Toward Measurement of the Community Consequences of Urban Freeways

RAYMOND H. ELLIS, Peat, Marwick, Livingston and Co., Washington, D.C.

The purpose of this paper is to propose a strategy for quantitatively estimating the community or social consequences of transportation projects. Specifically, a new measure—the residential linkage—is defined and its importance demonstrated through reference to the sociological literature. The application of this measure to the spatial definition of urban communities and the evaluation of alternative transportation plans is then illustrated.

•THE objective of this study is to explore quantitative strategies for incorporating consideration of community consequences into the urban transportation planning methodology. This purpose is value-free in that it does not imply that community impact should always be estimated when planning transportation projects. Rather, it is based on the assertion that public decision-makers may explicitly formulate community objectives, such as "improve the quality of the urban environment" and "increase the diversity and number of opportunities for residents," and ask the transportation engineer to estimate the relative contribution of alternative plans to the achievement of these goals.

There are several reasons to suggest that decision-makers will increasingly request transportation planners to evaluate the community impact of alternative plans. Numerous political controversies have developed throughout the country with regard to the location and design of major urban transportation facilities. Examination of these controversies demonstrates that the impact of the facility on the social and spatial environment through which it passes is usually the single largest cause of political opposition to a facility. Furthermore, this opposition has led to considerable delays in, and even curtailment of, elements of the transportation program (1).

Even a cursory reading of the newspapers suggests that individuals and groups are concerned about the consequences of transportation investments. Most frequently this has taken the form of protest concerning alteration of the environment in the immediate vicinity of the individual or group. A review of these controversies suggests that it is extremely difficult to identify much less measure or predict, the community consequences of transportation investment decisions. Community consequences identified in route location controversies are usually negative. Although progress is being made (2), a potentially large spectrum of positive consequences has been generally unexplored by both opponents and proponents of transportation projects. The neglect of these positive consequences has resulted in a strong emphasis on negative impacts and their amelioration. In addition, various authors have observed that other consequences, particularly impact on the social structure of an area, are important and neglected (3, 4, 5). It is apparent that the impact of a transportation facility on the community through which it passes is not sufficiently understood.

Merely predicting the aggregate consequences of transportation investment is insufficient since the distribution of these consequences is also relevant. Various individuals and groups (distributed in social, spatial, and temporal dimensions) are

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affected by transportation projects. It is clear that the impact of transportation investments on them is of considerable relevance to the decision-maker, if for no other reason than overlooking these impacts will result in citizens attempting to have their opinions considered through other channels. To summarize, the prediction of transportation impact on the urban community is an important and difficult task.

In the past decades, American society has become increasingly urbanized and wealthy. A national policy of concern with the "quality of life" implicitly places considerable import on the quality of the urban environment. In spite of the considerable wealth available, national resources are limited. It is imperative to analyze the contribution of each government program to the achievement of social, economic, developmental, and other goals. In view of the enormity of the problems of the American city and the major public and private expenditures devoted to urban transportation, it is particularly important that transportation programs be developed which maximize the derived social and economic benefits. Planners must view the transportation program as a versatile and powerful tool for shaping the macro and micro structure of the urban environment in accordance with prespecified political, social, and economic goals.

These observations are substantiated by the outcome of the Second National Conference on Highways and Urban Development (6) held in December 1965, at Williamsburg, Va. It concluded with an agreement on several basic principles, known as the "Williamsburg Resolves" which recognize that transportation is but one element in the total scheme of urban planning and, consequently, cannot be evaluated as a separate and individual function. As stated in the report:

> Planning agencies should emphasize the identification and evaluation of urban values and goals as an integral part of comprehensive transportation planning. There should be encouragement of research to develop more systematic techniques for rating all values and costs to be weighted in evaluating urban plans.
>
> The planning and development of facilities to move people and goods in urban areas must be directed toward raising urban standards and enhancing the aggregate of community values, both quantifiable and subjective; it should be recognized that transportation values (safety, comfort, beauty, convenience and economy in transportation) are a part of, and are to be given proper weight in, the total set of community values (6).

This research will concentrate on formulating a framework within which the transportation planner can structure his approach to estimating community impact and to measuring the contribution of alternative plans to the achievement of higher level societal goals. It will not provide a definitive methodology for evaluating community impact. Theoretical and empirical knowledge of the urban community is insufficient to permit such an approach. Furthermore, each transportation design problem is different and may require a unique analysis.

Mere estimation of community impact will not alleviate fears of urban freeways or quiet political controversies. It can provide an information base for comparing the effects of alternative locations and designs. If experiments can be devised to estimate the value implications of various levels of consequences, planners and decision-makers may have a firm quantitative foundation on which to base their decisions.

PERSPECTIVES FOR CONSIDERING COMMUNITY CONSEQUENCES

Many definitions of community have been presented in the literature (7, 8, 9, 10, 11, 12, 13). Two basic elements recur in most definitions: social interaction and spatial propinquity. Individuals and groups become involved in mutual activities through participation in organizations which have as their goal the satisfaction of physical, social, and psychological needs. A community is defined by the occurrence of this interaction within an appropriately limited spatial field.

Numerous approaches may be pursued for developing enhanced measures of community disruption. Each of the following strategies starts from a different perspective of the urban community. The first approach views the community as a distribution of power and is concerned with developing plans which will be approved and implemented. The particular analysis used depends on the perspective of the political decision process. If decisions are reached within the context of pyramidal power structure (14, 15), the analysis would concentrate on developing a plan which is acceptable to the leaders of the community. If decision-making is more diffuse and numerous groups, either alone or in conjunction, can defeat a plan (16, 17, 18), the analysis must be concerned with developing a plan which satisfies enough groups so that the plan is implemented. Dean (19) has proposed a model which specifies the minimum cost program for achieving this goal.

The advantage of evaluating community consequences in terms of the requirements for plan implementation is its intrinsic usefulness in getting facilities built. The approach shifts the burden of evaluating the consequences to the individuals and groups affected. Since these people have limited access to advanced technical information, they would tend to emphasize obvious factors such as aesthetics or level of sound. Further, some groups are more adept at exerting political influence than others, and their perception of the situation would be more intensively considered. Thus, important consequences might be ignored in the decision process and the differential effect distorted. It would appear desirable to develop an approach which allows for a more comprehensive and equitable application.

Another perspective views the community as an aggregate of people living in a specified geographic area. It hypothesizes that resistance to a facility is related to the existing organizational structure and defines this structure using various demographic indices (20). To the degree to which measures of community organization are a surrogate for potential disruption, these indices estimate community impact (21).

This approach focuses on the area traversed by a facility and defines the socioeconomic characteristics of the resident population. In this sense, it provides a better estimate of community impact than viewing the community as a distribution of power. On the other hand, the use of demographic indices to estimate community impact suggests that the consequences of a facility are independent of its characteristics. Thus, an eight-lane depressed facility would have the same consequences for the area traversed as an eight-lane elevated route. Further, the approach does not intrinsically allow for the empirical definition of community, and it would be stretching the point to suggest that the census tracts for which the indices are usually estimated correspond in any but the most general way to distinct communities. Viewing the community as an aggregate of people fails to define the community or to specify the impact process.

An alternative and more interesting perspective views the community as a system which has certain social and physical requirements for proper functioning. Within the framework of the community, a process of interaction takes place among the residents. The community consequences of a transportation project, then, are changes in the system as estimated by measuring perturbations in the process of interaction. Application of this approach is dependent on empirical measurement of the interaction process.

Emphasis on the interaction aspect of community is not original here. Sanders (11) places a heavy emphasis on the social importance of communication and the community as an arena of interaction. Meier (22) suggests that cities have developed out of the need for human communication and utilizes information theory to develop a framework for examining the communications process. Webber also emphasizes the importance of interaction as a concept for understanding the urban community: ". . . [It is] important that we also see the city as a culturally conditioned system of dynamic interrelationships among individuals and groups as these are modified by their locational distributions" (23). He suggests that "we can supplement our analyses by viewing the distribution of human activities as spatially structured processes of human interaction" (23). These citations emphasize the importance of interaction as a vehicle for examining the concept of community.

Bernard (7) discusses interaction in the context of the community's institutional structures and not from the perspective of the individual. Thus, he concentrates on aspects of the community subsystems, particularly their role in maintaining group norms and the processes of competition and conflict which develop among them. The role of the individual is emphasized in the literature of small group research (24) and interpersonal relations (25). Sociograms, aspatial plots of the pattern of social contacts among individuals living within a limited area, are used to study relations and their influence on the communications process (26). In their present form, sociograms are of limited usefulness for examining the consequences of transportation projects. Other contacts, such as relations with churches, stores, and schools, may also be of importance to households. Further, it is important to examine these contacts in a broad spatial context.

TRANSPORTATION IMPACT AND THE INTERACTION PERSPECTIVE OF COMMUNITY

Previous efforts to identify the community consequences of transportation projects have generally considered: (a) impact on various actors, including the individuals involved and the local government of the taking of property for the right-of-way; and (b) impact on the community, frequently referred to as "community disruption."

The delineation of these consequences is only as useful as the operational measures which are employed to define each impact. The effect of taking property is generally measured by the number of households or people and firms or employees who must be relocated. Consideration is sometimes given to the physical condition of the properties to be demolished and to the availability and location of new sites for the relocated people and firms. There is considerably less consensus on appropriate measures of community disruption, and serious methodological and conceptual difficulties have been encounterd in simply defining communities on the map (27, 28, 29). Impacts on the levels of public services, such as police and fire protection and accessibility to schools, have been used as measures of community effects (27, 30).

Two criteria appear important for evaluating measures of the community consequences of transportation projects: (a) How well does the measure spatially and socially define the community involved? (b) How well does the measure define the impact on the community of a proposed transportation facility?

One strategy for minimizing community disruption would locate the transportation facility so that it does not traverse the community. Such an approach requires that communities be spatially defined through either empirical or theoretical procedures. Examination of an aerial photograph or map of a metropolitan area shows that residential areas sprawl in all directions and these materials offer little assistance in defining communities. Urban areas are undergoing rapid social and physical changes, and procedures which define communities on the basis of a homogeneity of socioeconomic variables fail because of the considerable heterogeneity which is empirically observed (31, 32).

Researchers attribute spatial and social properties to a community; therefore, it is important to establish empirically the social interaction taking place. Complete definition of a community implies measurement of both the boundaries and the internal organization. Human interaction takes place within a physical and social framework which may be necessary for the proper functioning of the community. Physical elements such as a park, a bar, or a school may be critical points in the physical structure within which the life of a community takes place. In the West End of Boston, Gans found that commercial establishments served as important communication centers for the people of the community, but that the settlement houses were comparatively irrelevant to their daily lives (8). Similarly, certain individuals or social institutions may play important roles in the community. Thus, the specification of the community is not complete without the identification of the framework within which interaction takes place.

The second criterion is concerned with the quality of an index as a measure of the effect which a transportation or other facility has on the community. The community operates in a social and physical framework which has developed over time. The development of a new facility, such as a freeway, may shock this framework in a variety of ways. The important meeting locations, such as schools, churches, parks, or stores, may be removed. People playing key roles in the community may be relocated. Individuals may find it more difficult to communicate because of the barrier effect of a facility. Alterations to the framework affect the functioning of the community and this is the "community impact" which it is desired to measure. Since this functioning is essentially a process of interaction, the community consequences of a transportation facility may be viewed as perturbations in the communications process. Measures of community effects must, therefore, be concerned with estimating alterations to this process of interaction.

In the light of these criteria, it is apparent that current measures of community impact are deficient in several respects. Although schools may play an important role in a community, they are not the only important institution and their boundaries may be quite arbitrary. Since individuals are required to attend school and are administratively assigned to a specific location, changes in school service would appear to be a poor measure of community effect. Police and fire service districts are essentially administrative constructs, and there is little reason to believe that they correspond to communities as they have been defined.

Clearly, the number of people or employees who must be relocated is an important measure of community effect. Through consideration of the quality of the buildings removed and the availability of nearby alternative sites, an estimate is obtained of the effect of this forced relocation on the individuals involved. These measures do not, however, estimate the importance to the individuals of being located at the given site. Further, they do not consider the effects for those remaining in the area of removing some sample of the total population. Thus, the existing measures are deficient in that they do not permit a meaningful definition of community or a good estimate of the differential effects for individuals and communities.

DEFINITION OF RESIDENTIAL LINKAGES

By viewing the community as a process of interaction, considerable insight may be achieved into the impact of a transportation facility on the region through which it passes. It is suggested that the concept of a "residential linkage" be used as the basic tool for operationally implementing the theoretical view of the community as an interaction of its inhabitants.

Residential linkages may be defined as "ties between the housing site of the household and other spatially distinct points which are of importance to the individuals involved." The specification that a linkage exists implies that communication, but not necessarily a movement of people or goods, will take place between the housing and activity site. In the vocabulary of the transportation engineer, the residential linkage is a "desire line" for communication. The aggregation of the desire lines for all of the individuals in the community represents the process of interaction from the viewpoint of the individuals involved.

Any type of activity may take place at the nonhomesite end of the activity linkage. Certain types of linkages, to workplaces, stores, and friends or relatives, are probably close to universal, while others, to schools and churches are quite common. Still less frequent would be linkages to recreation or entertainment sites. Since the linkages are spatially defined, some methodological difficulty may be created by the occurrence of an activity, such as a social club, which does not have a consistent geographic location. Such activites should be included in the analysis, and the problem may be overcome by considering the most frequent locations for the activity or by defining a locus of locations and determining the centroid of this locus.

Existence of a linkage implies that some form of communication takes place. The impact of a new transportation facility on the linkage would appear to be a function of the mode of communications being used. Clearly, the impact of a new freeway on mail or telephone service is comparatively minor, as compared to its potential impact on the pedestrian and public and private transportation subsystems. Thus, it could be argued that the empirical determination of linkages should be confined to determining those linkages in which a physical transfer of people or goods takes place between activity sites. Whereas data on vehicle trips have been obtained for metropolitan areas throughout the United States, walking trip data are comparatively rare.

Determination of the importance of the linkage to the individual is particularly difficult since it involves measurement of levels of satisfaction. At least two aspects of importance can be distinguished: linkage substitutability and frequency of communication. The importance of a linkage would appear to be inversely related to the facility with which an alternate linkage could be developed. Unless a store serves other than commercial functions, it is comparatively simple to stop shopping at one store and begin shopping at another. Establishing a new linkage at a church or school or with an individual involves considerably more cost. It is hypothesized that the latter linkages are less substitutable and, therefore, more important to the individual.

A taxonomy of linkage types, perhaps based on ease of substitutability, would appear important. Within each linkage type, importance would appear to be a function of the frequency of communication. The linkage to the food store which is visited three times a week is considerably more important than the linkage to a furniture store which is visited once a year. Similarly, frequency of interaction provides an interesting, if not totally satisfactory, measure of the importance of friendship linkages.

STRUCTURING THE TRANSPORTATION IMPACT PROCESS

The transportation impact process may be defined as the set of events which transforms transportation system outputs, such as altered accessibility and environmental quality, into a final set of consequences, such as changes in land value and mobility. The residential linkage construct may be utilized as a vehicle for structuring a perspective of this impact process. Such an impact framework is shown in Figure 1.

A change in the transportation system, such as the opening of a new freeway or rapid transit line or the introduction of a change in service, may have a number of effects. If the individual's linkage pattern and frequency of interaction remains constant and he uses the changed facility, his communications costs would change. Thus, the introduction of a new freeway would cause a cost reduction, whereas the termination of service on a bus line would have the opposite effect. This alteration to the transportation system might also result in a change in the communications cost of nonusers of the altered facility or service. The barrier effect of a new freeway may considerably increase the cost of traverse movement, particularly for interactions using a walking or public transportation mode. If everything else remained constant, introduction of bus service on an arterial would tend to increase the travel time for other vehicles.

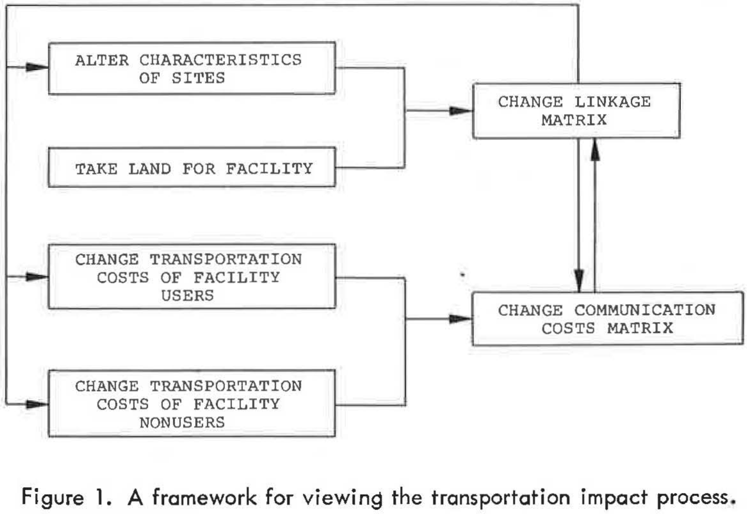

Figure 1. A framework for viewing the transportation impact process.

The net effect of these two changes is a transformation in the matrix of communications costs which, in turn, may cause the termination of some linkages and the initiation of others. Another store may be substituted for the one which is now on the other side of a freeway. A park, which previously took a 30-min drive to reach, is now visited because the travel time has been reduced to 10 min. The temporal aspect of mutations in the linkage matrix should be recognized. It might take months or even years for the individual to alter his linkage matrix in response to changes in the transportation system.

Linkages may also be altered because of the taking of land for a new facility. The individual or activity at either end of the linkage may be forced to relocate. To maintain consistency with the view that linkages are geographic specific, the maintenance of a tie to a relocated activity is viewed as the termination of an old linkage and the initiation of a new one. In some circumstances, the activity may cease to function. Parks may be taken for the right-of-way and not replaced and stores or institutions may cease operation.

Changes in the transportation system may also alter the characteristics of the linkage ends. The relationship between the construction of transportation facilities and the quality of the physical environment has been repeatedly emphasized. Changes in sound level, aesthetics, quality of the atmosphere, drainage, and safety may cause individuals to terminate linkages and to initiate others. Linkages may be altered by changes at the nonresidential or the residential end. A playground built on an excess portion of land purchased for an expressway may be used instead of the street. People may choose to terminate all of their existing linkages by moving to another residential site.

Individuals may also initiate linkages as the result of changes in communications costs and characteristics of the linkage ends. This possibility enters a feedback element into the flow model. Additional demand would alter the characteristics of most nonresidential linkage ends. A store might become more crowded and thus a less desirable place to shop. Since the cost of transportation is related to the demand (33, 34), the increased use of transportation facilities implicit in the initiation of linkages would alter the communications costs for users and nonusers of the facility. The impact process is, therefore, iterative although it is hypothesized that the process has internal equilibrating tendencies which result in the establishment of new, reasonably stable residential linkage and communications cost matrices.

This impact model could also be applied to the urban environment served but not traversed by a new transportation facility, although the relative importance of certain elements would be diminished. The impact of the facility on the termination and initiation of linkages because of alterations to the physical environment and relocation would be considerably reduced. This would lead to a greater emphasis on changes in the communications cost matrices and the resultant mutations of the pattern of residential linkages. Transportation and other communications modes can be substituted for spatial proximity as a means for allowing interaction.

RESIDENTIAL LINKAGES AS A MEASURE OF COMMUNITY

If communities can be spatially defined within a metropolitan area, the possibility exists of constructing expressways in corridors which bound rather than traverse communities. The route chosen through such an analysis should be the one which minimizes community disruption. Numerous approaches, perceptual (35, 36, 37, 38), ecological (29, 39), and empirical (28), have been investigated for use in spatially defining communities. In view of the mixed results of these previous efforts, the use of residential linkages as a measure of community appears to offer some promise. Through the application of an appropriate survey instrument, the residential linkages of the population in the study area would be defined. The essence of the procedure is to define communities through the delineation of concentrations of linkages. If loci of linkages were not observed, considerable doubt must be cast on the concept of urban communities as anything but historical constructs having a potential symbolic importance.

The precise operationalization of the procedure is, of course, dependent on the objective of the analysis and the resources available. One extremely simple but interesting algorithm for defining communities is the following:

1. Through survey methods, linkage data are obtained for households living within the study area. Since the purpose of the analysis is to define communities within this area, all linkages to regions outside the study area are discarded.
2. A zonal system is defined for the area. The size of the zone might vary from a block face or block to the dimensions of a census tract or travel anslysis zone, depending on data available and the size of the study area. The linkage data are appropriately adjusted and coded to the zonal grid.
3. Interzonal linkage data are tabulated and adjusted for the population of the origin zone to obtain an interzonal linkage rate. If the totals for the interzonal linkages were employed, differences in the levels of resident populations might distort the results.
4. Since the algorithm in its present version associates adjacent zones, it is necessary to map the matrix of interzonal linkage rates into a matrix showing adjusted linkage rates for adjacent zones. This may be done by considering the transportation routes as indicated in the survey data and summing rates at zonal boundaries. Alternatively, a set of routing rules could be developed and the rates summed. Finally, the rate from I to J and J to I is summed to yield an interchange rate between I and J for each pair of adjacent zones.
5. The zonal pair with the highest adjusted linkage rate is associated, the cell removed from the matrix, and the process is repeated. It is hypothesized that if communities do exist, clusters of zones (i.e., a community) should become evident. The analysis would terminate when each zone is associated with a cluster.

Aside from the somewhat tedious linkage rate adjustment procedure, this algorithm is extremely simple in both conception and execution. Two improvements would appear particularly desirable: the elimination of the adjustment procedure and consideration of the relative importance of different linkages. The former objective could be achieved by using an algorithm which ignored geographic proximity and associated zones in order of decreasing total interzonal linkage rates. The difficulty with such an algorithm is, of course, that there is no guarantee that geographically contiguous communities would be defined. These results would, in themselves, be of considerable interest.

The difficulty of evaluating the importance of various linkages has already been noted. Two dimensions of importance: substitutability, as approximated by linkage type, and frequency have been suggested. One method would apply the previous algorithm to each linkage type using linkage rates which are weighted by frequency of interaction. Different zonal aggregates, or communities, might result from the applications of the algorithm and some sort of adjustment procedure would be needed to develop the final set of community boundaries.

Other extensions of the procedure include the use of more sophisticated zonal grids and consideration of the ratio of the internal to study area over external to study area linkage rates. The use of a more complex geometrical arrangement of zones, as for example a hexagonal pattern, is suggested as a means for alleviating the previously noted adjustment problem. Of course, the boundaries of the zones must be adjusted to the circumstances existing in the study area. Considerable attention has recently been devoted to the wide range of contacts of urban residents (40, 41, 42). The ratio of the linkages within some specified geographic area over the linkages outside the area would provide an interesting measure of the importance of spatial propinquity. It seems clear that the importance of the local community, as measured by this ratio, is a function of the nature of the activity and the socioeconomic characteristics of the resident population.

The question of whether a community exists could be viewed as a simple hypothesis testing problem. The null hypothesis, that a community does not exist, implies that linkage rates are the same in all directions, although subject to some random variation. The test hypothesis, that a community does exist, implies that the linkages would tend to focalize. A measure of the spatial orientation of linkages could be derived and the parameters of its frequency distribution for the no-community case established. It would then be reasonably simple to test the null hypothesis that a given estimate for a study area is the result of random variation.

EVALUATION OF THE COMMUNITY CONSEQUENCES OF TRANSPORTATION PROJECTS

For many, if not most, transportation projects it would be impossible to locate the facility so that it bounds rather than traverses all of the communities in its path. Further, in many situations, it will not be possible to establish empirically precisely defined communities. This discussion will consider a methodology for defining the community consequences of transportation projects for the traversed urban environment. Its objective is to define an information package on community effects which, when combined with information on other consequences, outputs, and costs, will allow decision-makers to choose among alternative transportation investment programs. It is suggested that some of the material, particularly the discussion of the relocation of people and facilities, may have application when the same issue arises in connection with other urban programs.

The thrust of this discussion is that changes in the matrix of residential linkages may be used to evaluate and compare the community consequences of alternative transportation facilities and locations. Through this approach, a useful beginning is made on defining a measure for the previously incommensurable impact of "community disruption" and on providing an information base for considering the implications of relocation. The proposed information packages should be viewed as prototypes subject to modifications resulting from the needs of decision-makers, problems encountered in operationalization, and the conclusions of further research.

Before presenting this material, the danger of attributing solely negative value to alterations in the linkage matrix should be emphasized. In the case in which linkages are added as the consequence of a facility and no linkages are removed, there would appear to be a positive value associated with change. Similarly, the opposite situation of only removing linkages would appear to be of negative value. The intermediate situation in which new linkages are substituted for old ones is the most likely situation and the one to which it is most difficult to ascribe a normative judgment. Individuals and organizations are constantly changing their pattern of linkages when this is perceived as being in their own interest. The opening of a new supermarket may cause people to change an existing linkage with the neighborhood market. Certainly the proprietors of the local store suffer, but from the societal point of view, it would be difficult to place a negative value on this linkage change. The same view should hold if such a change occurs because the supermarket has been made more accessible because of the construction of a new transportation facility.

For most situations, therefore, it would appear difficult to place a priori negative or positive values on changes in the linkage matrix. A community's perception and reaction to these alterations is one measure of their importance. Attitude studies and examination of transportation related political controversies are potentially useful approaches for studying community response. Another measure of the import of altering the linkage matrix might be derived from careful longitudinal studies associating change with variables having a normative content, for example health and pathological behavior. Studies of this type have been conducted to investigate the consequences of relocating and rehousing families in Boston (43, 44) and Baltimore (45, 46). For the purposes of this study, it is assumed that there are costs associated with altering, and in particular terminating, a linkage. These costs would appear to be strongly related to the linkage's "importance" which was noted above as being a function of the linkage's substitutability and the frequency of interaction. This study approaches the problem of value by using these factors as dimensions of the proposed information structure.

A PROTOTYPICAL INFORMATION PACKAGE FOR COMMUNITY CONSEQUENCES

Transportation impacts include changes in the cost of maintaining linkages and changes in the matrix of linkages. These items are the basic types of information

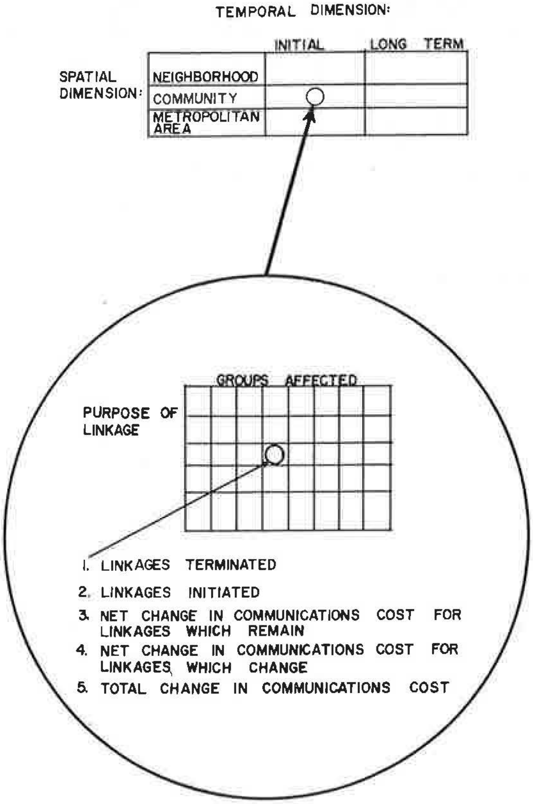

Figure 2. An information package for describing the community consequences of alterations to the transportation system.

which are presented in the cells of the matrices defining the community consequences of alterations to the transportation system (Fig. 2). Specifically, it is suggested that the following information be specified for each situation: (a) the number of linkages terminated; (b) the number of linkages initiated; (c) the net change in the communications cost for the linkages which remain, broken down by mode of communication; (d) the net change in communications cost for the linkages which change; and (e) the total change in communications costs.

Although the discussion has been couched in terms of the individual, it is clear that aggregate impact measures must be used for planning purposes and the measures proposed are designed to appreciate this fact.

Frequency of interaction for the linkages terminated and initiated has not been included for two reasons. Since the concept of linkage implies a minimal intensity of communication, frequency information is in some sense redundant. It is hypothesized that the relative importance of the changes is a function of the purpose of the linkage and the group impacted upon. The relationship between the type of linkage and the costs involved in establishing a substitute has already been noted. The following prototypical set of linkage types is proposed in the belief that the substitutability of linkages within a type is roughly similar but that it varies considerably among types: (a) work; (b) shopping; (c) educational; (d) recreational; (e) religious; (f) social (e.g., individual friends, neighborhood clubs); (g) community groups (e.g., civic groups, fraternal organizations, political groups); and (h) restaurants. The criteria which are used to define empirically a linkage are, of course, a function of the linkage type in question.

Under some circumstances, it may be important to distinguish the differential impact of a facility. The groups affected may be defined spatially, for example, by presenting the results for each community. This approach would appear particularly important when a substantial facility is being planned. In view of the varying adaptability of individuals to change, the identification of the individual or groups affected, as defined in a socioeconomic space, would appear important. This may involve the application of existing techniques for describing the social characteristics of a population (20). Alternatively, a set of groups may be defined using variables such as income, race, occupation, education, age, marital status, and family size or composition. In some situations, it may be necessary to specify groups in both a spatial and a social space.

The suggested community consequences matrix could be readily estimated for all linkages within the metropolitan area for one time period. Such an approach would appear undesirable for several reasons. One important effect of improved transportation is to permit interaction to take place within an increasingly large area. It is, therefore, relevant to specify changes in linkages in a spatial dimension. Three spatial realms, each having potential social importance (47) are suggested: the neighborhood, the community which is composed of a set of neighborhoods, and the metropolitan area. Since people are adaptable to changes in their environment, they respond to changes in the transportation system by altering their linkages and resources devoted to communications. The "disruption" caused by a new facility may dissipate rapidly, and it is important to clarify the linkage and cost changes in a temporal dimension. Two measurement periods are proposed: at the time immediately following construction of the facility and a long-term period of perhaps two years. Overall, it is hypothesized that the long-run consequence of transportation improvements is the initiation of linkages over an increasingly broad spatial realm.

APPLICATION OF THE INFORMATION PACKAGE TO THE ISSUE OF RELOCATION

Relocation of people and activities is a particularly difficult phase of a transportation construction program. Current freeway location procedures measure its effect by estimating the number of people who will be relocated. Such an approach does not consider the differential consequences of relocation for various socioeconomic groups. It is suggested that households not involved in the life of an area may be inconvenienced

(A) THE RESIDENTIAL SITES WHICH WILL BE TAKEN	Group Affected
Number of dwelling units taken	
Number of people to be relocated	
Total number of linkages to neighborhood (by linkage type and the mode of communication)	
Total number of linkages to community (by linkage type and mode of communication)	
Total number of metropolitan linkages (by linkage type and mode of communication)	
Proportion of people who could relocate within the same community	
Physical condition of the dwelling units which are to be taken	

(B) NON-RESIDENTIAL ACTIVITY SITES	Type or Name of Activity Opportunity
Number of linkages from the neighborhood	
Number of linkages from the community	
Number of linkages from the metropolitan area	
Probability of relocating this activity at an alternate site	
Proportion of people who maintained a linkage at the old site who will initiate a linkage at at the new site (a) Total (b) Previous linkages within the neighborhood (c) Previous linkages within the community (d) Previous linkages within the metropolitan area	
Physical condition of the facilities which are to be taken	
Conformance of the facilities to existing and projected land use plans and regulations	

Figure 3. An information package for considering the implications of taking land for the right-of-way of a transportation facility.

but not seriously affected by relocation, whereas those more heavily involved may suffer considerable unhappiness.

An attempt is made in Figure 3 to define an information package for considering the implications of taking land for the right-of-way of a transportation facility. The package is divided into two sections considering, respectively, the implications for the residents displaced and the implications for businesses and institutions such as stores and schools. For both cases, the residential linkage construct appears to offer an operational approach to defining the implications of relocation. As previously, it may be important to define differential impact by defining the groups affected in a spatial and/or social space.

It is suggested that the implications of relocating an individual are a function of the proportional change in the communications costs associated with initiating linkages to the nonresidence sites of his previous linkages. If an individual's linkages are metropolitan in scope, the combination of relocation in a reasonable location and the new transportation service may result in a reduction in net communication costs. On the other hand, if the individual maintains linkages with his proximate spatial environment and is not able to relocate in the immediate vicinity, the implications of relocation may be quite negative. The spatial distribution of the relocated population's linkages and the probabilities of relocating in the neighborhood and community have, therefore, been introduced into the suggested information set.

The consequences of relocation for nonresidential activities would appear to be a function of the number of old linkages which will be initiated with the activity at the new site although this is only a first estimate, since other new linkages would probably be developed. It is suggested that the broader the spatial extent of the linkages, the smaller the effects of relocation. Finally, the physical condition of the facility and its conformance to existing and future land-use plans and regulations are important considerations in evaluating the effect of relocation.

Admittedly, the symbolic import of a home or facility in a certain area is not considered in this approach. If this symbolic significance represents a collective value which is reflected in property value, the individual is compensated for his loss in the price which the purchasing group pays for the land. Examples of property values reflecting symbolic values exist in many cities, for example Georgetown in Washington, D. C., and Beacon Hill in Boston. On the other hand, the values ascribed to social contacts in the proximate environment are less likely to be generally held and may not be reflected in property values. The present analysis could be viewed, then, as a device for measuring these social values.

SOME PROBLEMS AND PROSPECTS

The prototypical information packages for describing the community consequences (Figs. 2 and 3) are deficient in several respects. These packages are cumbersome and considerable problems may be encountered in obtaining and comprehending this mass of data.

Suppose that a decision-maker is concerned with choosing among five alternative routes having community consequences for two groups in each of five communities. With 5 pieces of information in each cell, 8 linkage types, and 6 consequence matrices, 2400 data points must be furnished for each alternative. Presenting 12,000 pieces of information on community consequences would probably overwhelm most decision-makers and make it difficult for them to draw any conclusions whatsoever. The fact that the community consequences form only a relatively small portion of the information set required to evaluate alternative transportation plans merely compounds this problem. The preceding clearly leads to a requirement for a synthesis at the technical level of the community consequences information. Through this interpretation, a decision-maker would be furnished with an estimate of the impact on a community, perhaps on a 7 point scale ranging from very positive through neutral to very negative, and the ability of negatively affected communities to adapt to the new situation. Considerable further research on the impacts of existing transportation facilities would be needed in order to establish a data base for this interpretive activity.

Current modeling capabilities for determining the consequences for the linkage matrix of changes in the transportation system are insufficient for obtaining all of the data suggested in Figure 2. Existing transportation planning techniques could probably be adapted to determine and predict linkages at the metropolitan level. At present, the problem of estimating impact on neighborhood and community linkages appears less tractable. New procedures will have to be devised to predict the effect of changes in communications costs on the pattern of linkages and the implications of linkage alterations for the functioning of the community.

These problems are not insurmountable and should be rendered less so by the following observations. It is not the intent of the preceding discussion to suggest that the information outlined in Figures 2 and 3 should be collected for every transportation alternative proposed for an urban area. Levels of detail exist in the planning process, and the suggested information packages are intended for application at the most extensive level of analysis. Useful but less detailed estimates of community consequences could probably be derived from readily available census and travel data.

Furthermore, it does not appear necessary to develop this information for all of the groups in all of the areas traversed by a facility. Portions of the existing literature can be interpreted to define socioeconomic groups and areas which are of particular concern. Results obtained by Greer and Kube (48) suggest that the social importance of a local area is related to the life style as defined by the urbanization index (20). Their cross-sectional analysis of areas in Los Angeles showed that the smaller the proportion of women in the labor force, the greater the fertility index, and the greater the proportion of single-family dwelling units, the greater the proportion of people for whom the local community is important. Studies of the West End of Boston clearly show the social importance of the proximate environment for an ethnic, low socioeconomic status community (4, 43, 44). In this case, the social life of the inhabitants took place within an extremely confined area. Areas and groups of particular concern can, therefore, be defined prior to expensive field surveys, and extensive analysis can be confined to these areas.

Not all linkage types should be viewed as being of equal importance. Although this has not been empirically established, linkages to work, social activities, community groups, and schools would appear to be more important to the individual than linkages to shopping facilities. Undoubtedly, linkage importance will vary with the group in question, but this observation does suggest study priorities for field investigations. Finally, it is suggested that the immediate consequences are of somewhat greater importance to the political decision-maker, particularly if these are the consequences on which his constituents base their decisions at election time. In this case, the more easily predicted short-run impacts are more important than the long-term effects.

Two criteria, delineation of the physical and social framework of the community and measurement of community impact, were suggested for evaluating alternative approaches for defining the community consequences of the transportation system. Properly applied, the residential linkage construct defines the boundaries and the internal organization of the community. In particular, facilities, such as stores, parks, and schools, which play a critical role in the community's functioning would be identified, thus furnishing the transportation planner with information critical to the minimization of community description. As an evaluation tool, the construct provides an unambiguous and theoretically appropriate measure of community effect. Instead of measuring the inputs (i.e., noise, air pollution) or the results (i.e., changes in land value) of the impact process, it examines the process itself. This feature will permit controlled investigations of the consequences for various groups of different types of transportation facilities. Through this research, hard information can be obtained on the community effects of transportation facilities.

Although the preceding discussion must be viewed as highly exploratory, it would appear that the existing transportation planning methodology can be usefully applied to operationalizing the residential linkage construct. The existing data acquisition and manipulation technology could be adapted for use in field surveys to define residential linkages. Transportation planning models could be refined to provide metropolitan level linkage information, although more difficulty would be encountered at the neighborhood and community levels. Finally, the use of the construct as a design tool appears particularly promising. Through research, procedures that define the transportation program providing the maximum positive or minimum negative community consequences could be developed. In this way, higher level community goals could be entered directly into the transportation planning methodology.

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