ANALYZING TRANSPORTATION NEEDS OF URBAN AREAS--A NEW TECHNIQUE

A paper presented in the Convention in Print of the
American Transit Association, published November 3, 1944.

By Thomas H. MacDonald
Commissioner of Public Roads

The past few years have seen a striking growth in the so-called "public opinion surveys." Automobile manufacturers have attempted to get a jump ahead of their competitors by questioning drivers as to the details of appearance, operation, and performance of the vehicles they would like to be driving. Similarly, processers of food have found, for example, that the size, shape, and future usefulness of the container sometimes have as great an appeal to the customer as the product it encloses, and accordingly have directed their packaging policies with due regard to the results of opinion surveys. Government agencies have by a sampling technique determined the probable consumer demands for many products once peace releases our war machine for the production of civilian goods. The best known users of this survey technique are, of course, those who conduct the public opinion polls that reveal with such startling clarity the political thinking of the country.

If such a wide variety of items in our daily lives can be precisely analyzed by a sampling process, why cannot the American public's travel habits and needs be similarly analyzed? Before answering this question let us look briefly at the reason for asking it.

At the time of passage of the original Federal Aid Road Act in 1916 very little highway improvement had been completed. Although city streets were generally paved, the mileage of improved rural highway was small indeed. What mileage was improved extended from the cities in more or less groping fashion into the nearby rural areas to provide some measure of relief from the confinement of the city to the urban motorist who wished to extend his travel horizons, and to induce a greater volume of trade to the mutual benefit of the city merchant and the rural consumer. By the time of enactment of the Federal Highway Act of 1921, however, a number of States had recognized that orderly development of highway transportation required the establishment of a system of roads of the first order of importance on which expenditures for improvement should be concentrated. This first Federal Highway Act endorsed this principle, and substituted for the haphazard improvement characteristic of the early days of the automobile the construction of a connected system of highways known then and now as the Federal-aid highway system.

Over the course of a quarter century, by a consistent adherence to the sound policies of the Federal Aid Highway Act as it has been amended from time to time as conditions demanded, improvement has been extended

to all of the more important rural highways. Today we find it possible to travel with comfort and generally at nearly any reasonable desired speed between virtually any two communities in the country.

True, many miles of highway barely suffice for the present traffic volumes, and will have to be increased in capacity and improved in safety features to meet post-war traffic demands. Moreover, many miles have suffered from the concentration of wartime loads and the inability to provide needed replacement because of wartime shortages. Much still remains to be done to our rural system merely to keep abreast of the necessary demands of travel.

But by contrast, from the standpoint of moving traffic, the main rural highways have attained a degree of improvement far beyond that now found on the city street. Here surface condition may still be adequate, but in often repeated instances traffic has become almost hopelessly snarled and internal movement is experiencing a slow stagnation. Our major problem of tomorrow is to bring the main rural road system up to its full utility by greater efforts at its extremities. We must free the main routes through and into the cities of their increasing congestion, and we must build the essential feeders in rural areas. Products must more from farm to market, from industry to consumer, and people must move from home to work and in their social and recreational pursuits freely and efficiently if we are to develop effectively the resources of the Nation. Restrictions to movement at the ends of the journeys, with which we shall be faced soon after the war, will be as intolerable as the resistance of the main line mud of the early twenties.

Both in magnitude and complexity the city problem stands as a challenge. Approximately half of the total vehicle miles of travel are performed within the limits of municipalities. Almost exactly half of the motor vehicles registered in 1941 were owned in cities having a population of 10,000 or more. The importance of the city to rural highway traffic is seen in figures that show that over 85 percent of all trips on the rural highway have either their origin or destination, or both, within municipalities. Undoubtedly many of the remaining 15 percent of the trips that have both rural origin and destination pass through one or more incorporated places. The influence of the city extends outward from its limits along the rural highways, an influence that is reflected in rural highway traffic for distances up to 35 miles from the largest cities. Even cities of as small as 10,000 population have an effect on traffic for distances of 5 to 6 miles beyond their boundaries. The magnitude of the problem is thus the result of the combination of the internal movement within the city itself and the volume of traffic attracted to the city from its outlying suburban and rural areas.

The complexity of the problem is obvious to any who drive in city traffic. Narrow streets are expected to serve traffic of all characteristics. Improvements in the form of new routes or widening of existing streets are hampered or prevented by highly developed and consequently

high-valued property. All classes of vehicles--passenger cars, taxis, trucks, busses, and sometimes streetcars--must be accommodated. Pedestrians are difficult or impossible of control. And generally the streets are expected to serve as terminal facilities for private passenger cars and for trucks, busses, and streetcars as they stop to load or discharge cargo or passengers.

Highway administrators have long been aware of the existence and importance of this condition. The urgency of the urban problem was emphasized particularly in the report "Interregional Highways" prepared by the National Interregional Highway Committee and transmitted to Congress by the President on January 12, 1944. The material on which this report was in large part based had been developed as a result of years of study and research by the State highway departments through the highway planning surveys. In a number of States, city and State officials have been actively collaborating for many years in the joint solution of this common problem. And it is probably largely because of the mass of factual information on the whole street and highway problem that has been assembled by these planning surveys that legislation now before the Congress proposes for the first time continuing appropriations in significant amount earmarked for expenditure solely within urban areas.

Because the problem of urban travel is common to State and urban agencies, a separation of the responsibilities for the solution of its component parts is difficult and probably undesirable. A satisfactory solution requires a truly cooperative approach.

An improvement on a main through route even if designed primarily to aid rural traffic approaching or passing through the city will inevitably work to the benefit of the city travel. The new facility, undoubtedly superior to the parallel streets, will attract to it substantial volumes of purely intracity traffic. Studies show that on present routes through cities, improved only by widening and modern traffic control techniques, traffic volumes increase from figures such as 4,000 to 6,000 vehicles per day at the city limits to as high as 30,000 near the center, even in medium sized cities of 200,000 to 300,000 population. That the volumes in the larger cities are not greater on such streets probably means that this figure represents approximately their reasonable capacity.

To gauge the extent that city traffic will be attracted to a superior facility requires a knowledge of the entire city's travel needs, now and in the future, and of how the facility itself may serve to remold the city travel pattern. A facility well located and adequately designed can aid in the orderly development of the community along sound planned lines; one improperly placed or inadequately designed can retard if not prevent this desirable urban development.

During the course of the rural highway planning surveys, techniques for studying rural needs had been worked out in detail. Volumes of traffic had been recorded both manually and by various mechanical or electronic

devices designed for the purpose. Origins and destinations too had been determined in rural areas and on roads approaching cities of various sizes, in the latter cases generally to find the amount of "bypassable" traffic. A variety of procedures were developed to fit various conditions involved.

But none of the procedures developed for such areas was entirely applicable to urban travel studies, not so much because the particular techniques could not be applied to the more intensive problem, but more because of a difference in fundamental concept of the different studies.

In both rural and urban areas the end result desired is the same-- a measure of the movement of persons and goods for which provision must be made. In rural areas this movement can be measured with reasonable accuracy in terms of vehicles. In urban areas, on the contrary, a study of the movement of passenger cars, trucks, and busses is not enough. We must get down to the basic measures of the travel of individuals themselves, whether it be by private vehicle, bus, streetcar, taxi, or rapid transit. In the city, effective planning calls for a detailed knowledge of the daily movements of masses of people, and the provision of facilities for that movement by whatever type of vehicle is indicated as most appropriate. And of course to supplement that knowledge is required an equally detailed knowledge of the daily movement of goods and a provision of equally appropriate facilities.

We come then to the reason for asking the question: "Can the public's travel habits be adequately analyzed by 'opinion surveys'?" The reason is that travel habits must be determined, and there seems to be no other feasible way to do it. The answer to this question is "yes." And the results of surveys of this type already completed in a number of cities back up this affirmative and positive answer.

In the surveys now being conducted all travel for a specified day is determined for a representative sample of the city's residents, a sample so carefully controlled that the results can be expanded to show in detail the total internal movement in the city for a typical day. Along with the travel are determined a number of items of important corollary interest. The success of this or any other sampling technique depends on the selection of a truly representative sample, of a known proportion of the universe in size, or if the sample is not truly representative of the entire universe, the degree to which it is biased must be known with great accuracy. In selecting persons at random for questioning about a certain issue, for example, care must be taken to determine such factors as their occupation or income group if it is expected that persons in different occupations or income groups might think differently on the issue. Then to determine the thinking representative of the entire population, the results of the questioning of each group are given a weight equivalent to the proportion that group is of the total population. The difficult feature is not so much the questioning or the mathematical work of expension of the sample. It is rather the determination of the proper factors by which to weight the results of the questioning.

To aid in development of the method of sample selection the Public Roads Administration was fortunate in having the cooperation of the Bureau of the Census. That bureau, through the Division of Special Surveys, regularly conducts surveys to collect widely varying types of data, generally using some sampling technique. Their recommendation was to select a sample purely on a geographical basis, on the theory that in a sample so selected all other factors would be automatically included in proper proportion.

Thus, for a travel habit survey by this means, the first requisite is the selection of a sample inflexibly chosen as to geographical distribution, and adhered to in the interviewing without the slighest deviation. The natural tendency of an interviewer, on finding the occupants of a designated house absent, to call on a neighbor must be strictly avoided. It should be obvious, of course, that the travel habits of a person easily found at home must be quite different from those of a person seldom there, but this distinction is frequently overlooked unless its importance is stressed.

The size of the sample varies with the size of the city. In the smaller cities in which surveys have been conducted, those with populations up to about 150,000, a ten-percent sample has been used. As the size of the city increases, and as the volumes of travel with which we must deal also increase, a smaller sample is adequate. In cities around 500,000 population a five-percent sample has been found to be sufficient, and for larger cities in which studies are now contemplated, it is probable that the sample will consist only of one address in forty.

The manner of selecting the particular addresses to include in the sample varies with the city and with the material there available that is useful for the purpose. Generally the Sanborn maps have proved most helpful. Where coverage by these maps is complete and they are reasonably up to date, the street and number of each unit to be interviewed may be listed directly from the maps. These listings may be checked by a variety of means such as city directories, Census statistics, water or other utility company records, assessors' records, and other sources. No single method of sample selection is arbitrarily determined in advance. Instead the sources in each city are reviewed and the most complete and accurate used as a base, with other less detailed records used as a check. In newly developed or outlying areas it is sometimes necessary actually to list all addresses from a ground survey, and to select those for interviewing from the list.

Whatever method is used, a sample is selected generally by working entirely around each block and advancing block by block throughout each census tract. The census tract is used as a basic unit of area because it is usually of a suitable size to serve as a useful zone of origin or destination of travel for analysis purposes, and also because of the large amount of data on population, housing, and other trends that are available for all cities by census tracts. These data can obviously be of material value in estimating the trends of travel in the various sections of the city.

Of equal importance with the selection of the sample is the selection and training of interviewers, for the success of the survey depends on the ability of the interviewers to obtain full and accurate information. This in turn is dependent on the manner in which the interviewer presents himself or herself to the residents of the selected addresses, and the thoroughness with which he or she understands the purposes and needs of the survey.

In nearly all of the surveys thus far conducted the responsibility for the work has been assumed by the State highway department, and the immediate direction of the work has been assigned to the highway planning surveys, where personnel well qualified by experience and training are available to organize and supervise the study. Generally, also, various city and local agencies have cooperated, principally through the provision of office space and some personnel assistance. In substantially all cases the Public Roads Administration has assigned one or more men to assist in the organizational and training phases where the experience they have obtained in previous surveys is most valuable.

Capable interviewers have been obtained without difficulty through the employment services for all surveys thus far undertaken. Women have been found to make the most effective interviewers, and they are also more easily obtainable than men. Wives of service men, school teachers during their vacations, or local housewives desirous of augmenting their family income represent the largest sources of interviewers. In some surveys high school boys have been employed, but they are not believed to be as satisfactory as women of more maturity.

The job of obtaining the desired information can be greatly facilitated by good advance publicity. Newspaper and radio releases properly timed have been very helpful, but of even greater value are post cards signed by the mayor or other official and mailed to the prospective interviewee two or three days in advance of the scheduled date of the interview. Cooperation in publicity has invariably been of the highest order, indicating not only a desire on the part of the local agencies to assist in the work, but also a recognition of the need for a realistic appraisal of the area's transportation needs.

With the organization to obtain the needed data established and trained, and with the public encouraged to be ready with the answers, what then are the questions that we ask? The questions are designed to elicit information principally on the number of trips by various modes of transport and their definition by place of origin and destination, the purpose of the travel, and the place and purpose of all stops.

The interviewer first ascertains necessary information for the control and expansion of the interview data, such as the number of persons regularly living at the address and the occupation and place of employment of each. Then for each individual of five years of age or older, details

of each of his or her trips for the previous day are recorded. A trip for this purpose is considered to be a one-way trip from origin to destination, such as from home to work or to school, or vice versa. The origin and destination to the nearest block or street address, the time of starting and arrival, the type of transportation, whether as a car driver, a rider in a car, or as a public transportation passenger, and the purpose of the travel are recorded for all individuals questioned. For those who drive cars, further questions show when and where the car was parked, in some cases the major streets traversed, and in all cases whether or not the driver passed one or all of a few well known points such as bridges or viaducts, referred to as control points. The place of each stop en route and its reason, such as for shopping, to get gasoline, or to pick up a passenger, also are recorded. These questions are considered to be the minimum by which a reasonable analysis of the travel can be made. In some cities additional data have been obtained, such as more detail on parking where that is an important factor.

It will be seen that the information is requested for the "previous" day. All interviews are scheduled from Tuesdays to Saturdays so that the travel data obtained are representative of weekdays, Monday through Friday only. It is this travel that is important in the daily flow of traffic in the city and it is this travel that has been least affected by wartime conditions. Week-end travel is so abnormal now as to make its determination of little value. With the resumption of more nearly normal conditions, sampling of week-end travel by this same means will be desirable.

Information thus obtained will show the travel of residents of the city on a typical day of the season in which the survey is conducted. This residential survey, however, leaves gaps in the total internal movement that must be filled in by other, but similar means.

Truck travel is ignored in the residence interviews. It is obtained by recording a selected day's travel, including all stops, for a representative sample of all trucks garaged in the city. Where the information cannot readily be obtained for the previous day, drivers have not objected to keeping a log of the following day's trips on a form provided. Similarly, information on taxi travel is obtained, using the manifest sheets in cities where such records are required, and elsewhere by requesting a representative sample of drivers to log a day's travel. Bus and streetcar trips (the vehicles, not the passengers) are determined from transit company records.

By such means all internal travel is accounted for. Added to this internal movement is the travel of nonresidents entering or leaving the area, determined by actual road interviews. The area included in the internal survey lies within a cordon which is cut by various radiating routes. At each point where any such route carrying a significant volume of travel cuts the cordon, traffic is stopped and its travel within the city determined, with detail as to purpose and stops, as in the internal survey.

Added altogether these several components provide a measure of the total travel, its origin and destination, and its purpose. How accurately is this measured?

There are two checks that are readily applied. The first is to test the adequacy of the sample as to size, which may be done by interviewing for an area, such as a census tract, not only the particular selected sample, but other samples of the same size or even the entire area. Each sample is checked against the other or each, expanded, is checked against the total. Such checks in the early surveys showed such a remarkable accuracy that they are no longer considered necessary.

The other test is not only a test of the adequacy of the sample in a statistical sense, but a measure of the completeness with which the travel is determined by the interview method. This test simply determines from the home interviews and the external survey the number of vehicles reported to have passed the various control points mentioned earlier. The figures thus determined can be checked by a volume count taken during the course of the survey. A check of this nature will also show immediately whether there is a reluctance to report or an inability to recall all travel. There has been speculation, for example, as to whether a driver might recall all of an evening's recreational travel, either because of a real or fancied misuse of his gasoline ration or for other reasons. There is little question, however, that all home to work and work to home travel will be recalled, and that travel accounts for 85 to 90 percent of all morning and evening peak traffic. Thus, if the "interview" volume checked the actual count at the control points during morning and evening peaks but showed a deficiency during evening hours, it could be assumed that the business travel was completely reported and that other travel was not, and appropriate adjustments made in interpretation of the figures. To date no analyses have progressed to the stage of control point checks, but preliminary information gives reason for condfience that substantially all travel is properly reported.

Analytical work required in the summarization of the results is straightforward and rapid, using punch card processes. Questionnaire forms are designed to be largely self coding. Punching, sorting, and basic tabulations of origin, destination, and trip purpose are completed easily and quickly. The cards are then available for the more comprehensive and time-consuming analysis of the probable travel needs of the future as influenced by the changes in the city structure and other factors to the extent that they can be forecast.

The methods employed in these surveys are advantageous in many respects. From an administrative viewpoint some of the favorable features are the following:

1. They can be conducted with personnel now readily obtainable.

2. Their cost, both in value of returns and in comparison with other types of surveys, is low. A survey of an area including as many as 1,000,000 residents may be conducted for $50,000, smaller areas for much less.

3. They are beneficial from the standpoint of public relations. Interviewers have been very favorably received, and the opportunity to carry a message into as many as 10 percent of the homes in the area, to show that officials are making studied efforts to provide transportation services of greatest utility to the individuals themselves can be expected to gain public support for the measures proposed as a result of the survey. The people will know that they have had a part in the solution.

4. They provide information that can be kept current with a minimum of effort and cost. Trends in factors influencing travel needs may be kept up by regular sampling of the sample, and checked by occasional repetition of the entire work when it is thought that conditions have changed sufficiently to require a resurvey. A small group steadily employed at interviewing and a minimum of analytical work will keep data constantly current.

5. They provide the basis for a complete study of travel needs by all agencies concerned and give opportunity for a cooperative approach to the solution that is best for all interests. Conflicting proposals advanced by a variety of agencies in a metropolitan area may be compared against the facts, rather than against one another.

From the viewpoint of the analyst who must interpret the figures obtained and forecast what may be expected a good many years hence, these surveys also offer many important advantages.

1. They show all travel within the city, whether it be by residents or nonresidents. Furthermore, they show travel by all modes of transportation and are not merely an independent survey of passenger vehicles, of transit riders, or other segment of the problem. The position of each can thus be analyzed and provision made for facilities appropriate for the most likely distribution of travel by the various modes.

2. They measure the travel needs of the community from area to area, even from block to block if such detail is desirable, without regard to distortion in present travel practices by existing street patterns, relative degree of street improvement, or relative degree of transit service between such areas. The results of these surveys when considered in light of existing practices will show at once where the latter are distorted because of inadequate planning or operational deficiencies.

3. Analysis of present travel needs is simple. Volumes of movement between various areas by various modes of transport are obtained directly from the basic tabulations first completed. General locations for necessary improvements are shown at once, and as soon as tentative specific locations for

improvement are chosen, detailed analysis of the figures, block by block, will permit a close estimate of the probable volumes that may be expected under present conditions.

4. Allowances may be readily made for changes that will come with conversion from war to peace. Travel to and from given plants or areas may be eliminated, decreased, or increased in accordance with the best judgment as to the future activity there, and moreover, the effect of the change may be traced throughout all parts of the city. Similarly, the effect may be evaluated of slackening in group riding or of the return to private vehicle from the use of public transportation enforced by war necessities.

5. Trends in travel may be gauged to some degree at least by trends in other factors such as social, economic, and occupational status. By measuring travel of residents in areas such as census tracts for which trends in other factors are regularly recorded, it will be possible to forecast the amount of travel by various modes that should be anticipated and appropriate provisions made for it.

6. Travel requirements may be measured in relation to proposed urban development. If a new area should, for example, provide within its confines shopping, social and recreational facilities, travel on arterial streets or expressways from that area for these purposes will be unnecessary. The amount of movement that will be thus subtracted from the major thoroughfares can be estimated, and due allowance made in design, not only for the artery but also for the circulatory system of the area.

Discussion of these surveys has been primarily from the viewpoint of the highway official, but the results should be of equal importance in the transit field. With the advent and growth of free wheel public transportation the interests and responsibilities of the street and highway officials on one hand and transit officials on the other have been necessarily drawn more and more closely together.

The officials responsible for the improvement of streets and highways must provide facilities as nearly as possible adequate for traffic of the volume and character expected during the life of the improvements. Obviously both the volume and character are dependent on many factors, among which policies of public transportation and city and regional planning officials are of paramount importance. Plans for street or highway improvement in urban areas will never be effectively drawn or executed without the full cooperation of all interests involved. The interests of public transportation and of over-all street and highway transportation can never be divergent. They must always be parallel. Indeed in many cases they are coincident.