and maintenance expenses (costs that vary with patronage) are relevant in the setting of fares. Here then is the classic case for the welfare economists—the situation in which marginal revenue (the fare) may be appropriately equated to marginal cost without being bothered by the problem of covering fixed costs. (I am assuming here, of course, that BART will not be so enormously successful that its carrying capacity will be so taxed within the next decade or so that "congestion costs" will arise and lead to proposals to ration BART rides through efficiency pricing. But perhaps I will be allowed to be impish enough to suggest that, if BART is as successful at the turnstiles as some of its enthusiasts hope, perhaps a moderate contribution to relief of the property taxpayers who are footing the major bill for the fixed costs would not be totally unthinkable.) Even this need not follow, however, if we reject economic tests. If we have found (or think we have) the impacts of BART in terms of social, environmental, or land use consequences to be sufficient to justify subsidy for capital costs, might they not also be sufficient to justify subsidy for the variable costs? Senator Sherman has recently proposed "free" trans-Bay bus rides on the A. C. system (the costs to be covered by vehicle tolls); is it unthinkable to consider "free" BART rides also? Indeed, if zero fares were put into effect now, there would almost certainly be an organized drive to continue the practice into the BART area of operations.

Whatever may have been decided in the past or may be decided in the future about BART's financing and fare policies will affect the magnitude and incidence of BART's impacts on the community, and should be considered in any appraisal of extensions of BART within the Bay Area or the construction of new systems elsewhere. When extensions or new systems are planned, total costs, not simply variable costs, are to be set off against the estimated beneficial consequences.

Federal or State Aid—In this connection, perhaps it is appropriate to restate an obvious danger. Any large-scale program of federal or state aid for urban transit runs the risk of distorting investment decisions simply because the benefits, whatever they may be, are almost entirely localized, but the aid (costs) comes in large part from abroad. There is an understandable tendency to compare total benefits to the community with only that portion of the costs that must be raised locally; the "external" financing is "free."

Perhaps the $100 million or so that the federal government has supplied BART can be satisfctorily rationalized as an acceptable national contribution to a billion-dollar experiment. But if the federal government is going into transit financing in a serious way, it should insist as a condition of its participation that all impacts be considered—the external as well as the internal, total costs as well as total benefits—in order to guard against unwarranted investment nurtured by "free" money. There is yet another consideration from the national viewpoint. A development ensuing from transportation improvements that may be regarded as salutary from one metropolitan area's point of view (for example, the attraction of additional growth) is not necessarily beneficial to the nation as a whole; there is much likelihood that the development may have been bought

with federal aid at the expense of other metropolitan areas. I am not, of course, singling out transit for special concern. I am just as concerned about federal aid for highways that tends to distort investment decisions and is often justified on the basis of benefits that are real for localities but illusory for the nation. We should insist that both highway and transit improvements be subjected to the same tests, and that these tests not be warped by the availability of federal aid. Whether it be federal aid, state aid, local taxes, or a combination of these, so long as there is subsidy to transit, the justification for it must be found beyond the realm of conventional economics.

Impact on Quality of Life

Many of the early hopes for BART could not be translated into monetary terms but were to accrue through improvement of land use arrangements and environmental and social conditions. In today's world it would be argued that BART would improve the quality of life. How are we to measure BART's impact in improving quality of life or changing life styles for the better? I suggested that some grip on questions of improved quality might be had simply by analyzing the nature and characteristics of changes in traffic volumes and flows. With this in mind, we should design data surveys of transit and nontransit users to incorporate information that will assist in appraising impacts on land use and social and environmental conditions. Costs as well as benefits must be considered. Too often, one side or the other of the equation is ignored, and net results cannot be determined. This holds for quality-of-life impacts as well as more conventional tests; if we acknowledge that certain benefits cannot be quantified, we must admit that certain costs also cannot be quantified but are real nonetheless. Unfortunately, the great difficulty in all of this is absence of consensus on overall goals of the region against which the various impacts of BART might be set off to determine whether, on balance, they are beneficial or detrimental.

Land Use—Land use planning theory tells us that changes in relative accessibilities of land locations will shift demands and affect site values, so that changes in land use will take place over time. If values are higher at the more accessible locations, we should expect more intensive development of the land (higher densities). There is some question, however, whether incremental changes in the urban transportation system are as influential in changing land uses as they were once thought to be, and perhaps actually were before the automobile introduced so much flexibility. Perhaps impact research will give insight to this question. In any event, BART's impact on land use may be rather difficult to isolate. In comparison with the whole, it is a comparatively small system; moreover, it is primarily serving areas that are already developed and are expected to retain their basic character.

I understand that significant changes in land use are taking place in many metropolian areas, perhaps quite similar to what is going on in the Bay Area but without any influence of a major change in the transit system. Perhaps comparisons among metropolitan growth rates and development patterns would be helpful for appraisal of BART's impact. Perhaps through motivational research we can discover whether BART was an important consideration in location decisions in the Bay Area.

The more difficult question is this: Assuming that we find that BART has influenced land use, how are we to determine that the changes are beneficial? We must at least consider the possibility that BART actually may have encouraged some "flight" to the suburbs, especially by whites, and not have been the centralizing influence that is so often associated with transit as contrasted to highways. This possibility, of course, has both political and social implications of broad import.

Land Values—Increases in land values are sometimes thought to reflect an increase in community values. Is this a valid conclusion? Some rent theorists would argue that improvements in the urban transportation system generally reduce differentials in accessibilities and therefore tend to reduce aggregate land values. Suppose this were to happen; is the community as a whole worse or better off for it? In any event, the BART impact is not likely to be so great or so ubiquitous that such a result will occur. On the contrary, BART is apt to affect certain lands by increasing their accessibility relative to other lands and thereby increasing their site values, but at the same time

bidding for locations beyond BART's sphere of influence will be reduced and their values lessened. The gains may be readily apparent and dramatic; the losses will be virtually untraceable for they fall into the category of "what might have been."

In the appraisal of total gains and costs, the geographical frame of reference becomes important. Suppose that major changes in land use and land values take place at Fremont and Concord at the end of BART lines in southern Alameda and eastern Contra Costa. These may be regarded as salutary within the area served by BART, but have such developments been attracted from, and at the expense of, developments elsewhere, perhaps in the 6 counties of the Bay Area not served by BART? We might also raise the possibility of a law of diminishing impact. Suppose that BART's original 5-county system had been built. Is it reasonable to surmise that BART's impact in the Fremont and Concord areas would have been less because its influence would have been diluted and more widely dispersed?

Environmental Conditions—Rearrangements of land use would, of course, be one of the major environmental impacts that BART could bring about—especially if it resulted in more intensive (higher density) use of the land and thus tended to release urban land for other purposes. More directly to the point would be the extent to which BART might divert existing traffic from highways in the short run and through new land use patterns tend to cut automobile travel in the long run. The great hope of environmentalists is that a reduction of automobile travel (or a slowing of the growth rate) will lessen the need for highway and parking facilities, thus easing pressures for intrusion of transport facilities into the Bay Area and reducing utilization of scarce urban land for transport service. A second hope is that diversion of travel from highway to transit might significantly reduce air pollution from internal combustion engines, as a result of both less automobile travel and less congestion for vehicles that continue to use highways. The issue rests on the transit system's ability to lure people from their automobiles. The question remains as to how effective transit can be in the fight against smog, as compared with more direct alternatives.

It has been said that ecology has become the "motherhood issue of politics." We are also told: "The emphasis will be on resource management from an ecological standpoint rather than an economic standpoint." And it has been noted, "Therein lies the drama of Detroit's anti-pollution battle. It is not only fighting fumes that foul the air. It is fighting time and an angry public demanding that something be done—like yesterday." These attitudes stir the emotions; they do not wash away the problems.

Social Conditions—If we want BART to improve the environment, we also want it to better social conditions. Indeed, economists are inclined to view the large public subsidies that BART and its partners will receive as the means to a substantial redistribution of income. The problem to be studied is who gains through transit subsidies and who loses through tax and toll payments. Can the net effects be determined? Do some individuals pay much and gain little? Do some pay little and gain much? How do the rich fare? How do the poor fare?

In the discussion of the need for urban transit, much emphasis is given to the captive riders, those who have no alternatives because they do not have automobiles or are not able to drive. Impact research should identify the captives—the poor, the young, the old, and the handicapped—and determine how effectively they are actually being served. It is not enough to show that service is available if the captives have little reason to use it. It should be remembered, too, that transit service is available now; BART may offer better rides but at a higher price.

In appraising the social impact of BART, especially in regard to the poor, we should not overlook that the poor will pay some portion of the taxes and tolls that support transit subsidies. For example, the BART financing package now includes $150 million from retail sales taxes and $792 million from property taxes (exclusive of interest charges), each of which tends to be regressive, bearing more heavily on lesser incomes than on higher. The use of highway-user taxes or tolls, either for direct support of transit or as a measure to improve transit's competitive position, also has income redistribution effects. However much automobile use is castigated today, it is worth remembering that there are real people in those vehicles, and it is they who

make the tax and toll payments. The "highway establishment" includes more than the perfidious automobile manufacturers and oil companies and misguided highway engineers; it includes a great number of people who are poor but "captive" motorists, particularly for the journey to work. It remains to be seen how many of these will be provided a viable alternative after the advent of BART operations.

A final issue to which I invite attention is the possibility of consciously manipulating the impacts of BART through public policies. Perhaps we need to know not merely what the impacts of BART will be but what we want them to be. This clearly requires some level of consensus on regional goals and a means whereby possible consequences of alternative courses of action may be evaluated in light of these goals.

On the one hand, it seems apparent from an economic standpoint, and perhaps by any other standards, that the carrying capacity of BART and its partners should be fully exploited through effective marketing of services. There is no reason why public persuasion should not be used to stimulate location of public and private sales and service facilities, employment opportunities, and training centers that will encourage use of transit. On the other hand, a broad conception of urban welfare cannot be based on the simplistic notion that whatever is good for BART is good for the total community. The question is not what the community should do for BART, but what BART should do for the community.

If the broad view is to prevail, it appears that a regional decision-making structure of some sort will be required in the public interest to resolve conflicts and weigh equities and values within and between urban transport modes. A number of specifics have already been identified: optimization of A. C.-BART operations; the need for rapid transit extensions within San Francisco as possibly opposed to extensions elsewhere; delay or completion of the southern trans-Bay crossing. In each case more than one agency is involved, and no matter how well-intentioned their efforts, they are likely to be somewhat self-serving.

A CONCLUDING NOTE ON IMPACT RESEARCH

I have wandered rather far afield in discussing impact research and have raised issues that need to be thought through even if they cannot be researched. If the tone has been somewhat negative, it is because I have some concern that difficulties of meaningful impact research will be underestimated and that dangers of incomplete or disjointed studies may be considerable. Some of us who have participated in or observed highway impact studies over the years have not been pleased with the results and foresee similar pitfalls in studies of transit impacts. The fault will not be BART's if it does not revolutionize urban living patterns. On the contrary, it will be unfair to BART if disenchantment sets in because impossible expectations regarding changes in life quality and life styles were aroused. Let us look at BART not as a miracle worker but as a potentially valuable addition to an enormous complex of urban transport facilities.

The purpose of impact research should be to deal with all consequences and their incidences, to establish that which can be established factually and through thoughtful analysis, and constantly to question unverified assumptions and assertions. Its most useful products might be reduction of the polarization that is currently taking place in urban transportation and restoration of "balance," not so much with regard to facilities themselves but within the people wrestling with the problem.

HIGHWAY STUDIES RELEVANT TO ANALYSIS OF RAPID TRANSIT

Floyd Thiel, Federal Highway Administration, U. S. Department of Transportation

Rail transit and highway transportation have fairly obvious differences. They also have similarities, and we may consider whether certain studies that have been made of highway facilities are relevant to analyzing the effects of transit systems.

Some studies supported by highway agencies are clearly relevant to analyzing such facilities as the Bay Area Rapid Transit system. These are the urban transportation studies that pay close attention to such matters as land use, trip generation, and choice of mode and route. Land use studies, for example, can be useful, especially for the before phase of a study. Relevant information and forecasts are available from several studies and agencies in the Bay Area, including the Bay Area Transportation Study (BATS), the Bay Area Simulation Study (BASS), the Projective Land Use Model (PLUM), and the West Bay Rapid Transit Authority. Those analyzing rapid transit systems may also want to peruse the reports that the U. S. Department of Transportation submits to the Congress each year dealing with fringe parking, relocation assistance, and the Traffic Operations Program to Improve Capacity and Safety (TOPICS). Fringe parking typically involves bus or rail transportation, and this may also be the case with TOPICS. Relocation provisions of the highway program seem relevant because people displaced by public programs in the future may receive assistance comparable to that established under the 1968 Federal-Aid Highway Act.

In addition to these continuing studies and programs, certain highway impact studies completed or under way may be able to provide some insight for the analysis of BART. These include studies with methodologies potentially adaptable to analyzing rail transit and studies involving a highway transportation service or effect somewhat like that of rail transit. A few generalizations are offered about highway impact studies in the hope that these may be helpful in planning studies of BART or other transit systems.

STUDY METHODOLOGIES ADAPTABLE FOR TRANSIT ANALYSIS

Study methods used in highway impact studies range from fairly simple studies of public attitudes and land values to studies using mathematical models to simulate the relevant transportation or economic sector. Fairly simple, short-term studies costing $25,000 or less have been fairly common in the 250 impact studies sponsored by highway agencies over the past 12 years or so. These studies often had fairly simple goals, for example, to learn the economic effects of one-way streets or median strips and the effect highways have on tax rolls, shopping patterns, and public services. Most of these studies provide no help for a comprehensive analysis of BART; however, a few are mentioned here in case they may be useful to students or others with limited research funds who may sometime be interested in studying some aspect of BART.

Studies of highway impact have typically involved analysis of such matters as land use, employment accessibility, educational opportunities, and accessibility to cultural and recreational activities. These are also being analyzed in a study of the Washington Metro System (1). One of the most successful studies of highway impact involved comparisons of land value, land use, population, and economic development in a study town and in 4 control towns about 4 years before and 4 years after highway construction. Towns typically differ in character and individually are not suitable as controls. Analysis of towns both separately and compositely, however, can reveal whether changes occurring in the study town are attributable to the highway. In this case, one of the primary study areas was a small town whose access time to downtown Dallas, 15 miles away, had been reduced from 30 to 17 minutes by completion of a limited-access radial highway (2). The study and control town approach provided specific information about dramatic economic growth in the study town; the analysts at Texas A&M University

involved in the study ascribed these to the highway. Comparison of study and control towns is apparently also being considered as a technique in the analysis of the effects of BART; for this analysis, it may be useful to combine control towns in order to de-emphasize individual differences between study and control towns.

Another highway study technique that may be useful in the analysis of the community effects of BART involves examination of the growth rates of selected geographic areas relative to the development of the entire area. For areas (or properties) examined, participation ratios can be developed. These ratios show whether an area's economic development is faster or slower than that of the region where it is located. Participation ratios based on the combined values of land and improvements can be used to compare economic development near a transportation facility with that for the whole region or with selected areas removed from the facility's influence. A closely related technique now being used involves analysis of an area's share of regional population and employment (3). The participation ratio approach was used by researchers at the University of Minnesota (4) and at the George Washington University (5) where good use was made of existing information, i.e., assessed values related to actual values by some sales of property. Participation ratios also lend themselves to analysis of economic development in fairly large regions, for example, a standard metropolitan statistical area or an even larger region.

Another device used in the past to learn whether a highway is associated with economic development, particularly central business uses, involves comparison of building heights and land area. This device is the Vance-Murphy technique and was developed at Clark University (6). This approach has been used to discern highway influence on downtown areas in Richmond, Virginia, and Long Beach and Oakland, California. It appears to be appropriate in central business districts or other intensely developed areas. A limitation on height of buildings around transit stations or in central business districts should not seriously affect this approach because type of development (e.g., retail, service, or residential) and amount of development are involved.

Studies of market penetration and participation of people in various activities can help show the effects of an improvement in transportation. Analyses of church and club participation, medical and educational services, and recreation show that improved highways tend to be associated with facilities for these types of activities that are more concentrated and spaced further apart (7, 8, 9). These types of investigations lend themselves to simple, inexpensive investigations using secondary data. For example, zip codes for patients or members of an organization before and after an improvement in transportation can provide insight concerning the facility's effect on an organization's geographic penetration. Additional studies, now under way or recently completed, that seem relevant include the nationwide study of highway needs, sociological and environmental studies concerned with matters such as noise, neighborhood boundaries, and disruptions, transportation needs of the elderly, handicapped, and the poor, and a classification of urban areas depending on their orientation to automobiles or transit.

HIGHWAY TRANSPORTATION SERVICE RESEMBLING TRANSIT SERVICE

Certain types of highways or highway service and effects appear to resemble those associated with transit and may be of interest because of this resemblance. Among these are radial highways providing access to downtown areas, highway bridges or other connections across water, and highway interchange areas.

Transportation facilities such as radial highways that improve mobility between central places and outlying areas have effects that are complex and difficult to understand fully, even after they occur. Some land economists contend that improved transportation, by reducing friction between places, reduces aggregate land rentals (and land values), other things remaining the same (9, 10, 11, 12). Wendt agrees that improvements in transportation add to the competitive supply of land but points out that the increase in population served by the improvement in transportation will increase the demand for urban land. Highway study findings support this view. For example, the North Central Expressway from Dallas to Richardson, Texas, 15 miles from downtown Dallas, was accompanied by an increase in the price of vacant land in both Dallas

and Richardson. Land values, in constant dollars, increased nearly 200 percent in Dallas and 500 percent in Richardson during the 8-year study period. Land in Richardson became much more competitive with land in downtown Dallas (2).

Bridges or other transportation facilities across rivers or other water sometimes result in dramatic changes in the areas affected. The fast economic gains associated with the Lake Washington Floating Bridge near Seattle and the Verrazano Bridge in New Jersey appear to be typical of what can result from substantial improvements in mobility between areas formerly separated by water.

Highway interchange areas and areas without direct access to the highway may also provide experience relevant to analyzing transit impact and land use needs around transit stations. Highway interchange areas near population centers typically attract so many activities that the interchange becomes congested. The problems at highway interchanges are by no means solved. However, there is already some interesting experience and a number of proposals available dealing with matters such as (a) parking areas near interchanges, (b) priorities for competing land uses depending on whether these are oriented more to the traveler or to the community, (c) arrangement of land uses depending on whether they serve inbound or outbound travelers, and (d) development in the interchange area and whether it should be guided and controlled by the local unit of government that may be concerned largely with growth of local tax rolls or a higher level of government responsible for rebuilding interchanges that become overcongested (13, 14, 15, 16). Fortunately, it appears that land planning around BART stations will eliminate many of the problems highway interchange areas have experienced with uncontrolled development and traffic congestion. There are, of course, differences as well as similarities between highway interchange areas and transit stations. Downs observes that development pressures are more concentrated but fall away faster at transit stations than at highway interchange areas. Also, transit stations and lines, at least subway lines, tend to be more compatible with residential development than highways are (17).

Experience in areas apparently cut off from highway access may also be relevant. Because of opportunities for visual exposure, areas located near limited-access highways but without direct access to the highway have attracted considerable activity. Land parcels within view of heavily traveled urban highways have even been valued highly in some cases where the parcel had no access to any public road; curiously, the market for such properties is not limited to abutting owners.

In addition to visual exposure of on-site facilities, billboard advertising could evolve along above-ground transit lines. Control of advertising along transit lines should be simpler than that along highways because questions of user needs would be absent. It seems doubtful that highway experience concerning techniques, attitudes, costs, affected groups, and efforts would have much relevance for transit advertising.

SOME FINDINGS AND INFERENCES FROM HIGHWAY IMPACT STUDIES

Several findings or inferences can be drawn from highway impact studies. Some of these involve a synthesis of study findings and some result from experience with the studies. These findings involve observations about quantifying study results, the value of diverse and unofficial studies, land value analyses, the need to use impact findings, and environmental considerations.

Quantifying Study Results

Highway impact studies typically identify affected groups and describe how these groups are affected. Where possible, these effects are reduced to numbers. Impact studies, however, typically pay more attention to the way benefits or effects are distributed among affected groups than to the reduction of these effects to a final number, benefit-cost ratio, or rate of return. Impact studies do ordinarily identify and array all relevant effects even though these can seldom be added together or to user effects to provide a net amount of impact. There is general and current recognition that no useful purpose is served by insisting on quantifying all benefits or effects. Congress, for example, has insisted on being told which groups are affected, and in what ways, and

may elect to forego overall benefits of a program (e.g., highway billboard control) if the effects on selected groups are considered to be unacceptable.

Researchers at Stanford University, recognizing the problems involved in using a value about which they were unsure, presented their findings for noncommercial time saved along highway routes in terms of time saved rather than in dollars, recognizing that noncommercial time saved has not yet been priced satisfactorily (18). This is a retreat from many earlier studies, and one that those analyzing BART may want to consider. Unless trip purpose is given close attention, placing a price on time saved may provide misleading results. For some highway trips and perhaps for some transit trips, time savings may be unimportant. Time saved while joyriding should not be regarded as a benefit.

The Value of Several Unofficial Studies

Sufficient effort needs to be made to provide an overall evaluation of a facility's effectiveness. Because time and money are usually limited, the insistence on the ideal study that will identify and document every effect is seldom practical. More analysis than can be afforded will almost always be needed. Because of this, encouragement should be provided for research efforts by students or others in addition to whatever official or major study is done. Highway impact study experience suggests that inexpensive research efforts can be very useful. They avoid many of the problems accompanying large studies: delay because costly studies require planning and funding decisions by managers whose time is limited, delay because of coordination problems between two or more levels of government, and delay because study findings need to satisfy the sponsors before being released. For these reasons, the workshops during this conference should perhaps attempt to design research tasks not only for a large, integrated effort but also for small, independent studies.

Experience with highway impact studies also suggests that more objective and useful evaluations are provided by researchers outside the operating agency. With a few exceptions, highway impact studies by universities and consultants seem to have been superior to those done by operating agencies. Operating agencies also appear to need the help of independent analysis on matters such as social, economic, and environmental effects more than on questions of traffic flow and direct costs.

Land Value Analyses

Land values are, of course, only one of the indicators used in impact studies. Land value analysis can provide an objective check of other indicators of change, e.g., opinion surveys or land use change. In fact, some such indicators need such checking with other indicators. Land use changes alone, for example, may not show anticipated changes that prudent investors may already be discounting. Land values can be an indicator of all the various direct and indirect impacts affecting property, whether the influence is a parkway, a noisy arterial, or a transit station (19).

Land value information is also often necessary to (a) answer questions local governments have about tax roll effects, (b) provide compensation for those displaced, (c) evaluate the feasibility of airspace development, and (d) acquire land in advance of actual need or in excess of needs. This latter need is becoming more important as support grows for having the transportation agency share in the windfall gains occurring near these facilities and as high interest rates complicate the feasibility of acquiring excess land. Land values have already received considerable attention in some analyses of transit effects (2, 20, 21, 22).

Impact Findings Should Be Used

Highway impact studies have undergone changes through the years. Early studies were intent primarily on learning about highway effects. Impact researchers are no longer satisfied to identify and measure highway effects. They now emphasize ways for using the impetus that highways provide to achieve broad community goals (26, 27, 28, 29, 30, 31). It is encouraging that transit studies and study plans recognize the need

to ascertain the effects of the system and also to perceive what adjustments can be made to improve the effectiveness of the system.

Environmental Considerations

Some highway studies have underemphasized environmental considerations. This hardly seems a danger for transit studies; some analysis of this has already been done (23). Even so, a technique used in a National Cooperative Highway Research Program study (24) may be useful in transit studies. This involves analysis of public attitudes concerning matters such as the ideal mode for different types and lengths of trips and an evaluation of service provided. An approach of this type could be used to find out the extent to which BART improves the image transit has had in the minds of many travelers (25).

CONCLUSION

Looking back, one may regard some highway impact studies as being less definitive than desirable. Questions asked about transportation systems today are more searching and complex than many of the questions asked at the beginning of the early impact studies. Study methods are also more sophisticated, and more research money is available than when highway impact studies began. Thus, highway impact studies are not as relevant to an evaluation of a system like BART as are land use and planning studies such as BATS, BASS, and PLUM. Even so, it may be of some help to those who will evaluate BART to know that many of the same characteristics analyzed in highway studies are among those analyzed in some transit studies—land use, employment accessibility, education, cultural and recreational opportunities, real estate and tax roll effects, civil defense, and effects on life style and the environment.

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NOTES ON THE METHODOLOGY OF URBAN TRANSPORTATION IMPACT ANALYSIS

David E. Boyce, Regional Science Department, University of Pennsylvania

The introduction of a large-scale transportation improvement, such as the Bay Area Rapid Transit system, into the urban system may be viewed as an experiment to determine the effect of service characteristics on travel patterns, location of activities, and related variables. Examples of such service characteristics are travel time and cost, comfort, and convenience. If one considers the available scientific knowledge on these implied relationships, such experiments are indeed warranted.

If the improvement is viewed as an experiment, however, a major question arises that is all too familiar to social and other nonexperimental sciences. This methodological question is (a) how to provide for experimental control and (b) how to obtain replications of the experiment, that is, repeated observations on the effect of the experiment on randomly selected subjects. The detection of the effect of any experiment that is without control and replication is seriously in doubt. In these brief notes I discuss why previous impact studies have been inadequate from this point of view and present some ideas on how experimental control and replication can be obtained.

SHORTCOMINGS OF PREVIOUS STUDIES

Hundreds, perhaps thousands, of urban transportation impact studies have been undertaken to date. Most of these have been the before-and-after study variety. Despite these major efforts, our detailed scientific knowledge of the effects of an urban transportation facility is extremely limited. Few generalizations have resulted, and our ability to predict impact remains essentially undeveloped. There are many reasons for this finding, some of which are inherent in the before-and-after study approach. The procedure of such studies is (a) to record the values of pertinent variables, such as land value, construction value, travel volumes, and speeds, for a period of time prior to the introduction of the facility; (b) to record the values of the same variables for a comparable time period following the introduction of the facility; and (c) to compare the 2 sets of values.

Experimental Control

There are 2 major deficiencies of such an approach. First, the before-and-after values are not strictly comparable. Regardless of the introduction of the facility, the variables are likely to change during the elapsed time period. This deficiency is overcome by forecasting the values of the variables of interest without the improvement (Fig. 1) and comparing these forecasts with the observed values after the improvement. In other words, direct comparison of the values from the before studies with the after studies is invalid; the proper comparison to make is between forecast values based on no improvement and observed values resulting from the improvement.

Another method for achieving comparability in the experimental sciences is to introduce one or more control observations. A control is an observation on which no experiment is performed. The use of a control is shown in Figure 2. In this case the comparability of the observation on the improvement and the control observation is established in the before period. After the improvement is initiated, the 2 are again compared in the after period.

Replication

Even if comparability of the before-and-after period is achieved, a second question remains as to what constitutes a real difference or change. Are the values recorded

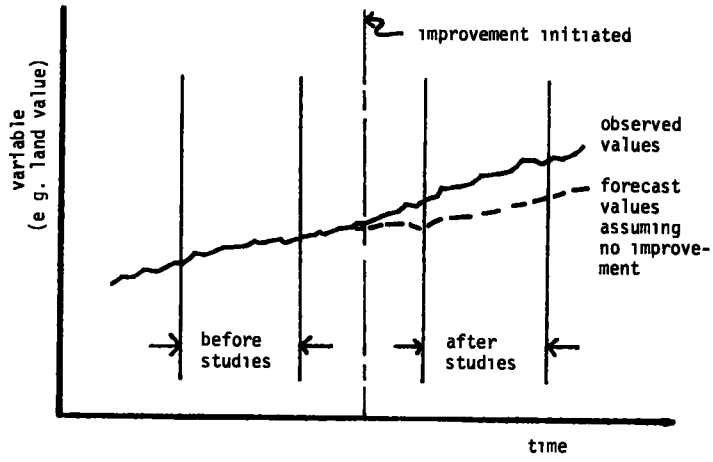

Figure 1. Comparison of outcome with forecast

in Figures 1 and 2 for the after period actually different? Based on the information typically given in such studies, the answer to this question can be made only in terms of one's judgment and experience. Such opinions are not particularly useful in predicting the effects of improvements in other situations.

In experimental situations the question of significant statistical differences between an experiment and its control is answered by replication of the experiment. The experiment is repeated several times, and the experimental error for the 2 types of observations is computed. The variance of the differences between the experiment and the control is then compared with the variance of the error within the 2 types. If the ratio of the variances associated with these between-and-within group differences is larger than that which could occur by chance, then it is concluded that the 2 types of observations are different. The procedure outlined briefly here belongs to a rich methodological area in statistics called analysis of variance (2, 3). An earlier paper by the author gives an example of an application to the analysis of travel patterns (1).

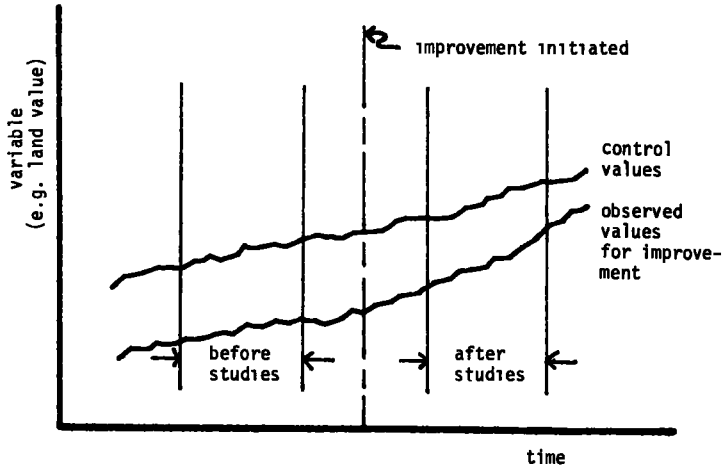

Figure 2 Comparison of outcome with control.

How can replications be achieved in a nonexperimental science? Clearly, if we regard the BART system as an experiment, it cannot be easily replicated from corridor to corridor or from city to city. However, by a careful definition of the problem, we may possibly view an urban transportation improvement as an experiment in the sense just discussed. A possible experimental design for such an experiment is as follows:

1. Let the impacts of interest be associated with points such as transit stations or freeway interchanges;
2. Consider each such point as a potential observation in an experiment;
3. Suppose that one or more corridors in which no improvement is made is identified, together with the hypothetical locations of the impact points (stations or interchanges);
4. To satisfy the randomization requirements of the analysis, draw a sample of points from both the experimental and control corridors; and
5. Compute statistics to test the hypothesis that the difference between the 2 corridors is significantly different from zero.

AN EXAMPLE: THE PHILADELPHIA-LINDENWOLD RAPID TRANSIT LINE

In order to illustrate the concepts of control and replication in a nonexperimental context, I have drawn an example from a proposed impact study of the Delaware River Port Authority's Lindenwold line; the technology of this facility is fully comparable with that of the BART system. Being unfamiliar with the details of the BART system, I am unable to assess whether the methodology is also applicable to that case; however, the concepts should be valid.

The Lindenwold line extends approximately 10 miles southeast from Philadelphia on a former commuter railroad right-of-way. It has 6 center city stations in Philadelphia and Camden and 6 suburban stations with parking for 5,700 cars. Ridership near the

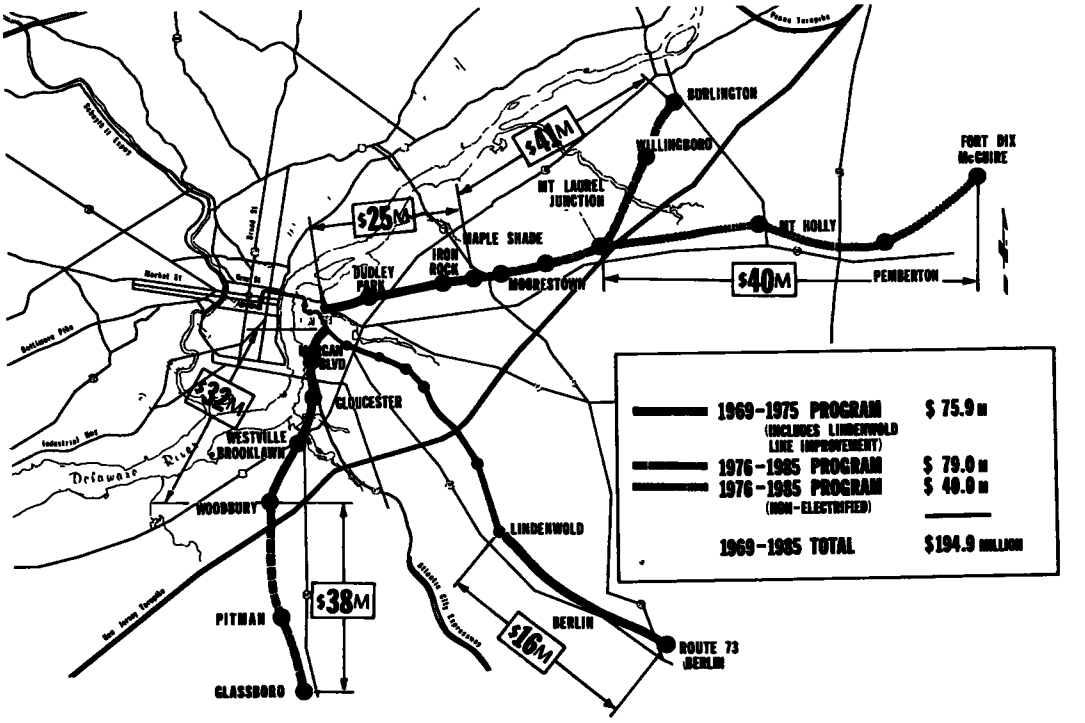

Figure 3. Southern New Jersey Regional Transit Improvement Program.

end of the first year of operation now exceeds 29,000 trips per day; average fare is about 47 cents with a range from 30 to 60 cents. Two additional lines, to Mt. Holly-Willingboro and to Glassboro, are planned for construction in the next 5 to 10 years, also largely on former railroad rights-of-way. All 3 branches of the 70-mile completed system will serve downtown Camden and center city Philadelphia and connect directly with the Philadelphia transit system. These lines are shown in Figure 3.

Now, as an example, consider the specific problem of determining the impact of the Lindenwold line on residential land value. Stations on the Lindenwold line constitute observations in the experiment. Proposed locations on the 2 planned lines provide for experimental control. Hypothetical station locations on 1 or 2 other abandoned commuter lines for which no rapid transit line is contemplated provide for control observations to account for land speculation on all 3 lines.

Stations could be divided into 2 types: (a) those serving residential areas developed prior to 1945 and (b) those serving residential areas developed after 1945. All corridors have at least 2 stations of each type. For each station a series of concentric zones of equal area could be defined. Within each zone the year-to-year changes in residential land value can be determined from sales value and assessment records.

These definitions of terms permit an experimental design to be stated. Let factor A be the corridor type with 3 levels or classes: Lindenwold corridor, planned transit corridor, and corridor with no transit. Let factor B be the distance from the station with levels consisting of areal rings extending 2 to 5 miles from each station. Let factor C be area type: prewar development and postwar development. Let 2 stations drawn at random from each category of corridor and station type constitute replications on the criterion variable, change in residential land value.

If a 3-way analysis of variance model is used, a large set of hypotheses, such as the following, can be tested:

1. Mean changes in land value are equal for all corridors;
2. Mean changes in land value are equal for all station types;
3. Mean changes in land value are equal for all areal rings
4. Mean changes in land value are additive for corridor type and station type (no interaction effect); and
5. Mean changes in land value are equal for prewar service areas for all corridors.

Many other tests could also be conducted, giving special attention to interaction effects and the assumptions of the model. Other variables could be studied such as changes in residential construction, employment, residential rents, land use conversion, and so forth.

CONCLUSIONS

This example serves to illustrate the application of control and replication concepts to the study of the impact of urban transportation facilities. The example also suggests that a rather large and rich methodology is available for studying such effects. These methods are extremely flexible, and are by no means limited to the simple example described. Their careful application should lead to useful results from impact studies of the Bay Area Rapid Transit system.

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SUMMARY OF THE PANEL WORKSHOPS

Kenneth E. Cook, Highway Research Board,
Richard Carll, San Francisco Regional Transportation Planning Committee, and
Phoebe H. Cottingham, University of California

During the conference the conferees were divided into 4 panel workshops to discuss specific issues related to (a) land use impacts; (b) impacts on travel volumes and traffic flow characteristics by all modes; (c) impacts on social and environmental characteristics; and (d) impacts on economics of the region and transportation systems. The panels attempted to define the significant issues and to determine research needs in order to assess the impact of the BART system on the San Francisco metropolitan region. On the final day of the conference a plenary session was held to review the activities of the individual panel workshops and to provide an opportunity for a general discussion.

PANEL 1: LAND USE IMPACTS

Britton Harris, chairman

The principal recommendation of Panel 1 has largely to do with data systems. The evaluation of land use changes influenced by BART depends substantially on the availability of information; this would require the creation of a data bank. The data system should be a regionwide system and serve many planning purposes besides the analysis of the BART impact. This data system should be coordinated with other types of efforts, and a 1975 census of the region should be encouraged. The data system should be concerned primarily with the Bay Area, and the panel does not recommend the establishment of an independent control area outside of the Bay Area in which parallel data would be collected. The qualitative and quantitative information of local development probably has to be investigated in detail and not on an aggregate basis. When control areas in non-BART regions are required, they should be established along the lines presented in the paper by Boyce.

The types of information to be gathered in the data bank must be based on considerations of potential users. One of the users might be the BARTD itself, especially for questions concerning system planning and extensions. Other users would be local planning agencies who are concerned with zoning and who have to adapt to the BART system. Other metropolitan regions throughout the country will be looking at the BART system to determine its economic feasibility and its ability to service the needs of the region. Likewise, national and state governments who have to allocate funds for transit will be concerned with the social, economic, and environmental effects of the BART system and its ability to help solve the passenger-transportation demands on an economically sound basis. Studies must be related to decisions that are both short term and long term.

Some of the specific research questions to be addressed relate to (a) land use impacts on central business districts such as San Francisco and Oakland and other local impacts and (b) development in corridors that are served by the BART system and those that are not and within counties and between counties. The welfare aspects of distribution and location of various segments of the population should be considered, including distribution, location, and accessibility by different segments of the population. These studies ought to be in a regional context and should include those parts of the region not served by the BART system.

Regarding land use models, the panel was inclined to pass a "self denying ordinance." There is a professional bias in favor of modeling, but the panel thought there was no clear way that models can aid in defining the impact of the BART system except for formulating some theoretical or conceptual understanding.

Schneider's work on the degree to which a region has been structured and Boyce's work on "regional temperatures" provide some theoretical ideas on which to base impact studies. However, there is still difficulty in interpreting social values of various

measures of change. For example, is the higher structuring of land use toward that of New York City, as compared to Los Angeles, a good or a bad thing?

In creating a data bank one should consider that the BART impact studies should last over a period of 10 to 20 years. Present emphasis should be on the data to be collected, and some of the questions of measurement and interpretation can be deferred until the impact of the BART system can be measured in 5 to 10 years. The priority now is to capture the data from which later impacts of the BART system may be assessed.

PANEL 2: IMPACTS ON TRAVEL VOLUMES AND TRAFFIC FLOW CHARACTERISTICS BY ALL MODES

Norman Kennedy, chairman

Following the recommendation in Zettel's paper, the panel directed its attention to considerations of traffic volumes and traffic flows as the initial starting point for the impact research. The panel thought that, because the primary purpose of the BART system is to relieve the traffic congestion problem, the impacts of the BART system must be measured primarily in terms of traffic volumes and traffic flow changes. If there are no significant changes in traffic volume and traffic flow, the BART system will not have a major impact on other transportation modes, land use, or on the economic, social, or environmental characteristics of the region.

The panel divided its considerations into 4 major topic headings: (a) major parts of proposed research, (b) significant items of research, (c) roles in research and action programs, and (d) possible beneficiaries of impact studies.

The panel defined 4 major parts for research: (a) research on methodologies—for example, how to improve home interview techniques, accident data for transit, and coordination of data collection with other agencies; (b) data collection activity and data base structuring; (c) interpretation of data; and (d) evaluation. The panel thought that some of the present survey techniques, though satisfactory, were extremely costly, and better ways were needed to obtain data. For example, the current home interview technique is costly and has a number of deficiencies. Research on how to collect similar data would be worthwhile. One suggestion for collecting data on the journey to work is to use an interview technique at the work site instead of at home.

The panel identified 3 items as being significant for research: (a) transportation consumers; (b) the transportation system; and (c) individual corridors. The research related to transport consumers should consider effects of automobile ownership, trip-making by mode, and trip lengths by mode. The data would most likely be obtained through interviews. Research relating to the transportation system should consider effects of persons making trips and vehicles making trips, system speeds, system accessibility, terminals, system safety, system reliability, system costs including travel costs, and comfort and convenience. Such data probably could be collected through traffic counts, studies, and interviews. Research related to the individual corridors—bridges, gateways, and selected freeways—is in progress and has been for quite some time by a number of agencies. A great deal of data is available from these various sources. Data on traffic flow and traffic volume were collected in the recently completed BATS study. The 1970 Census will reveal information on the journey to work, and presumably data systems initiated by BATS will be continued.

The third major heading—roles in research—was selected as an attempt to define the techniques in getting research in this area started and coordinated. One suggestion was to have a joint committee to coordinate the research and collect the data, perhaps under the auspices of the Regional Transportation Planning Committee. Another suggestion was to divide the responsibilities and have the Regional Transportation Planning Committee undertake research related to the transportation consumer and individual corridors and have universities or other research agencies undertake research relating to the transportation systems.

The panel considered the possible beneficiaries of such impact studies. Among possible beneficiaries are local communities and BARTD for consideration of system extensions; other cities in planning comparable systems; federal, state, and local agencies for funding and transportation policy making; and transportation analysts in evaluating models and prediction techniques and evaluating their accuracy.

PANEL 3: IMPACTS ON SOCIAL AND ENVIRONMENTAL CHARACTERISTICS

Donald Foley, chairman

One of the first questions discussed by panel 3 was whether research on BART should be designed mainly to aid in improving BART (including possible future extensions) or to aid designers of other metropolitan transit systems. It was decided that although the San Francisco Bay Area had peculiar characteristics, such as topography, research findings should be transferable as much as possible. The unique features of the Bay Area deserve some research and must be considered in the transfer of information to other regions. The panel considered the problem of identifying the social and environmental goals that a transit system such as BART might be expected to satisfy. It was pointed out that goals differed according to different interests in the Bay Area and that behind the BART system was a complex network of complementary and conflicting social, economic, and ecological goals and values that resulted in the construction of BART. Contributing further to the difficulty of research in this area is the continual changing of priorities attached to various goals over time. For example, at its inception the BART system was directed primarily at relieving the traffic congestion problem in the Bay Area. Because of the social and environmental considerations, which are now receiving increased public attention, these factors may be expected to play a considerably greater role in future evaluation of the impact of BART than they did when the decision was made to construct the system.

The panel spent considerable time considering whether, in designing impact studies, transit and automobile usage should be considered as competitive or as potentially complementary modes. Although diversion from automobile to transit might have been a primary consideration in creating the BART system, BART may offer a potential transit facility for persons who do not have ready access to automobiles. Also, transit may be able to penetrate high-density areas that are already in existence by means of tunneling, which does not require large amounts of land or displace substantial numbers of people. Therefore, the panel felt that both the competitive and complementary aspects between automobile usage and public transit should be considered in designing impact studies of the BART system. There was general agreement that the most urgent need was for feed-back information that could be used to improve the operation of the BART system.

TABLE 1

SUGGESTED RESEARCH ON THE SOCIAL AND ENVIRONMENTAL IMPACTS OF BART

Research Topic	Votes by Panel Members	Research Topic	Votes by Panel Members
Changing employment opportunities	9	Study of information system employed by BART to inform users and potential users	3
Low income	6	Study of the feeder systems and their ties to BART	2
Reverse commuting	4	Reliability and waiting time in use of BART and feeder systems	1
Latent demand for transit service	7	Impact on economic activity and commodity flow	2
Low income (also listed above)	6	Study of the attitudes and expectations of the original BART designers	2
Environmental impacts of the transit route	7	Study of BART goals and their fulfillment	1
Changes in character of neighborhoods affected by BART	4	Study of impact on highways in relief of congestion	2
Effectiveness of joint land uses of space adjacent to or under BART tracks and stations	2	Impact on car pool practices	1
Aesthetic impact	2	Leisure trips and miscellaneous trips by BART	1
Relocation impacts, renewal undertaken	1	Recreational opportunities	1
Measures of accessibility	4	Unpredictable impacts of BART	1
Analysis over time of election results on topics dealing with transit decisions	4	Study of BART stations	0
Studies over time of public attitudes toward transit	3	Special service features	0
Impact on political structure (or on power structure)	3	External connections with other transportation terminals	0
Institutional impacts	2	Safety features	0
Ecological impacts	4	Impacts on segregation-desegregation patterns	0
Pollution impacts, including air and noise pollution	1	Adaptability of BART over time	0

Because of the breadth of the topic, it was extremely difficult to systematically identify and attach priorities to needed social and environmental impact research. The panel therefore developed a list of possible research topics, and panel members were then asked to vote according to order of importance for the 6 most important topics. The topics and number of votes received are given in Table 1.

One interesting observation on study design is the possible comparison of the 3 portions of BART: one-third is above ground, one-third is at ground level, and one-third is below ground.

PANEL 4: IMPACTS ON ECONOMICS OF THE REGION AND TRANSPORTATION SYSTEMS

Harmer Davis, chairman

The panel thought that current economic impact techniques need to be reassessed. There was considerable discussion on how to evaluate the consequences of BART. There was general agreement that an analysis of BART must include the overall economic costs and benefits of the system, the effects on the other transportation investments, and the indirect effects on the economics of the region. The panel rejected the "shopping list" approach to evaluating the economic consequences. It discussed the potential clients for the research and their overlapping and conflicting nature. A suggestion was made that the economic consequences should be evaluated in terms of resources that are used up.

The use of cost-benefit analysis for determining the economic consequences of the BART system has many shortcomings. Not only economic but social and environmental consequences, which may use cost-benefit or other techniques, must also be considered. Even so, no immediate alternative is in the offing to replace the broad approach that may be categorized under cost-benefit analysis. The fact that costs and benefits are currently undergoing a substantial redefinition does not automatically nullify the value of the approach. The panel affirmed that in any analysis the total region should be used as the unit for analysis.

The question of subsidy was consistently interjected into the discussions. Some subsidies are real, and some are intergovernmental accounting transfers that are used to meet other objectives and are therefore bookkeeping activities and should be ignored in cost-benefit analysis.

Costs were discussed by the panel under the general categories of capital costs, operating costs, and indirect costs. Some of the factors to be considered in defining capital costs are the impacts of inflation and technology, governmental requirements, forced changes on the system, and extensions of the system regardless of their profitability. Operating costs, which include the maintenance and operation of the equipment and facilities, were thought to require new consideration for the comparison that will be needed. The indirect costs include the effects on other transportation systems, short- and long-term effects on the economy itself, and costs attributable to business, environmental, social, and institutional changes or distruption caused by the construction and operation of the system, including changes in traffic flow and police protection requirements.

The basic benefits to be anticipated are the change in time for commuting, i.e., the time costs saved by the system users. One of the primary concerns should be a study of the problems of estimating demand and predicting modal split under different policies and conditions. The relationship between the pricing of the services and a demand should be considered.

The redistribution effects of the BART system should be studied including its effect on the accessibility to jobs, on urban structure, and on the region's tax base. One research strategy might be to compare the alternatives of freeways, other BART systems, other transit systems, or making no decision for transit improvement.

The panel was concerned with the data base needed for such impact studies and felt that an overall strategy for data collection was warranted. As other panels pointed out, some data would be required on a continuing basis, other data could be obtained on a sampling basis. Planning and census agencies that collect data on a recurring basis

should work out a mutual scheme for sharing the information with all parties doing research requiring such information.

The panel voiced general concern that a generally accepted concept for economic evaluation has not developed in transportation as was developed in water resources in the early 1930's. A concerted effort is needed by transportation economists and planners to develop an acceptable technique for evaluating economic consequences of transportation improvements.

DEMAND ANALYSIS AND TRANSPORTATION COST AND PRICING FOR THE BART SYSTEM

Although the demand analysis, cost, and pricing for the BART system was discussed in the formal papers and in the panel discussions, some participants of the conference thought that it neither was given the position of importance that it warranted nor received sufficient consideration of the research needs. It was pointed out that the construction of the BART system was primarily predicated on its ability to divert highway users to urban transit and thereby reduce the need for future expansion of freeways and Bay crossings in the region. In addition, there is concern that the BART system should also serve low-income, minority, aged, and other groups who do not have ready access to automobiles and are dependent on public transportation facilities.

The participants pointed out that the outcome of the BART system not only will be a concern of the Bay Area but also will be examined as a case study by other urban areas contemplating urban transit innovations. Regardless of the social, economic, and environmental effects of the BART system, the key determinant in decisions by other cities to construct similar facilities will be the economic viability of the system and its ability to satisfy transportation demands and reduce urban traffic congestion. Therefore, several conference participants suggested that a section be attached to the panel summaries amplifying the need for an analysis of the demand, costs, and pricing of the BART system.

Some of the topics suggested for demand analysis research are, Who will use the system, when, and for what purposes? Who is not using the system? Why are they not using it? A primary research topic would be the effects that BART has on the demand and use of other transit systems and transportation facilities. Studies in other urban centers indicate that major improvements in rail transit have a marked effect on parallel bus systems. The effects of levels of service, comfort, and convenience on BART usage should be researched. Likewise, travel time comparisons and delays between BART and other modes should be researched to determine their effects on modal split.

Cost and investment analysis for BART should receive special attention. BART offers an excellent opportunity to examine the factors involving investment costs and decisions as to cost allocation. It offers an opportunity to evaluate factors determining interest rates and the ability of the system to recover capital investment as well as meet operational, maintenance, and depreciation costs. The system also offers an opportunity to examine the relationship between levels of service and the costs involved. Likewise, research is needed on comparison of capital and operating costs per passenger on the BART system with those on other transportation options.

The BART system offers some unique financing techniques such as the toll bridge revenues and property taxes to cover debt service. The effectiveness of such financing should be considered as well as its effect on tax and investment opportunities for other transportation systems in the Bay Area.

Intertwined in the demand and cost analysis is the need for research on pricing strategies for urban transit systems. Welfare economists have given considerable discussion to methods for pricing public transportation services and have made recommendations varying from free service to pricing that includes total operating and capital costs. The BART system will have a pricing structure initially based primarily on distance traveled; some readjustments are expected in the pricing strategy over time. The BART system will therefore afford an excellent opportunity to examine the relationship between price and demand and the effect of price strategy on diversion from other modes of transportation. Varying the pricing structure will require decisions regarding whether the objective is to optimize revenue or passenger usage and a consideration of the economic and social consequences of such decisions.

GENERAL DISCUSSION

COMMENT

Paul Wendt

I have just a couple of observations that I suspect some of you may share with me. The first is that it is very difficult to separate what we have identified as land use effects, economic effects, and social effects when we are talking about something that is as key an element as transportation is in economic and social life. For this reason I suspect many of us have had some difficulty in delineating these activities. I think that the very unity of these elements calls for the use of some kind of interaction model that can be used to study the interrelationships among transportation development, housing location decisions, and land value changes. These are very complex, and they are very difficult to isolate and to study individually without considering their interaction. We are doing some work at the Center for Real Estate and Urban Economics that involves application of a large-scale simulation model we developed. One of the projects is the new towns decision model. We are endeavoring to use the forecasting model as a basis for identifying an area in which we may expect development of a new town in the Bay Area. Now obviously this has to be related to the transportation facilities and the people's travel behavior. We are trying to mesh that, so to speak, with a rate of return with a financial decision model by the developers of new towns. Another area of research is one dealing with the impact of BART on land values. Here we are finding, of course, that land value changes reflect anticipation. One observation we have made is that we ought to have been out in the field 2 or 3 years ago looking at the history of land value changes to get a real feel of the impact that BART is likely to have in that area. A third area in which we are presently engaged is a study for Marin County in which we are trying to identify the probable impact of some alternative strategies for transportation development. I felt that the reports have been very helpful, and I thought you might be interested in some of the things we are doing right now.

QUESTION

Do you think the present data on land use are adequate as a base for a before study of the impacts of BART?

ANSWER

Britton Harris

Well, one has to say that, if they are not, it is just too bad. Some difficulties arose from the way the BATSC data were collected, and these have not all been ironed out. Some data are missing. These have to do with the floor area and the volume and conditions of buildings and would be desirable in a long-range study. Land value is something altogether different. There are no data in the BATSC's files, but on the other hand one can do some research on a sample basis by using transactions to try to identify some trends. In any case, it is a very difficult task, and I am not sure that the land value data that you will have in 1975 will be any better than what you have now after 1965. You can always study any particular station but, out of context, land values are not very meaningful. You can interpret or use as a proximity for land value such things as building volume because high-rise buildings only go up on expensive plots. Finally, what happens around stations is only part of what happens in a region. It seems to me that you cannot put any interpretation on the fact that land values rise around the stations. Although this may occur, we do not know how to interpret or evaluate it.

QUESTION

We have been discussing how the results of the BART experience can be of the greatest utility to as many people as possible faced with large decisions in policy and planning in large metropolitan areas in particular. Unlike an expressway, a transit facility does not contain within its geometrics all of the givens of fixed services. Is it beyond prospect that some part of the BART experiment could contain deliberate changes in one or more of these service variables for experimental purposes?

ANSWER

Ward Belding

I think that first of all with respect to variation in fare and differential pricing the flexibility we may have in this area will depend on the financing arrangements that are still being worked out as far as the rolling stock is concerned. Other variables in terms of flexibility of service, coordination of feeder services, and so forth are still under study to some degree. So as far as I know our plans will be continually reevaluated as we start the first year or so of service. I do not know if we can go beyond this at this point. We are concerned with making the services as responsive to changing demand patterns as possible within the operating constraints that we face.

COMMENT

Vincent Roggeveen

One of my interests is transportation folklore, and one of the pieces of folklore that I detected at this conference is that exciting things are going to happen at BART stations and in other cities too if a rapid transit system is built. I would like to suggest an addition to the study: that is, why nothing happens at many rapid transit stations. Some transit systems have been operating for 60 to 70 years, and nothing has happened during all of those years. Maybe it is something in the zoning, something in the access, something in the land ownership, something in the neighborhood, something wrong with parking, something lacking in imagination on the part of private or public sectors that causes lack of development at a location. I submit that in the BART system I can think of some stations that have exciting possibilities. I can think of other stations where I can predict that nothing is going to happen. I would like to suggest that stations attract development, land use changes, employment, social impact. I believe that you could look at existing transit stations all over the world and find that at many nothing has happened and a good research topic might be to ask yourself why this is so. Could changes be made that could create activity at particular stations?

C. D. Foster

When I was over here a few years ago, everybody was getting worked up over public transport and its place in urban transportation and arguing that public transit was necessary and that the day of the highway in cities was coming to an end. Others said that highways were here to stay and that subways were a very expensive indulgence. Again, I find a lot of people repeating the public transport case pointing to a number of facts, some of them relevant, some of them irrelevant. Clearly the cost of building highways has gone up enormously, and a lot of opposition has developed and adds to the cost of urban highway construction. One suspects that a lot of people who are clanging for transit do not know what they are clanging for. There are always other alternatives to highway construction such as decentralization of the cities. In my own country, I am very enthusiastic about public transport and I believe in its future. This is no reason, however, for believing in its future anywhere else. If Warren Higgins will permit me, I will say that after spending some time in Boston I think that there may be a justification for future expansion of public transportation in Boston. Whether or not BART is justified in the San Francisco Bay Area is quite a different order of affairs. Rail transit is tremendously contingent on particular population densities and particular types of development in different urban areas. The case for rail transit should be

evaluated on the basis of an analysis of expenditure decisions with some idea of a rate of return, cost-benefit analysis, and the impact on the net wealth of the area as a result of this change. I think that it is very important to get some feeling for the total effect—the total costs and benefits—whether it is positive or negative.

Edgar Horwood

The Danish railway system compares in scale to the BART system. It is a combination of a line-haul system that connects separate cities and urban stations with close spacing. It does not have the same speed that the BART system will have, but nevertheless it was one of the best European systems that I have ridden in terms of dependability. The important fact to note is that the ridership has been decreasing steadily since the postwar years in spite of the fact that Denmark has the highest automobile taxation of any western country, in spite of the fact that freeways are not being built at a rapid pace, and in spite of the fact that the Danes have developed housing near the rail stations. In spite of these developments, ridership has continued to decline. I asked my friends why this is, and they state that Denmark is going through a stage where still some segment of the population is buying automobiles for the first time. The number of females in the labor force is rather high, and this brings up the problem of single households supporting jobs at 2 different locations, which makes it hard to optimize location with respect to jobs. Also the trend of job development in the outlying centers is continuing. I think we have something to gain in studying these other transit systems.

Henry Bruck

Our review here has been very helpful in clarifying issues and in reminding us of the variety of things that need to be looked at. There are, however, some other messages that we ought to keep in mind, such as a reminder of how incredibly bad the state of comprehensive planning is. We are advocating ex post impact analysis in this conference, but it should have really been planned for, at least in a large measure, beforehand. We need to know not only the impact of these systems but what the consequences would have been if alternatives had been chosen. I do think that we ought to keep the future transportation planner in mind as we do these studies. I hope that in the future some serious thought will be given to allocating a much larger amount of money to planning. If you look at the costs of planning for the BART system and its relationship to the total cost of the system, you can see that less than 1 percent of the total cost of the system was related to planning. If you compare this to similar types of business decisions, the planning investment tends to be on the order of 7 or 8 percent. The second point that I think we ought to give some thought to is the great number of studies that have been proposed. We have defined 4 areas in which these impact studies might be made. I think that we will also have to have studies of what happens to the system itself when it is in actual operation. These will involve collection of data on operating costs based on actual experience and the collection of data on ridership. Aside from these studies, we should give some thought in the future to allocating research efforts among the various areas of transit impact.

David Boyce

Identifying impact is going to be very difficult. The impacts that will occur will be either zero or very subtle. In South Jersey, where a line has been in operation for a year, not very much has happened around stations. Between 15,000 and 30,000 people are getting to and from work in a new way, but beyond that little other impact is apparent. I think it is going to take some careful long-term studies to determine the effects of new transit systems.

John Gibson

I think everyone probably came to the conference with certain preconceived ideas of what they would get out of it, and no doubt they will go away with their own conclu-

sions as to what they actually gained from it. I think, from my standpoint, the conference certainly developed a prospectus of research areas that could be of use not only to the Bay Area but to many other cities and certainly to the national programs that would be involved. Although this prospectus needs further work in identifying specific projects and what useful results can come from them, certainly this prospectus should be enough to allow us to get started on some useful research. I would suggest that based on this we get started, because time is getting short. As for funding for the research, clearly there are a number of topics that will be of interest to various groups and governmental agencies. I think that some of the foundations and industry may have interests, and it might be more appropriate for them to fund rather than for the federal or state governments to do so. Earlier in the conference, I mentioned that we were considering the need for an overall study—one that would look at what was being done in several cities to see whether the data being collected could be comparable and also to do an overview look at what the national implications were. I would be interested in hearing from any one of you regarding any of the subjects discussed at this conference.

PARTICIPANTS

VLAD ALMENDINGER, System Development Corporation

DONALD APPLEYARD, Department of City and Regional Planning, Department of Landscape Architecture, University of California, Berkeley

BERNARD AVERBUCH, Market Street Development Project

CHARLES G. BEER, California Business and Transportation Agency

WARD D. BELDING, JR., Bay Area Rapid Transit District

DAVID E. BOYCE, University of Pennsylvania

M. L. BROOKS, Urban Mass Transportation Administration, U.S. Department of Transportation

H. W. BRUCK, Massachusetts Institute of Technology

W. N. CAREY, JR., Highway Research Board

RICHARD R. CARLL, San Francisco Bay Area Regional Transportation Planning Committee

T. L. CARLSON, Bay Area Rapid Transit District

KENNETH E. COOK, Highway Research Board

JAMES M. COONEY, Legislative Analyst Office, Sacramento

BETTY CROLY, Alameda County Planning Department

ROBERT DATEL, California Department of Public Works

E. SAM DAVIS, A.C. Transit

HARMER DAVIS, Institute of Transportation and Traffic Engineering, University of California, Berkeley

RONALD J. FISHER, Urban Mass Transportation Administration, U.S. Department of Transportation

DONALD L. FOLEY, Department of City and Regional Planning, University of California, Berkeley

C. D. FOSTER, Massachusetts Institute of Technology

W. L. GARRISON, University of Pittsburgh

JOHN GIBSON, U.S. Department of Housing and Urban Development

WILLIAM GOLDNER, Institute of Transportation and Traffic Engineering, University of California, Berkeley

BOB GRAHAM, San Francisco Bay Area Regional Transportation Planning Committee

BRITTON HARRIS, University of Pennsylvania

C.A. HEDGES, Office of the Secretary, U.S. Department of Transportation

WARREN J. HIGGINS, Massachusetts Bay Transportation Authority

W.S. HOMBURGER, Institute of Transportation and Traffic Engineering, University of California, Berkeley

JOHN HORTON, University of Waterloo

E. M. HORWOOD, University of Washington

S. KASHIN, Marin County Transit District

NORMAN KENNEDY, Institute of Transportation and Traffic Engineering, University of California, Berkeley

MARK L. KERMIT, Contra Costa County Public Works Department

NORMAN LIND, City of Oakland

WARREN LOVEJOY, Port of New York Authority

JOHN MARIN (for A. A. Dehaesus), Contra Costa County Planning Department

D. R. McCULLOUGH, Southern California Rapid Transit District

JORG MEISE, Institute of Transportation and Traffic Engineering, University of California, Berkeley

LEONARD MEREWITZ, School of Business Administration, University of California

WALLACE D. MERSEREAU, Bay Area Rapid Transit District

SUMNER MYERS, Institute of Public Administration

HENRY D. QUINBY, Parsons, Brinckerhoff, Quade and Douglas

R. E. REOHEL, Institute of Public Administration

MARSHALL F. REED, Highway Users Federation

VINCENT J. ROGGEVEEN, Stanford University

CHARLES ROUMASSET, U.S. Department of Labor

A. ROBERT SCHMIDT, Ontario Government

M. SCHNEIDER, Creighton, Hamburg, Inc.

JAMES A. SCOTT, Highway Research Board

ROSS T. SHOAF, San Francisco Department of Public Works

WALLACE F. SMITH, Center for Real Estate and Urban Economics, University of California, Berkeley

JOHN H. SOHRBIER, Massachusetts Institute of Technology

ARTHUR W. SPENGLER, Urban Mass Transportation Administration, U.S. Department of Transportation

WILBUR A. STEGER, CONSAD Research Corporation

MICHAEL STEPHENSON, California Division of Highways

HAL TAYLOR, California Division of Highways

F. I. THIEL, Federal Highway Administration, U.S. Department of Transportation

P. F. WENDT, School of Business Administration, University of California

GEORGE WICKSTROM, Metropolitan Washington Council of Governments

D. L. WIEMAN, California Division of Highways

R. D. WORRALL, Peat, Marwick, Mitchell and Company

ROBERT YOUNG, Federal Highway Administration, U.S. Department of Transportation

R. M. ZETTEL, Institute of Transportation and Traffic Engineering, University of California, Berkeley

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