THE BART RESIDENTIAL IMPACT STUDY:
A LONGITUDINAL EMPIRICAL STUDY OF ENVIRONMENTAL IMPACT

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BACKGROUND

The Bay Area Rapid Transit system (BART) has begun operations after over ten years of planning. In 1970 a group of University of California faculty became concerned that this immense urban project -- the first new metropolitan transit system to be constructed in the United States since 1908 -- would come into being without any objective assessment of its impact. A conference sponsored by the Highway Research Board and the University of California was held on the Berkeley campus in the fall of 1970, for which a number of papers were written (Highway Research Board, 1970) and in which research needs relating to BART were discussed and given priority. In 1971 a collection of related projects was proposed by the University of California to the U.S. Department of Transportation and the Department of Housing and Urban Development, and in May 1972 funding for the collection of pre-BART perishable data was awarded.

Among the several research projects being undertaken, two relate particularly to the quality of the urban environment. The first is a study of the impact of BART's environment on travelers in the Bay Area, the second is a study of BART's impact on the surrounding residential environments.

BART, like any urban project, has both internal and external impacts. The internal impacts of projects have in the past been of most concern to engineers, planners, and designers. The users have been, at least in the rhetoric of public relations, the predominant

clients for most projects. Today the emphasis has shifted to the external impacts of projects on their surrounding environments. Indeed, many environmental impact reports ignore the internal impacts of projects. Both internal and external impacts of BART are under investigation, in a pair of studies being carried out in parallel. One focuses on the internal impacts of BART's environment on existing and potential travelers, both typical and marginal travel groups -- i.e., both commuters and the aged, poor, handicapped, teenagers, and housewives. That study will be reported elsewhere. This paper will concentrate on the study of external BART impact -- BART's effects upon the residential quality of areas through which it will run.

Before describing this project we would like to set it within the context of urban environmental impact studies, particularly those relating to ground transportation, which form one of the major groups of environmental impact reports being submitted to the Environmental Protection Agency at this time.

URBAN TRANSPORTATION IMPACT STUDIES

Impact studies on urban freeways began to emerge in the middle 1960's in response to or as part of the protests against freeway projects in San Francisco, Chicago, Baltimore, Boston, and other cities. In these cases the impact of freeways on community values -- such as the taking of houses and jobs, and the relocation of residents -- was the dominant issue. The Highway Research Board held two conferences during this period, the proceedings of which were subsequently published as monographs -- one entitled Transportation

and Community Values (1969), the other Joint Development and Multiple Use of Transportation Rights of Way (1968) -- which attempted to broaden the considerations of highway planning to include the impacted corridor.

The passing of the National Environmental Policy Act of 1969 with its requirements for environmental impact statements therefore found the Federal Highway Administration somewhat more prepared than other federal agencies to conduct environmental impact assessments. However, during the late Sixties and to this moment the Department of Transportation has tended to emphasize procedural solutions rather than those based on objective assessment of environmental consequences. Influential research studies (Manheim, 1969; Fielding, n.d.) have rightly focused on the importance of community participation, outlining procedures whereby community groups and community values can be brought into the decision-making process, and in 1972 the Federal Highway Administration came out with its process guidelines, PPM 90-4. But while these political solutions may resolve many immediate community conflicts and should open the decision-making process to broader participation, they have left the substantive measurement of impacts without detailed guidelines, except for Highway Noise Standards (PPM 90-2).

As a consequence, environmental impact statements submitted to the Department of Transportation with respect to highway projects demonstrate a wide variation in quality and depth, a predominance of the rather superficial generalities that have been common in urban planning for the past twenty years, and very little hard empirical evidence. Most environmental impact statements at present are little

more than checklists of guesses about possible effects, even though they have the appearance of objectivity.

Environmental impact measures such as changes in noise level, sedimentation in water, air pollution, visual intrusion, or likelihood of flooding constitute the core of most environmental impact studies. While these measures appear to be objective, they are usually selected by professionals or scientists, and are therefore limited by professional perceptions of environment and impact. To this extent the measures are subjectively selected, even if their magnitudes are in a quantified form. Few impact reports find out how impacted population groups weigh these measures.

The scanty empirical research on community impacts has usually utilized census data to develop indices of social or economic change (e.g., Hill, 1967; Burkhardt, 1971; McLean and Adkins, 1971). These studies are limited to the few relevant census measures, and they are limited by the ten-year collection points. Other studies, particularly of noise and air pollution, have focused on land value as an indicator of impacts, but land values are affected by a multitude of influences and attribution to particular environmental influences is a precarious assumption.

Attempts to assess more comprehensively the environmental impact of a transportation system in an empirical way are scarce, indeed. Small-scale studies have been carried out by Appleyard and Lintell (1972), and more comprehensive efforts have been undertaken in Great Britain by D. H. Crompton (1971) on arterial streets and by Llewellyn Davies Associates (Bor and Roberts, 1972) on urban motorways. Although these studies do not appear to have used systematic

interview techniques, they have looked at a variety of impacts. To date no impact study has attempted to relate a comprehensive set of environmental measures to measures of population response in a systematic way.

BART RESIDENTIAL IMPACT STUDY

The BART environmental impact study can therefore make an important contribution to impact assessment procedures, in addition to the implications its findings will have for the understanding of environmental impact.

1. It is an empirical assessment of impact and human response to this impact.
2. It is geared to the collection of a wide range of measures whose effectiveness as indicators of environmental impact will be evaluated in order to select the most relevant for subsequent use.
3. It is committed to monitor impacts over a period of time to compare before/after conditions and of sufficient length to rule out Hawthorne (Roethlisberger and Dickson, 1939) and sleeper effects (Krech, Crutchfield, and Livson, 1969).
4. It will provide immediate information on the impact of BART to aid in the planning and management of BART's right-of-way and station areas.
5. It will develop predictive models of impact that may be applied to future transit extensions and future transit systems.
6. It will in its later stages compare the environmental impacts of BART with those of the routes of freeways, buses,

and other urban transportation systems, thereby assessing BART impact realistically, in context.

Our definition of environmental impact may be appropriate here, since the word is used in many ways, and especially since others at this symposium are talking about impacts on the natural environment. This study focuses on the effects of BART upon the physical, social, and functional environments of impacted populations. It will look at BART's effects on the everyday lives of those who live around the system, on the amenity qualities of their physical environments, on their social contacts, and on their access to local facilities. Many of these impacts may be termed perceived environmental impacts, since the residents will be aware of them; others, of which they may be unaware, such as a slow increase in traffic volumes on local streets may be termed effective environmental impacts. Impacts of BART on the natural environment will be considered if they affect the amenity quality of the physical environment for its residents through, say, unsightly erosion or other deterioration of their perceived residential area.

The external environmental impacts of BART will be both direct and indirect, local and regional. The direct local effects on residential neighborhoods -- effects on such variables as ambient noise, local access patterns, safety, privacy, territoriality, physical character, social networks -- should be relatively easy to measure and clearly attributable to BART. However, the secondary or indirect local effects -- which may be more important in the long run -- will be more difficult to attribute regarding causation. Indirect impacts of BART, say those mediated through traffic patterns

around stations, can be assessed with fine-grain traffic information. Similarly, the impacts of land use, population, and zoning changes around BART can be assessed, but their attribution to BART becomes less clear. Has a new office building located near to BART because of BART or because of a regional shopping center?

Indirect regional impacts -- not part of this study -- suffer even more from these difficulties of attribution. Is a new subdivision in Walnut Creek built there because of the new BART station or because of the freeway system or for other reasons? Other studies (Lee, 1972) are attempting to determine these land use impacts. Environmental quality studies can assess these regional impacts when the land use studies have been made. However, our initial focus is on local impacts.

SAMPLING IMPACTS OVER TIME

The impacts of a project are expected to change over the several phases of its evolution. The phases that appear to be significant in the evolution of the BART system (Figure 1) are:

1.	Pre-project history	prior to 1962
2.	Site clearance and construction	1962-1971
3.	Post-construction and pre-opening	1971-1972
4.	Opening of operations	1972-1973
5.	Post-opening and impact stabilization	1974-future

Since the study did not commence until after construction was complete (Phase 3), the prior history of impact will be gathered through examination of secondary data and through the interviews, which include questions on the respondents' perceived history of

BART's impacts. All pre-BART perishable data -- i.e., that which would be lost once the system started to operate -- was collected during the summer and early fall of 1972. Subsequent waves of data collection are scheduled for the summers of 1973 and 1974.

The "site clearance and construction" phase (Phase 2) may have most impact around stations with large parking lots and in the "cut and cover" type of subway sites such as on Market Street in San Francisco or along Hearst Avenue in North Berkeley. The construction phase of transportation projects often includes the destruction of buildings and relocation of families and users, and the generation of noise, dirt, fumes, and heavy truck traffic. The post-construction, pre-opening phase (Phase 3) may be a hiatus in which relief from construction impacts is mixed with anticipation of the opening.

The "opening" phase (Phase 4) of BART will probably be the time in which people will be most vulnerable and sensitive to impacts. It could be a "honeymoon" period; it could be one of surprise and disappointment. In the first few months of the system's opening BART has frequently been front page news, sometimes favorable, sometimes unfavorable. This will probably be a time when people are most aware of and articulate about environmental impacts such as annoyance from lights or added traffic around the stations. Later they may well have adapted to environmental changes or have screened them out of awareness. It is therefore a most important time to interview people. However, early studies in the General Electric plant at Hawthorne determined that almost any change in management had a favorable effect on production -- withdrawing benefits such as coffee breaks, as well as introducing them, but in many cases the

favorable reactions were temporary "Hawthorne effects" (Roethlisberger and Dickson, 1939).

The "impact stabilization" phase (Phase 5) will be difficult to identify as beginning at any particular moment. It may be characterized by a stabilization of attitudes, and by the emergence of various adaptations in behavior, which may include altered ways of using neighborhoods and outdoor spaces, physical changes to homes such as protective walls or outdoor lighting, even to population change over in certain neighborhoods. The best strategy for identifying arrival at this phase will be comparative analyses of the repeated annual data collections. Comparisons between the 1973 and 1974 data may show such stabilization, or, if impact responses are still in change, a subsequent wave of data collection will identify it. Total stabilization may never arrive. Identification of the regularized period may need relative rather than absolute criteria to separate the period of high awareness and rapid adaptation from that of low awareness and minor behavior change. Patronage may slowly increase (as happened on the Lindenwold Line in Philadelphia) and land uses around the stations may continually change, so that impact responses in some areas may take many years to stabilize. The identification of the stabilization phase will also be complicated by the phased opening of different sections of the BART system over a one year period.

Another source of misinterpretation becomes increasingly important: <u>secular effects</u>. When, as in the case of assessing BART impact, a matter of months and even years may be necessary to perceive long-range and enduring effects as distinct from reactions

during the "honeymoon," "shake-down cruise," or "sea of mud" phase (Rosow, 1963), the danger of misinterpretation due to secular trends is grave.

Urban areas are undergoing all manner of planned and spontaneous change. BART is only one such development in the Bay Area. Focusing on BART as an innovation must not preclude awareness of other changes, and particularly of the impacts these other urban events may have upon the same "indicators" that are viewed in monitoring BART's effects. Assessment of BART impact must, of necessity, be carried out in the context of a changing urban environment and population. It is crucially important not to attribute to BART, effects which actually derive from some of these other urban processes.

Understanding the extent and direction of BART's impact requires their evaluation in the context of secular effects. Viewing BART outside this context may lead to erroneous conclusions of "no impact" as well as to attributions, to BART, of favorable or unfavorable consequences of other urban processes. In some instances, "no change" may actually represent a favorable impact (Carp, in press). For example, if automobile traffic increases in the Bay Area generally, with its attendant congestion, noise, and air pollution, BART-area residents may benefit -- relative to others -- if use of BART maintains automobile traffic at its present level in their neighborhoods, or even if the increase in their local traffic is less extreme than it is in areas distant from BART.

The ideal would be to compare the post-BART condition with that which would have prevailed, at that point in time, had BART not

been introduced. Patently, that is impossible. A good approximation could be obtained by comparing pre-post BART measures with those taken at the same points in time in situations identical to the Bay Area, with the single exception that no rapid transit system existed or was introduced.

"Control areas" similar to the Bay Area in physical configuration, population composition, and other relevant characteristics is not readily available. The control area would have an additional requirement: it would have to be one in which a rapid transit system similar to BART had been constructed but would not become operational during the course of the investigation. Obviously, such "experimental control" is unrealistic. Nevertheless, the problems consequent upon its absence must not be ignored. Two control sites have been selected which are several miles from any BART station or track (Carp, Appleyard, in preparation). The two control sites were selected by a statistical selection process to be as similar to the more common types of BART site as possible. Data will be gathered on these sites to distinguish whether changes recorded on the BART sites are part of Bay Area trends or attributable to BART.

Because of the very large number of variables which must be included in statistical procedures to clarify (1) the impacts of BART as distinct from those of secular events which occurred during the time interval and (2) the ways in which BART impacts are mediated or modified by characteristics of (a) BART itself, and of the (b) physical and (c) social context, large sample data representative of the impacted population are necessary, if generalizable conclusions are to be drawn.

Therefore, as one research strategy, an impact zone was defined as that comprised of residential areas within one mile of BART (Carp, Appleyard, et al., October 1972). Of necessity, considering the limited relevant evidence available at this time, the definition of "impact zone" was in large part arbitrary. However, existing evidence and extensive preliminary field observations suggest that the direct environmental effects of BART and many of the secondary environmental effects will be confined to residential areas within one mile of BART.

Moreover, it is anticipated that, insofar as changes reflect BART impact, they will occur in systematic patterns about BART stations and BART lines. Generally, the intensity of BART impacts will depend upon proximity to BART. Effects are anticipated to be greatest upon residential areas immediately contiguous to BART stations and lines; and effects are expected to diminish or decay with distance from the rapid transit facility, most of them dissipating before reaching the outer limit of the impact zone. For each type of BART-impact, a particular "gradient of effect" in relation to BART is hypothesized.

In this research strategy, then, distance of the site from BART is used as a variable to control for secular effects. This assumes, of course, that secular effects -- urban processes in no way related to BART -- tend to be randomly distributed within the two-mile strip bisected by BART. This assumption, which seems reasonable, can be checked with records of such events as highway and building construction, and changes in land use and land value during the interval between collections of pre-BART and post-BART data.

To implement this system-wide research strategy, interview data have been collected from 2541 persons 18 years of age and older who live within one mile of BART, throughout its length (Carp, Appleyard, et al., October 1972). Census descriptors of the social context and geographic descriptors of the physical context have been recorded for the residential site of each of these 2541 respondents (Carp, Appleyard, et al., in preparation).

When post-BART data become available, predictions regarding the patterns or gradients of effect, centering on BART and diminishing with distance from it, will be tested in terms of change-scores. The existence of these "gradients" -- indicating lawful relationships of score-change with distance from BART -- will distinguish BART impacts from secular effects. Change-over-time which is randomly distributed over the BART-impact zone is likely to reflect more general processes of urban change.

The sample size and full coverage of the BART system will allow multivariate analyses to study BART impacts as they vary according to (1) the local configuration of BART, and the local (2) physical and (3) population characteristics. Obviously, the exact size and shape of any BART impact will depend not only upon distance from the facility, but also upon the characteristics of BART in that area; upon the land contour and intervening barriers; upon proximity to other transportation facilities such as freeways, arterials, airports, and railroads; and upon other characteristics of local land use; as well as upon the composition of the local population. It is exactly because of the rich variety of factors which modify the basic relationship between BART impact and distance from BART that

a large number of sites, representative of the entire range of possibilities, is requisite to adequate analysis of BART impact.

Selected Site Strategy

The system-wide design has limitations in relation to the study's goals. Even a large sample provides rather thin coverage within a small environmental unit such as a cluster of city blocks which might constitute a neighborhood. In order to understand BART impacts upon the quality of residential areas, it is necessary to make fine-grain studies in a few selected small areas. These detailed, intensive studies are an essential complement to the broad-gauge, representative approach, for full investigation of BART impact upon the residential quality of areas through which it runs.

In addition the special-site strategy will be of unique value in regard to one essential lack, which this study is intended to remedy. This is the absence of instruments for direct assessment of the residential quality of an urban environment. A major goal of this study is to develop "environmental indicators" which will enable a trained observer to score the residential quality of an area. Such instruments will enable direct assessment of the environmental impact of the introduction of a rapid transit system, a freeway, a factory, or whatever. They should be of inestimable value in the planning phases of urban developments.

Intensive observations of behaviors and behavior traces, and detailed inventories of environments are necessary in an adequate search to identify potential "indicators of environmental quality." Work at this level of detail cannot be carried out in an area the

size of that necessary for the multivariate analysis of BART impact in its complex and changing physical and social context.

Therefore, in order to identify these "environmental indicators," to devise objective and reliable instruments to measure them, and to validate these instruments in terms of their relationships to residents' evaluations of the areas in which they live, it was necessary to complement the BART-wide strategy with one which takes a sharp focus on selected areas within the impact zone.

BART impacts are predicted to be strongest, nearest to the rapid transit facility. Therefore, the interface between BART and the residential area is an excellent milieu in which to carry out the initial steps of indicator identification and instrument development.

Consequently, special sites were selected within this interface, some for unique characteristics which will be helpful in understanding BART impact; some because they share many characteristics with other BART sites, and therefore are in some measure representative of a larger number of interface situations. Intensive, detailed observations have been made in these sites of residents behavior, behavior traces, and other environmental variables (Appleyard, Carp, et al., in preparation). A supplement of 600 interviews has been conducted with respondents who live within these special sites, to provide more intensive coverage of residents' evaluations of their neighborhoods, which will be used to validate the selection of "environmental indicators."

Twenty-five sites of predominantly residential character immediately around the stations or channels were therefore selected

for a supplement of interviews with persons who lived in close proximity to each other and to BART, and for a more detailed physical environmental analysis (Carp, Appleyard, et al., October 1972). These sites were selected either for their representativeness of various transit-environment configurations or for their uniqueness. The most significant variables in the selection of sites have been:

1. station versus channel sites;
2. elevation of the tracks: elevated, grade, subway, tunnel;
3. adjacent transportation channels: freeway, railroads, arterial streets;
4. housing value, density, ethnic character, and income of surrounding residential environment;
5. flat or valley corridors.

Eleven stations and fourteen channel sites have been selected. Each site extends for about one quarter of a mile along the tracks and straddles the tracks for one quarter of a mile on each side.

1. Traffic data: traffic flows and composition will be measured on major and minor streets.
2. Interviews: these will be identical in form to the random sample interviews.
3. Environmental observations: field observations, analyses of maps, aerial photos, and ground photos.
4. Behavioral observations: field observations of outdoor behavior and behavior traces.
5. Secondary data: census, crime, accident, and land value statistics.

The details of these surveys will be explained later.

A Socio-Environmental Impact Model (Figure 1)

The classification systems for environmental impact statements are usually organized by environmental types, e.g., air, water, noise pollution, vegetation, soils, wildlife, visual impacts, while their relative meaning or importance to impacted populations is seldom discussed. In more remote natural contexts the populations may be difficult to find, but in an urban context they are all-important. The model on which the selected sites study is based therefore considers both environmental change (A) and population response (B). The intention is to measure, if possible, the variables in each box of the model to gain a comprehensive understanding of the relationships between environmental change and residential populations over an extended period of time.

To assess the environmental changes in the selected sites, an inventory of the changes in impacting environments as well as changes in impacted environments is necessary. The impacting environments include the BART stations and tracks as well as the indirect impacts of traffic and land uses generated by BART or any other direct source of impact in the area such as facilities already in existence prior to BART. The impacted environments are the homes, street blocks, and other facilities used in the residential area. Measures will be made of quality and change in both impacting and impacted environments.

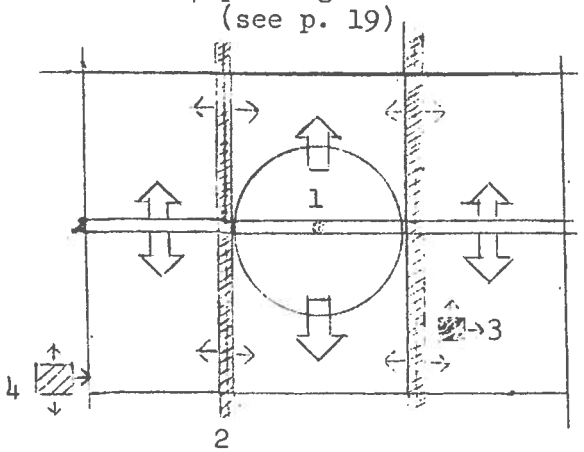
Another possible effect might be due to the news media. If, for instance, the news media report BART intrusions in one residential area such as noise or crime problems, then the evaluations and

perceptions of people in other areas may be affected. A preliminary media analysis program has been initiated.

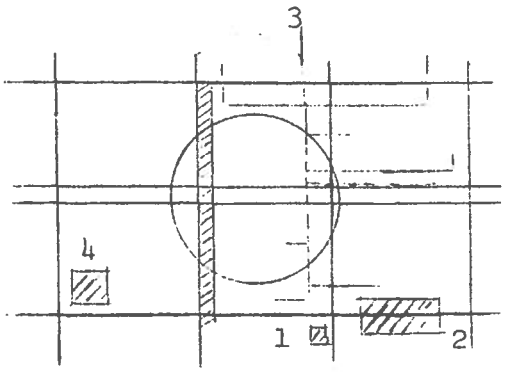
The effects of these various environmental changes on the residential populations will be assessed through as wide a range of response measures as possible. Changes in perceptions, evaluations, and behavior will be measured. Measurement of changes in physical and mental health were contemplated but temporarily rejected due to their expense. The characteristics of impacted populations will be gathered through the interviews.

In the following sections we will illustrate some of the ways we hope to measure environmental and response change by identifying the spatial units of impact and response to be sampled and the measures of impact and response to be related to each other.

Spatial Units of Impact and Response



Impacting Units
(see p. 19)



Impacted Units

The urban environment as used and perceived is an amorphous agglomeration of overlapping and changing spatial units. It is not a collection of discrete entities, as many neighborhood planning studies would have us believe. The task of identifying spatial units of analysis is therefore a precarious one. Yet certain units are the focus

of change and the focus of impact, and for purposes of comparability between sites and between types of impact, units are extremely useful. Since the subject of study is the physical, social, and functional environment, the units of analysis should be based on salient features of each of the three systems. Although physical and behavioral units are not always congruent in the urban pattern (Appleyard, 1969; Steinitz, 1968), nor congruent with perceived spatial elements -- paths, nodes, landmarks, districts, edges (Lynch, 1960) -- our strategy will be to focus on units where congruence between the physical, behavioral, and perceived is likely to be high.

Changes may occur in four kinds of impacting units:

1. The BART station and channel areas where existing land uses, transportation facilities, and environments are replaced by BART facilities.
2. Adjacent transportation channels where changes in traffic levels and types related to BART might occur.
3. Adjacent land uses that might change due to BART's presence.
4. Non-BART-related transportation and land use changes occurring in the area such as urban renewal projects, freeway construction, or facilities already in existence prior to BART.

It will be necessary to gather information on the behavioral and environmental conditions of each impacting unit, which will involve collecting detailed traffic and land use information as well as detailed information on BART, the speed and frequency of BART trains, etc. The environmental emissions of the impacting units, including such characteristics as noise and pollution emissions,

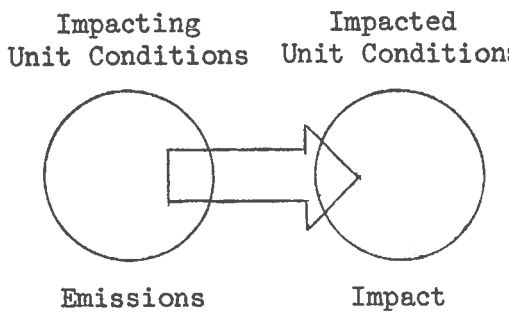
overlook points, territorial definition, behavior settings, and visual disruptions should also be assessed.

Within residential areas four types of impacted unit are being considered:

1. Homes: particularly the homes of those being interviewed.
2. Street blocks or some portion thereof: street blocks are clear physical units and are sometimes behavioral units, but they vary in size, which makes comparability difficult and which suggests the need to use standard sized portions of street blocks.
3. Access paths: access across the tracks between neighborhoods and to local facilities may be disrupted by BART; selecting typical access routes from equidistant points (e.g., 100 yards, 200 yards) on either side of the tracks may constitute a comparable measure.
4. Local facilities: the impact of BART on local open space, on commercial facilities, schools, libraries, etc. may affect the everyday quality of the residential environment, and will therefore be considered.

Both ambient conditions in the impacted units and the environmental impacts of BART and other impacting units upon them will be observed.

Environmental and behavioral measures will therefore be of four kinds:



1. Conditions in impacting units;
2. Emissions from impacting units;
3. Conditions in impacted units;
4. Impacts on impacted units.

In addition to assessing change in impacted units, it will be useful for certain measures to sample the impacted zones. These may be identified from the patterns of impact derived from the units, or from measurement at points selected at various distances from the tracks. For instance, measures of noise level or visual intrusion will be taken at varying perpendicular distances from the tracks at different points along the system.

Impacted Populations

The characteristics of the population in each of the selected sites will be analyzed from the interviews and from census data. Their representativeness will be checked against the 2500 random sample interviews. Characteristics such as length of residence, age, occupation of chief wage-earner, education, household composition, marital status, home ownership, household vehicular ownership, house-income, and perceived health have been recorded in the interviews.

The intensity of BART's environmental impact on various population groups can be assessed both through environmental measures of change in their residential areas and through the perceived intensity of impact as reported in interviews taken in each area. The vulnerability of different population groups to environmental impact will be assessed through interview questions on such matters as health problems and sensitivity to noise, and through respondents' evaluations of the relative importance of various impacts. Lower-income groups, for instance, may feel more vulnerable to aspects of BART impact which affect employment, income, rent, and neighboring, while affluent groups may feel more vulnerable to BART impacts on comfort, convenience, and aesthetics.

Environmental Concerns

The departing point for assessing environmental impact has been the listing of possible environmental concerns that might be held by various impacted populations with which to evaluate BART's impact. These environmental concerns include:

1. Safety: safety from hazards on the tracks, from construction, from BART cars or the live rail, and from hazards due to traffic or poor sidewalks, etc. around the stations for pedestrians or automobile drivers; safety from crime in streets or in residences, which may increase or decrease around the stations and rights-of-way.
2. Convenience: auto, pedestrian, and bicycle access to local facilities, particularly transit stops, stores, schools, parks, churches, and the like as well as to friends and neighbors.
3. Ambient comfort:
   a. Noise: noise levels due directly to BART or to indirect effects such as traffic.
   b. Air pollution: fumes, smells, dust, or dirt due to BART or to local traffic.
   c. Vibration: air- or ground-borne vibration due to BART or local traffic.
   d. Light: day or night lighting levels from BART trains, the shadows from BART structures, the glare from parking lots, or the headlights from local traffic.
4. Privacy: visual intrusion from the BART trains, station platforms, and parking lots; indirect visual intrusion from strangers and through traffic in the area.

5. Territoriality and personal control: degrees of perceived personal control, felt responsibility, and involvement in local streets and neighborhoods and in physical improvements to those neighborhoods.
6. Social interaction: contacts with local friends and relatives, and involvement in community activities which may be affected by severance due to the BART tracks or to BART-related changes in local traffic levels.
7. Attractiveness and maintenance: degree of perceived aesthetic quality, identity, imageability, naturalness, cleanliness, and maintenance of street blocks and neighborhood.

These concerns have been expressed by neighborhood residents in other studies (Appleyard and Lintell, 1972; Michelson, 1970; Wilson, 1962; Lansing, et al., 1970). Our task in the BART study will be to see which of these are important to different impacted populations and to assess the valence (positive or negative) and magnitude of BART's impact on such concerns.

Response Measures

We expect to find evidence of response to the above environmental concerns in people's perceptions, behavior, and conscious evaluations of the state of their environment. Response to environmental impact cannot be fully assessed or explained without some understanding of each component of the model. Environmental change may bring about changes in perceptions, in behavior, or in evaluations, and changes in each may be affected by the others. If we only look at attitudinal change -- for instance, in response to noise -- and find relatively little change in a person's verbal

attitudes, we may still miss a behavioral change -- such as a move of his bedroom to the other side of the house from the noise source; or we may miss a change in perceptions -- that he can no longer hear certain sounds that he could hear before such as natural sounds -- because ambient noise has risen. Thus, the configuration of his perceived environment is changed, although his attitudes have roughly the same valence as before.

A thorough examination of evaluations, perceptions, and behavior will help explain response to environmental change. For instance, if people feel that a transportation route intrudes on their neighborhood, it will be useful to know what size they perceive their neighborhood to be. There is some evidence that perceived territory differs according to social class (Orleans, 1967). Hence, perceived environmental impact may differ by social class under identical environmental conditions. In another case, a person who plans to use BART may feel more friendly towards it in his own neighborhood than if it were useless for him. Differences in attitudes under these conditions would not be understood unless perceptions and expected behavior were known.

Evaluations and perceptions will be obtained from the interviews; various aspects of spatial behavior will be obtained from a variety of sources, including interviews, direct field observation, and secondary data.

Evaluations

Direct questions in the interviews seek to establish attitudes to the several dimensions of each of the above concerns. The pre-BART interview (Phase 3) is divided into two parts. In the first

part evaluations of ambient environmental conditions in the local environment are sought. In the second part evaluations of the impact of BART's construction and post-construction phases (Phases 2 and 3) and preconceptions about BART's opening and post-opening phases (Phases 4 and 5) are gathered.

Within each area of environmental concern, attitudes towards a wide range of sub-concerns have been sought. For instance, in the section of the interview devoted to ambient noise, questions inquire about noise experienced inside and outside the home and at different times of day; noise experienced during the activities of sleeping, relaxing, resting, children napping; talking; listening to radio, TV, records, tapes; reading, concentrating; eating, or other activities. A further question asks if there are any problems with the following kinds of noise:

noise from industry/business
construction
garbage collection
traffic on freeways
highways or major roads
traffic
trucks
buses
motorbikes/motorcycles
hot rods/dragsters on local streets
aircraft
trains
sirens from police cars/ambulances/fire engines
fog horns
neighbors in general
music from neighbors
neighbors talking
neighbors' children
neighbors' dogs or other pets
neighbors' equipment or machinery
appliances in own home or building

These questions will put BART's noise impact into its ambient sonic setting rather than assessing it as an absolute measure.

Questions about the dimensions of BART's possible noise impact inquire whether it is:

shrill/sharp/piercing
rough/rumbling
uneven/irregular
loud
unexpected
occurring at a bad time
lasting a long time

These questions do not limit themselves to the "loudness" of BART, which is the quality measured by the decibel, because there is no certainty that loudness will be the dominant dimension of BART's acoustic impact.

Similarly, questions on the visual intrusion of BART into the residential area start with the residents' assessment of the ambient aesthetic attractiveness of their area, and then ask about the several possible dimensions of BART's visual intrusion. Questions on privacy, social disruption, and other matters follow the same pattern.

Besides evaluations of specific attributes of BART, some questions attempt to get at a more "gestalt" type of response. General questions on whether they think BART is a good or a bad idea, and how they feel about BART running near their homes are asked.

Perceptions

Several questions in the interview seek to establish the residents' perceptions of environmental units. They are asked to define in words what they mean by the word "neighborhood." They are then asked to delineate the boundaries of their neighborhood on a street map of their residential area. Other questions ask residents

to describe BART, the local station, and the level of its perceived intrusion, whether they can see BART from their house or street.

Preconceptions of BART's future influence on their neighborhood are also sought. Will homes go up for sale, high-rise buildings be constructed, stores come into the area? Will there be more or less traffic, more trash and litter, more dirt and dust? Will there be more danger of children or adults straying on the tracks? Will it be a better place for children to play? Will it be better looking? Will it "go downhill"? These and other preconceptions may well explain subsequent attitudes when BART actually begins operation in particular neighborhoods.

The influence of the news media on perceptions of BART may be very powerful. A content analysis of newspaper references to BART is planned, the the newspapers read by each interview subject are recorded. It should therefore be possible to see if the selection of environmental attributes by the news media directs the public's attention to them, and whether news media bias affects perceptions and attitudes.

Behavior

Field surveys on the 27 selected sites observed outdoor behavior, behavior traces, and environmental adaptations (these were carried out in the immediate area of BART channels and stations, and on street blocks in the adjacent neighborhoods).

The structure of this survey -- as with the interview -- stemmed from the a priori set of hypothesized concerns. Thus, any behavior traces or adaptations that might constitute evidence of levels of security, territorial occupancy, intrusion, or other

environmental problems were first listed, pretested on a number of sites, and reassessed before final versions of the field survey forms were developed.

Behavior Observations

The behavior observation surveys focus on the kinds of people and activity that occur in the immediate environment of BART and in the adjacent residential areas. The kinds of activities that take place on streets at different times of day may be good indications of whether the street is considered a safe place to be, whether neighboring is common, or whether people find it comfortable in terms of microclimate, noise level, or other factors which affect willingness to be outside. They may also indicate whether the street is used as a through street. Similarly, observing the kinds of people using streets and sidewalks might indicate whether there are strangers in the area. Activities are defined by posture -- standing, moving, sitting, lying down, sleeping, etc. -- and by type -- waiting, reading, talking, walking, riding a bicycle, roller skating, running, climbing, ball games, playing with various items, home cleaning, gardening, car washing, etc. People engaged in such activities are characterized by perceptible qualities such as approximate age, sex, race, dress. The location of activities, whether in sun or in the shade, whether in front yards, on sidewalks, or in the street, will also be recorded. A standard length of each street block (75 paces) has been observed, and surveys have been taken at three different times of day: non-rush hour, rush hour, and evening on three consecutive weekdays (e.g., Tuesday, Wednesday, Thursday) during the

summer months. In addition, pedestrian origin-destination surveys have been taken at paths crossing the tracks in selected areas.

Behavior Traces

Behavior is ephemeral and therefore difficult to observe accurately without huge investments of observation time; but traces or evidences of behavior, which are often more permanent, can provide useful and observable clues about behavior, if the observer is experienced.

Traces of behavior which have been observed include the presence of objects of various kinds -- furniture, bicycles, baby carriages, game equipment, small toys, gardening equipment, tools, locked or unlocked cars, etc. -- which have been left out in front yards or on sidewalks. Other traces may be of past play activity, skid marks, bottles, trash, broken glass, junk, graffiti, broken equipment or street furniture, damaged trees, and other acts of vandalism. Behavior traces may be indicators of such concerns as the relative security, sense of territory, privacy, or friendliness of an area. These surveys have been taken one time for each site in front of and around ten houses on each street block.

Environmental Modifications

More permanent environmental adaptations can provide similar clues. They include vacancies, personalization signs, informational signs, grilles and other protective screens, refurbished paintwork, recent expansion, fences, walls, new plantings, and trees.

Other Behavior Data

Crime and accident levels, which are the most direct indicators of safety conditions, will be obtained at as fine a grain as possible, although these levels are difficult to determine, because individual cities often adopt different methods of classifying such data. Land value and rental data, frequently used as the sole indicators of impact, will be gathered to the extent feasible, partly to test the validity of these data as indicators of impact.

Migratory behavior, which may be a sign of dissatisfaction with the area, will be most usefully gathered from the interviews, supported by evidence from real estate offices, since the ten year interval census data will provide evidence of transiency only over the long term.

Environmental Measures

Finally, a set of environmental impacts are being measured objectively. These, too, have been generated from predicted concerns of safety, convenience, comfort, privacy, territoriality and personal control, social interaction, attractiveness, and upkeep.

One may ask why environmental measures are needed when perceived impacts and the effects of impacts on behavior can be established through the home interviews. There are several reasons, two of which stand out:

1. A precise description of the local environment of each interview subject and any changes in its character will be necessary to explain responses to impact. For example, the distance of the house from the BART station and tracks, from other major impacting uses, whether it can actually

be seen from BART, whether the houses are set back from the street and from each other, or are close together -- all features may affect population response. Without such knowledge of environmental conditions as well as social conditions, it will be impossible to be sure that worries about noise or visual intrusion, for example, have a foundation in physical changes or not. People may "feel" they have less safety, while actual safety remains the same. Of course, apparent changes in safety or privacy levels may be as important to the inhabitants as real changes, but the chances of ameliorating apparent changes may be greater.

2. If objective environmental measures are found to be correlated with measures of verbal, behavioral, and behavior trace responses, then environmental measures could be established as indices of impact response, and, hence, in other impact studies might be used in lieu of the more costly and difficult interview measures.[1]

3. Finally, in impact situations where no population is yet present, the only measures available may be environmental measures. The ability to predict human response would greatly assist planning.

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[1] A good example of such a measure is the Traffic Noise Index developed in the United Kingdom (Griffiths and Langdon, 1968). This index, which is a composite measure of noise loudness over a 24-hour period, has been validated to predict the level of satisfaction or dissatisfaction in concern from decibel counts. There are still questions about the reliability of this index, but the utility of such a measure should be clear.

Environmental measures will be taken of the four situations outlined in the section on units -- conditions in and emissions from impacting units, conditions in and impacts upon impacted units. Measuring points will be located at representative points within the spatial units. Measures of impact zones will be taken during Phases 2 to 5 of the project. Environmental conditions as they stood in Phase 1 will be estimated from aerial photographs which have been obtained.

The kinds of environmental measure to be used will vary in level of sophistication, from the use of human observers and listeners to direct instrumental measurements. An attempt will be made to develop simple low-budget non-instrumental measures and to check their reliability against good instrumental samples. As many measures as possible will be taken from ground level and aerial photographs to minimize site surveys. These measures will be checked where necessary with on-site recordings.

The following section describes some of the environmental measures under development. It should be reiterated that they may or may not turn out to be indicators of the variables they seek to measure. That such measures can be deceptive may be illustrated by a recent study of marked crosswalks, which found that despite their apparent safety, their real safety was lower than that of unmarked crosswalks. More pedestrian accidents per volume of pedestrian traffic occurred on the marked crosswalks, probably due to the false sense of security that they gave (Herms, 1972).

Automobile and pedestrian <u>safety</u> will be assessed separately. The continuity and condition of pedestrian sidewalks, the number of

traffic conflict points, the presence of speed controls, stop and other signs, areas of poor traffic visibility, and poor night lighting conditions will be among the recordings made. Qualities which may indicate security from crime include several items that increase surveillance capabilities (Jacobs, 1961; Newman, 1972) such as good outdoor night lighting, visibility of houses from the street, and vice versa, and lack of hidden places along sidewalks.

Convenience will be assessed by comparing the distance of access paths from homes to local facilities before and after BART's construction. In addition, horizontal detour indices will be developed between points at standard distances on either side of the BART tracks for both pedestrian and automobile trans-track movement; and vertical detour measures will be developed for pedestrians. These measures will be correlated with the perceived convenience of each area, as expressed in the interviews.

Ambient comfort measures will be partly instrumental. Noise meter measures of loudness are planned to be taken at a fixed distance from the tracks in each selected site over two 24-hour periods. In addition, if budget permits, noise, vibration, wind, temperature, and night lighting measures will be taken at different distances from the tracks and on selected street blocks. Measures of wind protection and visual analyses of lighting conditions may contain both instrumental and observer measures. Observer measures such as the "walk away" noise test (see H.U.D. Noise Guidelines), which measures the distance from which a male conversational voice can be heard, may be used to see if such "quick and dirty" measures are reliable approximations of instrumental observations. The latest

H.U.D. Noise Guidelines propose also more simple measures of noise impact, through map analysis of distances from major arteries, freeways, airports, and other noise sources.

Privacy measures will relate mostly to homes. Homes, back yards, and front yards that are directly overlooked by BART stations, trains, and parking lots will be accorded a privacy intrusion measure, depending on the angle of overlook, distance from tracks, and speed of passing trains. Ambient privacy intrusion from surrounding buildings and the street will also be assessed. Visibility of front door, ground floor, and bedroom windows might be indicators of such intrusion.

Territoriality: An inventory of open space, assessing apparent territorial ownership and access, will be made to see whether BART has increased or decreased publicly available open space, and the dimensions of the publicly visible environment. Attributes of territorial "openness" to public use include the lack of fences, walls, or prohibitive signs, and the presence of visible entrances, pedestrian paths, and public amenities such as benches and other sitting places, and fountains. The varying degrees of formality that such open spaces have may attract different age groups.

A distinction between the way BART treats its territory, and the "openness" of public and private land around the right-of-way, will be a particular subject for examination. The "no man's lands" that frequently occur around transportation routes can be places where kids can find adventure, or potentially dangerous areas (Suttles, 1968) or both.

Social interaction: Environmental features that might encourage street block social interaction include the provision of meeting places such as benches, stoops, small play areas, wide sidewalks, and good night lighting. Distances between adjacent houses, the setback of houses from the street, and the width of the street may also be relevant. A measure of the "delay time" -- the percentage of time in a defined period that a pedestrian has to wait for passing traffic before crossing the street, combined with the width of the street -- has been developed in Britain (Crompton, 1971) to assess social disruption and inconvenience.

Attractiveness measures will assess the ambient quality of the visual environment and the visual intrusion of the BART system on the local area. Since attractiveness in the minds of many people often depends on the presence of certain environmental attributes (such as vegetation, trees, distant views, water) or the absence of others (such as asphalt, blank walls, cyclone fencing, or signs), measures of their presence or absence should provide some indices of aesthetic quality. Likewise, the visual intrusion of the BART stations or tracks on local views, and the change from pre- to post-BART views may affect attitudes towards BART's impact on the residential environment.

The quantification of visual scenes has been under development in recent years (Appleyard and Older, in preparation; Shafer, et al., 1969), and we propose to use a photo-analysis method traditionally used by lighting engineers (Hopkinson, 1971). Slides have been taken with a 180° fish eye lens looking down all selected residential street blocks, on the principal access paths, and at different

distances from the BART tracks. These slides will be overlaid with a grid of millisteradians specifically calibrated to the camera in order to measure the solid angle of view subtended at the eye by selected attributes. Hence, a street block can be rated for its percentage of perceived vegetation, buildings, sky, and for the percentage of visual intrusion represented by BART buildings, structures, and parking lots. It will be necessary to ensure that these photo samples are representative of the area.

In addition, relational attributes, the degree of interest or monotony, orderliness or clutter, spaciousness, and scale in pre- and post-BART situations will be assessed. In other studies (Appleyard and Duchek, 1971) such qualities have been assessed on nominal (1 to 5) scales. The BART study will aim for more precise measures.

Besides rating the ambient quality of the residential streets and the BART right-of-way areas, comparisons between the character of these two areas will provide a measure of the character disruption, if any, that BART has created in each area. For instance, local streets heavily planted with trees, while the BART area is not, or the BART parking lots fully planted, while the local streets are not, each constitutes a character contrast or disruption.

In addition to view analysis, the imageability of each residential area, pre- and post-BART, will be analyzed from direct field observations (Lynch, 1960) to test whether imageable or heterogeneous areas are more or less susceptible to perceived impact.

Reliability of Measures

Apparently objective observations of behavioral or environmental conditions may, in fact, be quite subjective and variable. Therefore, reliability checks are performed. On the behavior observations, inter-rater reliability checks were carried out by having, in selected cases, two separate teams of observers rating the same street blocks and areas at the same times and on different days. Correlations between these ratings were found to be high, indicating a satisfactory degree of reliability between raters and across time.

CONCLUSION

The techniques of environmental impact assessment designed for the BART study are aimed at exploring as comprehensive a set of impacts as possible within budget constraints, and, through multivariate analysis, having these environmental measures of impact validated by evaluational, perceptual, and behavioral responses. Validated environmental measures, i.e., those with high weights in the multiple regression analyses, will be confirmed as good indicators of environmental impact; those with low weights will be dropped or considered less important. Some iteration is likely. The validated environmental impact measures from this study can then be applied to other impact situations.

Despite the complexity of the impact measures, the measuring instruments, once developed, should be relatively simple to apply. Interviews take only one hour of time per respondent. The environmental observations are planned to take two people one day each for every 1/4 mile by 1/4 mile residential area, supplemented by another day of office data collection. The behavioral observations took two

observers three days for each site where repeated measurements were needed to ensure an adequate sample. Such levels of assessment should not therefore be beyond the capability of most planning operations; and once the measures are validated, it is likely that the numbers of measurements will be reduced.

The fineness of these measures might seem trivial and unnecessary to some people. We would argue that the minutae of the everyday environment is what people often value -- small details and configurations that are quite fragile and can be destroyed easily by large-scale intrusions, but which affect people's sense of well-being in an environment, their sense of privacy, of friendliness, of caring for a piece of territory. If we are concerned with the survival of remote species of wildlife on this planet, we should be as much concerned with the less dramatic but more immediate conditions in the places where people live.

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