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Transportation Technology and the Urban Poor

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ABSTRACT

By defining technology in terms of both hard and soft components, it is possible to examine briefly techniques for planning that must precede implementation of any new urban hardware system. These planning techniques are strongly tied to goal definition of the urban resident, and methods are illustrated through which needs can be quantified in a series of matrices. Examination of a quality-cost trip purpose space further illustrates a method by which alternative systems, as derived from their goal constraints, can be defined. Brief descriptions are given of some possible hardware systems that may be implemented either immediately or in the long- or short-range future.

Introduction and Definitions

It has often been stated that all that is needed to improve our deteriorating urban situation are jumps in technology that would enable low-cost, high-quality housing to be built at great rates, magnificent new computer-controlled mass transit systems to be built, and similar dreams that somehow shift current demands to the future.

This paper on the technology of transportation is an attempt to, first, define what technology encompasses and, second, to place technology in proper perspective in terms of a parameter for defining specific urban transportation problems and their related goals.

It is necessary to establish two main classifications of technology interrelated, yet, perceived by the user in final forms in quite separate ways. These shall be referred to as *hard* and *soft* technologies.

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1. *Hard technology*
   Hard technology refers to the user product or products that permit or facilitate use of an associated product. For example, the automobile is a user product, and pavement systems and signal systems are products associated with its use.
2. *Soft technology*
   Soft technology refers essentially to the processes used in planning the hard technology, or the product. This would include such diverse items as computer programs to develop trip generation models, and methods employed for disseminating information on transportation services. The sophisticated decision making process is certainly an example of soft technology.

The dual definition of technology shall be referred to in an assessment of the transportation needs of the urban poor.

Defining Transportation Needs and Goals

There is no question that the fundamental goal of the urban poor is to improve the quality of their life. While this goal is a somewhat intangible item, it can be quantified by a series of measures generally applied to the community at large. These measures include median income, job category, house value, and years of education to name a few. Goals for improvement would then include:

> Improved jobs, improved job skills, availability of less demeaning work, improved opportunities for families where both heads of household work.
>
> Improved housing conditions, within and without current dwelling areas.
>
> Improvement of cultural awareness in the broadest sense.
>
> Improved markets, and variety of market availability.
>
> Improved medical facilities.

Having defined these goals relating to life style, it is then incumbent upon the transportation planner to devise methods of quantifying travel needs in terms of trip purpose. One handicap that faces the planner is that much demand might be latent. For example, Fig. 1 shows a curve that relates to total trips (daily) per dwelling unit to median income.[1] While plotted for Washington, D.C., this figure is typical for most urban areas. It illustrates that as income increases total trip making increases. This can be related to the mode of transportation in that as income increases, it is

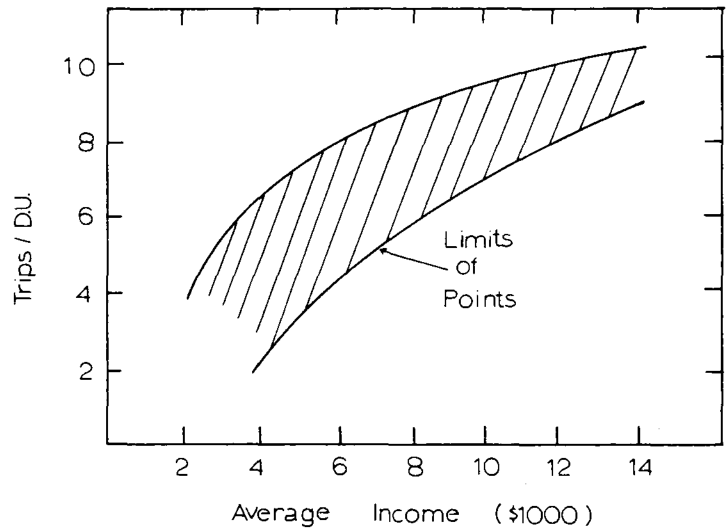

Figure 1. Trips/D.U. vs. average income (after Mertz & Hamner).

more likely that there will be one car in the household, and with further increases households gain additional cars. Because of the convenience of the car it is much easier to make trips for any purpose. Thus, it is more likely that trip frequency will increase.

However, the important point is not that trips increase with increasing income, but the reverse—fewer trips are made by low income families. This does not mean that the necessity for increased trips is less, but that the ability to make trips for other than work—essential shopping and urgent medical services—is decreased. One constraint upon the planner then is to develop means for increasing the trip-making ability of the poor.

It is possible to quantify such trip-making patterns in terms of available modes. These are illustrated in the following examples for an area of Buffalo, New York, that is characterized by a nearly 100% black population and very low median income. While 49% of the households of the area are autoless, less than 25% of the workers are from autoless households. One third of the jobs are beyond the city line and an auto is a necessity to get to the jobs as evidenced by the 87% who either drive or ride to work in suburban areas.[2]

It is also noted that the auto is the most preferred mode for food shopping trips. But where that was unavailable, walking was generally preferred to bus trips except where the trip was combined with another purpose, e.g., work trips. Both through quantitative study and home interviews it has been stated that the current large buses are not adequate for trips such as food shopping trips. Further, lack of a car also implies lack of access to a competitive market. This may present a handicap in forming economic shopping habits.

Planning constraints that serve as valuable inputs into the planning models can then be summarized:

1. Auto ownership in this low income area of study is generally one-half that of the city as a whole.[3]
2. Trip making, when autos are not available, is much more limited both in number and distance.
3. Fewer trips do not imply fewer desired trips; it implies lack of suitable alternatives to make the desired trips.
4. A wide variety of trip purposes exist, distributed over a wide range of age groups, all of whom do not have the same travel patterns. This has strong implications on design of mode to satisfy travel desires. Trip-length category illustrates the difficulty in trip-time assignments. A trip time for social purposes that a younger person considers short might be considered excessive by an older person making the same trip.

Transportation Limitations and Needs

While transportation should serve the basic purpose of trip making, choice of modes has a much greater impact on the total environment, often intruding into other aspects of daily life. Thus, in examination of limitations and needs, it is necessary to study two aspects:

1. Trip making and influence of mode and geography
2. Impact of mode choice on environment

TRIP MAKING

The interrelationship between development of the auto, decline of public transit, and suburbanization of population has been well documented. What is less well documented is the impact of population shift, population changes (ethnic and income), and decline of public transit on the core area urban poor.

Most large cities find themselves fighting an exodus of the middle class, leaving the poor, and most likely black poor, in the core area of the city, in neighborhoods that are in constant decline in terms of net worth. This distribution is often maintained by established patterns of segregation in housing, schools, and jobs.

An example of population shift is given for the city of Buffalo whose population declined during 1960-1970 from 532,000 to 455,800, a decline of 14%, while the nonwhite percentage of the total has increased from 14% to 20%. During this period the metropolitan area has shown a net gain indicative of the population shift to the suburbs. Imposed on this population is a transportation system designed to meet the needs of the suburban residents through two basic modes, the auto and public transit.

In Buffalo the public transit system is a privately-owned bus network, CBD oriented. By measure of walking distance to stops, it has apparent good coverage. But it does not meet the needs of those in the core area whose basic trip pattern is often against the CBD-oriented flow. For example, the city of Buffalo has 6.25 bus-line miles per square mile of land area, and most areas in the core have higher ratios of bus coverage. However, in the black core area no buses run directly to major sources of suburban employment which include large manufacturing and industrial plants, and private homes. The buses are not scheduled for shift work and have no night owl and abbreviated weekend service. The company also makes no special advertising attempts in areas of low car ownership, and makes information available only at a limited number of bus stops or through the mail. The current bus fare is 35¢ plus 5¢ transfer. Ten work trips a week (for one ride + transfer) amount to over 6% of the gross income of a worker on minimum wage. What becomes clear is that for a family of a low income worker, additional trips (shopping, recreation, medical) become expensive in terms of utilization of income, even if transit were accessible and convenient The fundamental mode of transportation is the auto, and as noted previously, the auto is used for most work trips (either as driver or rider). While the bus system is primarily affected by geography and population, the impact of the auto is greater on the environment.

IMPACT ON ENVIRONMENT

The auto can have a severe impact on the environment whether it is mobile or stationary. Any developing plan should attempt to alleviate or minimize current disruptive patterns and certainly should not reinforce them. Examples of disruption are cited:

a. *Moving vehicles*
   Heavy traffic and resultant noises and air pollutants
   Disruption of pedestrian traffic in densely populated areas
   Overcrowding of narrow streets in emergencies, rendering them impassable to special vehicles (e.g., ambulances)

b. *Stationary vehicles*
   Excess use of land space for parking
   Clogging up crowded paths of movement
c. *Support systems*
   Disruption of neighborhood continuity through expressway construction
   Relocation problems caused by expressway construction

It should be noted that expressway construction, providing access from suburbs to CBD, does not always provide similar access through well placed interchanges from the inner city to the suburbs or other areas of travel desire.

Techniques For Planning–Software

Having briefly assessed the process of goal selection as the initial input into the preliminary planning phases, it is now possible to examine available planning techniques using soft technology.

Most of the preliminary decisions regarding implementation of new hardware systems, based upon studies of travel patterns and quantified through complex models, are made through extensive use of available computer facilities. The transportation planner, in general, has no real input into the improvement of computer technology, *per se*. However, the computer, as well known, is really only half of a tool, the other half being the information supplied for digestion. Thus, it becomes the responsibility of the planner to make decisions regarding use of this tool, decisions that are really the most sophisticated technologically. This doesn't mean sophisticated in the sense of being mathematically complex or obtuse, but sophisticated in the sense of the developed modes being most highly representative of the true prototypes, even if they are the planning process itself (i.e., a trip generation model).

A series of matrices has been developed that evolves into a ranking system that can be used to determine actual hardware. They are illustrative of the current ability to quantify goals for transportation without first depending upon constraints of the hardware.

Matrix 1 (MAT 1) (Fig. 2) identified minimum acceptable vehicle requirements that would be associated with a variety of trip purposes. The constraining requirements are space, time, cost, and comfort. Thus, for example, a rider might trade off a high level of comfort for a rapid work trip, but might demand a high level of comfort for a social trip. These items can be quantified. It may be possible to start from the assumption

Trip ↓	Space	Time	Cost	Comfort	Total Daily Use
Work					
B.C.	1.15	1.35	1.60	1.40	13.1%
W.C.	1.00	1.65	1.85	1.60	11.6%
Shop					
Nec.	1.40	1.00	1.15	2.00	7.1%
Lux.	1.30	1.70	2.40	2.20	12.1%
Home	1.20	1.60	1.70	1.70	11.4%
Pers. Bus.	1.10	1.30	1.90	1.70	9.2%
Soc.–Rec.	1.50	2.30	3.20	2.90	16.3%
Med.	1.30	1.60	2.20	1.80	11.4%
School	1.25	1.10	1.00	1.00	7.8%

Figure 2. Vehicle requirement matrix (MAT 1).

that mean trip times, by purpose now experienced in various urban areas, can be assumed to be acceptable mean times as an original reference point in planning. Thus, an average of an 18 minute auto work trip (for Buffalo) might be a real goal for work trip time, especially if true alternative modes are to be developed or suggested.

A set of data has been evaluated for MAT 1 to illustrate the effectiveness and use of this concept. In developing this data a value of 1 was given to a minimum requirement in a given column and multiples of this unit were developed for the rows.

Space: The unit value was assigned to white-collar work trips where comfort might be sacrificed for time and high density, and where the rider usually carried no objects. Note that the space requirement is, in a sense, contradictory to the low rate of car occupancy in work trips.[5]

Time: A distribution of travel time shows that minimum acceptable are applicable to shopping for necessities.[6]

Cost: Cost can be associated with trip frequency and necessity, for other than work trips. School trips are, by demand, lowest cars, with a low allocation given for necessities shopping.

Comfort: Minimum comfort required is again in school trips, where little demand is made on transportation other than it be a conveyance between activities. A higher demand is placed on shopping trips due to extra facilities needed for parcel storage and carrying.

A further column in MAT 1 is one that defines total daily use. This actually relates to time (by mode) taken for a specified trip to the total time taken in all trips per day and can be specified on an individual or household basis. This column is essential as an aid to establish possible modal split alternatives. For example, consider the case of a one-auto household, where the auto is used for the home-work-home trip. A variety of other trips taken during working hours can actually make the auto-time travel a small fraction of the total daily travel time. If trips are delayed until the worker is home, it is possible that a variety of trips possible during working hours will not be made or are spread out over a greater time base. It may also constrain the nonwork activities of the principal (or only 1 driver in the household).

There is no question that such an analysis would help establish latent travel demand if the matrices were developed for a varied income base, or for an auto-ownership base.

Matrix II (MAT 2) (Fig. 3) delineates acceptable quality associated with a variety of vehicle types. The types are unspecified according to actual vehicles (i.e., auto, 50 passenger bus, etc.) but give designations such as multi-passenger private and multi-public high speed. What can be derived from this matrix is the performance that will be expected by the passenger according to the associated type vehicle. Ease of access for an elderly person, for example, will be rated highly in a public type vehicle.

MAT 3 (Fig. 4) quantifies aspects given in MAT 1 and MAT 2 by giving a preferable vehicle type by mode for a specific trip purpose. This would be a next step in defining modal split and, together with acceptable performance levels, helps give further constraint towards defining a vehicle to serve as a true alternative where modal split is desirable or imperative.

Vehicle Type / Acceptable Quality ↓	Single or Multi-Passenger Private	Multi-Public Low-Speed	Multi-Public High-Speed	Pseudo Private
Noise	X X X			
Ease of Access				
Ride Comfort				

Figure 3. Quality matrix (MAT 2).

To arrive at data for the discrete information bits demanded by MAT 2 and MAT 3, special survey techniques as well as human factors engineering must be used. It may be necessary to use distribution functions where the response is not closely centered about a mean value, and note that upper and lower limits of acceptable quality (together with a range of "a" % within one standard deviation of mean) must be used in final design estimates. (See Fig. 5.)

A quantification tool of great use in conjunction with MAT 2 and MAT 3 is shown in the three- and two-dimensional space plots, mode planning

Vehicle Type (mode) / Trip Purpose ↓	Single or Multi-Passenger Private	Multi-Public Low-Speed	Multi-Public High-Speed	Pseudo Private
Work	X X X			
Shop				
Social				
Medical				

Figure 4. Mode evaluation matrix (MAT 3).

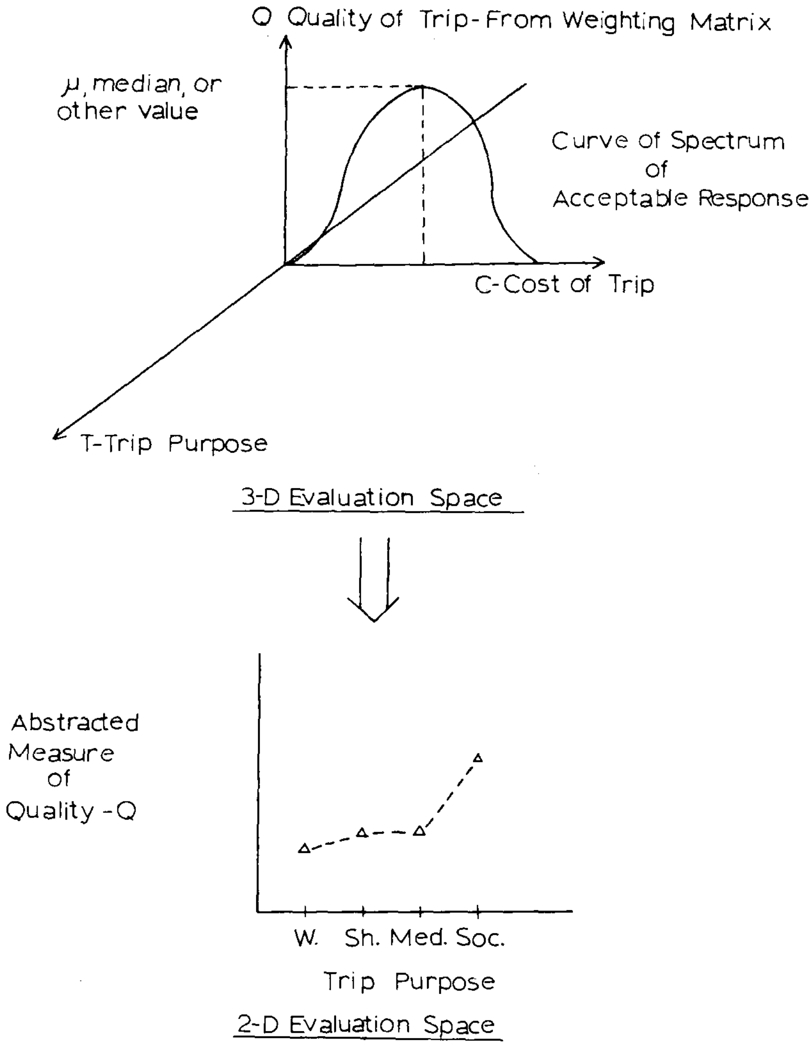

Figure 5. Mode planning spaces.

spaces. Difficulties in arriving at figures to use from attitude surveys make it necessary to use distribution of response spectra such as shown in the 3-D space. Here, for example, acceptable cost per trip is plotted against percent accepting that cost (i.e., a cost density function), and this is distributed along an axis of trip purpose. From this spectrum, a mean value, a median value, or perhaps a value acceptable to a certain percent of the population can be established for time and quality. A measure of these variables F(Q,C) can be established and plotted in two dimensional space against trip purpose. Any significant ΔF, as shown in 2-D space, i.e., any large change in this function with trip purpose, can be examined to determine whether such a ΔF is truly compatible within one mode. Thus, someone willing to pay 40¢ a trip to go to work (public transit) may be willing to spend much more for a social trip (as established by the trip spectra). While the cost function for the bus may be compatible for both trips, cost functions for the auto may not be, and comfort spectra may be totally incompatible. Such graphical analysis helps define potential use of alternate modes in modal split analysis. It should also be noted that the matrix-ranking system represents descriptions of perceptions of the state-of -the-art in current technology, for they are derivative of user responses to the actual operating systems. These systems, (i.e., public transit, auto-highway) are the basis for perception of the user who can give more realistic information in what he prefers in terms of life style (time, cost, space), than imagined responses to an imaginary system.

The planning techniques described are examples of software analysis, which together with rapid data processing, statistical analysis, and model building capabilities of high speed digital computers are essential components of decision making at the pre-hardware choice stage.

Techniques For Planning—Hardware

In the previous section general planning techniques that are adaptable to any transportation process for any group(s) were presented. In returning the discussion to the urban poor, it should be noted that the data utilized for these matrices would be obtained through special area surveys.[7] As techniques for zonal analysis have been discussed in detail previously, they shall not be repeated here. What should be noted is that values of the MAT 1, which leads to rankings in MAT 2 and MAT 3, will be substantially different from values of the matrix if defined for the urban area as a whole. A brief example of using total modes (work trip) to enter the matrix will be given. Assume that the mean work trip time is 18 minutes by auto and 30 minutes by bus (figures representative of Buffalo). If 40% of the work trips are by bus in low income areas (generally corresponding to 50% or higher no-car households), and 20% of the work trips are by bus for the entire metropolitan area, the weighted work trip times would be 23 minutes for the low income area and 20 minutes for the area on the average. Note that the bus trip length is only the ride and does not include waits or walks. In this example use of travel time alone would be misleading, for in the same time (approximately 20 minutes) approximately twice the distance would be covered by the auto as by the current bus trip and more than twice the number of job opportunities would be intercepted by using the auto. Hence, a descriptive goal for hardware design would incorporate a range as well as time (or an average mph figure including stop time), or even assign a value to potential opportunities.

There are two major areas of immediate transportation needs in poor areas that help define vehicle types.

1. Better access to work trips—trips readily adaptable to peak hour analysis, with day-to-day travel times well defined.
2. Better access to need trips—hospitals, shopping, personal business—trips poorly defined by peak hour and of widely varying travel time length.

From the criteria discussed thus far, it is evident that personal-type service is the most apparent lack in transportation for the urban poor. It may be necessary to assume that most major urban areas will have high-speed rapid transit in the next decade serving mass ridership at limited (though numerous) access points. Many urban areas such as New York, however, are finding that their mass transit is becoming rapidly obsolete and will have to be replaced by somewhat compatible systems.

Recent investment in new systems construction has been spurred on by sponsorship of the DOT through UMTA in actual operating systems. For example, JPL will manage an urban shuttle system installed on the campus of West Virginia University. In an article reported in the *N.Y. Times* (Sunday, Oct. 4, 1970), an administrator of UMTA said:

> "Before the end of 1972, we hope to have this experiment carrying students, professors, and others in 3.2 miles of guideway on 90 automated cars at speeds up to 25 miles per hour."

Three systems bidding for the WVA facility are:

1. Alden Self Transit System (Social Guideways)
2. Vargo-Inc. (Monorail)
3. Dashaveyor (Constructed Guideway)

These three systems, all relying on specially constructed guideways (with implications for large capital investment), are of necessity mass-transit oriented, although designed for personal comfort. At this time it would seem that the success of such projects is dependent upon the ability of the modes to be truly flexible enough to provide alternatives to both cars and buses, and to saturate areas where demand is high so that a variety of trip purposes can be served. Thus again, in referring to the design criteria, the element of access to mode, once the mode has been developed, is of prime importance. If new modes are to be merely superimposed on old public transit routes, for example, the dilemma of the ghetto resident in going from a densely populated area to a variety of alternatives will not necessarily be solved. Again the dilemma asserts itself as one in which only a totally independent guideway, or dual mode vehicle would satisfy the demand for all trip purposes.

The Auto as a Quantum Jump in Technology

In assessing new technologies, it is useful to look for reasons of success of old modes of transportation and question whether similar impacts can be made. The automobile has had a greater impact on transportation in the U.S. than any other mode for a variety of reasons.

1. It is inexpensive–the perceived cost per trip as a percent of total income is low.
2. The guideway system is universal–almost geographically independent. The auto can travel on even the roughest of guideways, making the route choice for one vehicle almost without limit.
3. As a module it is produced in such a wide variety of designs and space orientations that the individual can purchase what he conceives to be optimal for his travel requirements, and will meet the conditions cited in 1 and 2.

Much demand is focused on new technologies to solve current problems and in that way, perhaps, we lose sight of true future impact. As an example, the new mass-transit systems to be discussed in a later section have evolved to alleviate problems of high density traffic in centralized corridors, often from low density residential areas, through medium high density mixed land use corridors to industrialized (blue collar/high density) core areas. The presumption in evolving transit is that people will continue to define their activities with great separations of space between them. However, if population densities continue to increase as land costs reach premium levels, the difficulties of travel (illustrated by demand on rapid transit that clearly show the inadequacies of the New York City subway system) may force changes in life style. Such a change may actually be a reversion to the pre-1920 concept of living where you work. Future transportation technology must begin to incorporate in their planning understanding of the directions of current social forces.

Assessment of Technology

Of the technologies available immediately, in addition to new mass ownership of automobiles, one of the most promising is the dial-a-bus system. This demand-operated system can apparently provide trip service on a (nearly) door-to-door basis at a fraction of private taxi cost while retaining some elements of mass transit. Further, this system is one that is capable of becoming increasingly more sophisticated as greater investments are made in it. It is possible to go from a totally noncomputer system to a totally computer operated system in which demands would be fed into programs to determine route and minimum ride time. What a total computer operated system would lack is the ability to make decisions based on priority of need (i.e., all calls receive same priority) or to give specific requested information, although that is a minor problem readily overcome. This system is also readily adapatable to providing nearly fixed route service for a specific group with time-period requirements (i.e., work trips), but would provide the added advantage that there would be no total time fixed route requirement, and thus would operate somewhere between bus and taxi service.

Service in the intermediate-to-long-range future can be provided through bimodal vehicles, pallet systems, and unimodal vehicles with new propulsion devices. All of these systems would be designed to be readily integrated into a total system that would permit quick access to any point in a metro area, either through connector vehicles or bimodal use (i.e., as flexible vehicle on street system, then locked into a guideway system). To maximize use, the vehicles could be publicly owned or leased, and programmed for dispersion for other trips when a rider is not using the vehicle. The vehicles should be characterized by safety and ease of use. The mounting number of highway accidents each year underlines the fact that the automobile is not truly an easy vehicle to use. Automobile control systems would extend use of the vehicle to the young, the aged, and the infirm.

The fact that bimodal vehicles or hybrid vehicles appear so attractive at this point underline the fact that with the exception of the automobile there is no one single mode of transportation that is suitable for all trips. Further, the auto is not always the ideal mode for the work trip, especially where traffic densities are high; but at present no real alternatives may exist.

Future Commitment

The future success of any transportation system is not dependent upon transportation technology alone. For example, in Nashville, Tennessee, a limited access highway was to be placed through the Model Cities area, bisecting a vital neighborhood. The ability to design and utilize an air rights structure over the highway may possibly maintain and even enhance the original neighborhood. In Baltimore, planners for the new interstate highway along the harbor insist that the highway design is only compatible with major renewal, relocation, or rehabilitation plans for the area.

These are two examples of a new type of commitment to transportation planning that now exist. In deriving the matrices in an earlier section, the impact of total future planning should be considered. Job automation, increasing education, suburbanization of the black, redevelopment of core areas, diminishing population growth through birth control, are all examples of implementation of totally new technologies that have impact on population characteristics that are in themselves determinants of travel. For this reason it is important that short-range problems receive much more attention until we establish methods of true long range planning. The urban poor live today and need today's commitment.

Acknowledgment

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