Data Needs and Data Collection-State of the Practice

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In this paper, an attempt is made to examine the state of the practice in the area of data collection for travel forecasting, particularly that using behavioral travel-forecasting procedures and models. Because of similarities in data needs and data collection, the five planning areas of this conference have been grouped in this paper into three subsets: strategic and long-range planning, project and urban-microscale planning, and systems operations. The primary data-collection purposes considered are the need to calibrate, validate, and update models of the travel process and the need to provide information that can be used directly in planning or policy formulation without the intervention of a model. A secondary purpose is to provide data for improving or updating forecasts or for direct use in existing calibrated and validated models to predict current or future values. Although these are not exhaustive, they encompass the primary areas that motivate the majority of data collection and are adequate for discovering the state of the practice in data collection.

Before proceeding, it is appropriate to consider the reasons why there should be a workshop concerned with data issues and why there should be a paper on the state of the practice in data collection. First and foremost, data collection is one of the most seriously ignored areas of transportation planning. If one reviews past transportation study reports, there is rarely any mention of the data-collection procedures used as the basis of the forecasting and plan development. If there is any mention at all, it is usually as a footnote at best. There is no recognition in published transportation reports that data collection contains sampling error, nonresponse error, and the like, all of which will implicitly affect the quality of the forecasting models and the results obtainable from them. It seems that transportation planners have assumed that the clients for transportation planning cannot understand the fact that sampling errors and other measurement errors will exist and that such admission would compromise the acceptance of the planning. This may well be a correct perception, but correct or not, there has been a suppression of such information in technical reports. Although it is not clear which is cause and which is effect, there appears to be general ignorance of the effects of measurement and survey sampling error on planning and a simple formula is used that equates data quality to response rate. There is also a lack of understanding and attention to sampling and survey design issues.

Few transportation planners receive any formal training in survey sampling and survey design. Most transportation surveys are conducted by the transportation planners and technical people themselves; in very few instances are specialists used in data collection. Typically, a transportation survey is put together too hurriedly and based on someone else's design, which supposedly worked. In general, the entire attitude toward data collection is a cavalier one. Particularly in the context of the current penetration of new travel-forecasting techniques, issues of data collection have been raised in a totally new way. Transportation planners are being faced with decisions that they are unaccustomed to dealing with: questions of sample size, of special survey instruments that cannot be designed by borrowing from earlier surveys, and of models that are much more transparently dependent on high-quality data and are extremely sensitive to measurement errors. Only very recently have concerns been expressed about nonresponse bias (1,2) and the effects of this on model and general informational quality.

Another reason for a concern with data collection is that with a lapse of between 15 and 20 years since most of the major metropolitan areas in the United States undertook their original data collection for travel forecasting, there is increasing pressure to update both the data base and the models. This pressure arises both from the perception that 15-20 years without major data updates is too long a period for the original data to still be valid and from the fact that there are known to be major departures from trends clearly established in the 1950s and 1960s that implicitly affect travel behavior. The transportation professional finds it increasingly difficult to go to a hostile public hearing and defend his or her models and predictions on the basis of data this old and this far from current behavior. At the same time, there is clearly not the availability of funds for data collection that existed in the 1950s and 1960s, which made it so easy to collect large bodies of data with relatively little attention to data quality and sampling efficiency.

There is a somewhat tenuous line to be drawn between the state of the practice and the state of the art, particularly as to when one can consider that a procedure has entered into the state of the practice. In this paper, a somewhat generous interpretation--to the state of the practice, at least--is taken, so that a procedure is considered to be in the state of the practice if there is evidence of at least one use of the procedure in a practical transportation study.

As already mentioned, a difficulty arises with covering the state of the practice because there is relatively little accessible documentation of it. In the development of new procedures for data collection, documentation is provided in the research literature. Applications, on the other hand, are generally the subject of reports with limited circulation and with little publicity generated in connection with the specific project being undertaken. This paper relies, therefore, on my knowledge together with additional anecdotal information from colleagues.

DATA NEEDS

Before proceeding to discuss the individual areas of data needs, I must reemphasize a notion that should be well accepted by anyone engaged in data collection but is frequently overlooked. Data should always be collected for a purpose. Good instrument design and good methodology design can only follow from a clear statement of the purposes of data collection. In the context of planning issues, the primary generator of data needs is a modeling process or an analytical process. The data needs are therefore defined by the available models and analytical procedures. It is likely that in the following discussion, some readers will feel that there is an omission of the treatment of data needs for emerging planning areas such as strategic planning. This is unavoidable if no process exists yet for planning in such an area. Data support planning; they do not define it. Conversely, one cannot define data needs before the process that the data support has been defined.

Strategic and Long-Range Planning

The primary data needs in these context areas are for the calibration, validation, and operation of travel-forecasting models and the components of the planning process. The gradual penetration of travel-behavior models into practical planning has brought with it two significant changes in data needs: an emphasis on the collection of data about individuals instead of about zones or traffic facilities and a transparent sensitivity to errors in the data collection itself and therefore a need for much greater precision in measurement. Apart from this, the behavioral models have raised some unresolved issues and uncertainties in data needs rather than a clarification and a new, defined direction, as is discussed in the next few paragraphs. Principally, this has come about through the debate on reported versus network data and on assigning choice sets or determining reported or perceived choice sets.

In the event that one takes the position that behavioral models should be calibrated, validated, and operated on network and analyst-determined data, a position that is discussed at more length later in this paper, then the use of behavioral models does not change the basic data needs beyond the introduction of an emphasis on individuals and households and the reduction of the total data set size required. There is still the need to collect data on individual trips and to define the origin and destination in a way that permits geocoding to a zone system that relates to an existing network and also to define such items as mode or modes of travel, time of day, and trip purpose. Given current planning considerations, there is usually also a need to include occupancy of an automobile. In addition, there is some increase in the richness of the socioeconomic data collected and some difference in the definition of the specific values to be measured, such as the use of vehicle availability rather than car ownership. These changes are not due solely to the travel behavior influence; the concern with more careful conceptualization of the travel process that lies behind the behavioral models is also a primary reason for the improvement in the care and definition of socioeconomic variables. Beyond this, however, the data needs defined here are little different from those of the earliest comprehensive transportation studies undertaken in the 1950s.

If one takes the alternative position that behavioral models should be calibrated, validated, and possibly used with some elements, if not all, of reported or perceived data and with traveler-defined choice sets, then the data needs are changed quite significantly. Principally, this introduces the need to collect the type of data used in behavioral models from the individual traveler. These data are primarily the travel costs and the times of different components of the trip, such as walking, waiting, and time spent in the vehicle. In addition, the individual may be asked to identify alternative travel modes that could be used for the same trip and may also be asked to provide estimates of the values of the same cost and time variables that he or she was asked about for the chosen mode. Data on the trip purpose, the time of day, and the mode or modes of travel all remain the same as before. Although some instances exist in which joint mode and destination-choice models have been built for an ongoing transportation study (3), the major penetration of behavioral models is still into modal split only, and there is no change in the data needs generated by the destination-choice models. Indeed, one of the primary constraints often placed on the execution of a new model or models in the travel-forecasting process is that compatibility be retained with the existing data bases and with other components of the model stream, so that there is a definite limitation placed on the extent to which these models have introduced change into the data needs themselves.

Project and Urban-Microscale Planning

In many respects, the execution of project planning and urban-microscale planning still relies heavily on the same travel-forecasting models that are used for long-range planning or on parameters derived from them. For example, elasticity analysis or pivot-point procedures (4) use elasticities or coefficients from the travel-forecasting models used in long-range planning. Sketch-planning models, which may be used in the opening phase of project planning, are usually the same type or structure of model but are applied at a different level of geographic aggregation. In these respects, the data needs are the same as those described in the previous section of this paper for strategic and long-range planning.

The primary data need that has been added from awareness created by the behavioral travel models is that of attitudinal data. However, it is hard to say whether such data collection should be considered part of the state of the practice. It is true that a number of instances exist in which attitudinal data have been collected to support project or urban-microscale planning [a study of public opinion surveys by Stormes and Molinari (5), a survey by the Northeast Ohio Areawide Coordinating Agency (6), and a study by Tri-Met in Portland, Oregon (7), among others], but it is less clear whether in any of these instances the information gathered on attitudes, perceptions, or preferences has been used outside the research sphere. Nevertheless, it may be considered that the addition of attitudinal data to conventional measures of the quantity and location of travel is a change in the data needs that can be said to have derived largely from the behavioral approach to travel forecasting.

Systems Operations

In the area of systems operations, it is not clear that there has been any change in the data needs in the past two or three decades, and certainly it does not appear that any stem from the introduction of travel-behavior methodology. There are generally two components to such data needs: data on the operation of the system itself, such as speeds, delays, loadings, and capacity, and data on the manner in which the system is used by the individual traveler, although this latter component seems to have had much less importance in most studies. The major change that has occurred in the data needs for systems operations has been an increasing recognition of the need to obtain good data on the operation of existing rail and, more particularly, bus systems. These data include schedule adherence, maximum load points, load profiles by route segment and by time of day, boarding and alighting volumes, revenue generation and fare profiles, and use of transfers where available.

System use has largely been obtained by some form of intercept survey, such as roadside interviews for highway-based traffic and on-board surveys on buses. The state of the practice here seems to have changed little from the early studies and is influenced little by travel-behavior considerations. Roadside interviews still collect basically the origin, destination, purpose, time of day, and number of occupants in the vehicle. Similarly, on-board interviews have collected origin, destination, purpose, time of day, fare paid, and transfer use. Perhaps the one identifiable addition to the latter has been mode of access to the bus stop and mode of egress from the bus stop and some instances in which riders have been asked to report the time they spent waiting for a bus and the distance they traveled to get to the bus (8,9). Possibly these additional data components have arisen from an increased awareness of the behavior of people in traveling rather than from any other direct source and are needed to support the types of decisions that have become more people-oriented as a partial consequence of travel-behavior methodology.

As is discussed later in this paper, the major changes are more in the area of the sampling and survey instruments than in the data needs per se. The state of the practice in systems-operations data needs, then, has changed relatively little in the recent past and shows only a very minor influence from travel-behavior methodology.

Network or Reported Data

As mentioned previously, this is probably the major area that has affected data needs and is a direct outgrowth of travel-behavior models and procedures. Although there has been a considerable amount of discussion of the issue in various locations, it is worthwhile to review the arguments here, particularly because the controversy has not been resolved and this conference may be able to cast some further light on the issues.

Proponents of the use of network data support their position primarily from the argument that only network data will be available for forecasting, particularly for long-range forecasting, and that the lack of a systematic relationship between network and reported data, which prohibits the forecasting of reported-type data, also leads to differences in coefficient values between models based on reported and network data. Proponents of the use of reported data argue that such data are a better approximation to perceived data and are therefore behaviorally more sound. These data should give rise to more accurate and realistic coefficients, which in turn will yield more correct elasticities and pivot-point information for short-range planning applications. Furthermore, although it is recognized that the reported data cannot be forecast, the contention is that the forecasts with network data will be no more in error (and possibly less) than models using network data with network-derived coefficients.

Studies (10) based on comparisons between actual travel-time components and network-derived components have shown that network data approximate in-vehicle travel times fairly well but do not provide good measurements of other travel-time components. The extent to which in-vehicle travel times will be reasonably good approximations from network data also depends on the zoning of the region. The studies of comparisons of network and measured times are, however, incomplete, because they were based on a situation in which the zone systems in use were reasonably adequate for the size of the region. This is frequently not the case. A number of metropolitan regions have a far-from-adequate zone system. In such cases, there are serious deficiencies even in the network-generated line-haul times. Inadequate zones are defined here as ones that are too large and that therefore compromise the use of disaggregate-based models.

Specifically, when zones are too large, the approximations involved in using centroid-to-centroid travel times become large, so that many trips are allocated incorrect values of line-haul times or distances. Also, an increasingly large number of trips become intrazonal and so are removed from most of the travel-forecasting activity. An additional large number of trips will be provided with a path along one centroid connector to a common node on the highway or transit network and then along the next zone's centroid connector; thus they have no impact on the networks and also receive times estimated only from centroid connectors. I encountered problems of this nature in building models for the Oahu Metropolitan Planning Organization. The island of Oahu, which has a population of more than 850 000, is divided into 159 zones; some of these are as large as 15 $miles^2$ in area. Regionally, more than 20 percent of the trips are intrazonal. In addition, when the networks for highway and transit are built as independent networks, there are tremendous opportunities for severe inconsistencies to arise between the two networks, which may generate incompatible travel times from the two networks. This produces numerous outliers in the calibration data for the modal-choice models. In the same case, initial attempts to build disaggregate mode-choice models from network data produced counterintuitive positive signs for in-vehicle travel time, because the highway network (independent of the transit network) ran at too high a speed.

Although studies of the relationship between network and reported values do not appear to abound, those that have been undertaken do not provide evidence of a consistent, mathematical relationship. Rather, to the extent that relationships have been shown to exist, they indicate that there are both random and nonrandom elements to the relationships and that there are significant differences in the relationships for the travel mode used and travel modes not used and whether one is an automobile user or a transit rider; for example, values of variables like times and costs are underestimated on the mode used and overestimated on other modes (11). Such patterns of response will certainly give rise to differences in coefficient values between the use of reported data and either measured or network data. More seriously, however, network data have been shown to do a consistently poor job in providing estimates of variables such as walking and waiting times, parking costs, etc. Coefficients for such variables are likely to be severely compromised because of the lack of variance from zone-based data and the existence of large variances within the zones.

There has been no resolution of this controversy to date. Applications of behavioral models have used network and reported data with almost equal frequency. Proponents of each alternative remain unconvinced of the merits of the arguments in favor of the alternative approach. Empiricism has been unable to establish a clear direction in this area of data needs, and although theory provides direction, there are conflicting theories and they point in different directions. Nevertheless, empiricism may well hold the eventual answer to the dilemma. Given the disarray of theory on this issue, the resolution probably depends on a sufficient lapse of time to be able to test the goodness of forecasts from the alternative procedures. For this, careful design of comparable models is required for several study areas. Using both types of model in forecast situations and comparing the performance once the forecast time is reached would provide much useful information to resolve the issue. It is to be hoped that some metropolitan governments will have both the temerity and the unusual perspicacity to build models both ways and subject them to the test.

A similar situation exists with respect to choice-set definition. Two alternative procedures are considered--allocation of choice sets by the planner and reporting of the choice set by the traveler. To a large extent, the arguments for either approach are very similar to those raised for network versus reported data. In this case, the controversy concerns the definition of the modes available to a traveler for a disaggregate-choice model. The allocation method is usually executed by the analyst or planner, who allocates all modes to individuals in a given zone simply by whether the network indicates that there is a path available by the mode for the specific trip interchanges of individuals in the zone. The alternative is to ask individuals in a survey what modes they have available and to allocate accordingly. Thus, if an individual indicates that two-occupant and three-occupant automobiles are available but not one-occupant automobiles, even though he or she is from a household that has one or more cars and has a driver's license, only those two automobile alternatives would be assigned. The presence of one or more automobiles and the respondent's having a driver's license would lead the analyst to allocate all automobile modes. Two problems arise from this. The first is the danger of allocating alternatives to individuals who are in fact captive. The potential errors introduced by this have been described elsewhere (12). The second problem is simply that of identifying too many people as having certain alternatives available, which biases the model constants and potentially biases some coefficients, because an alternative that seems to the analyst to be widely available is not and therefore is chosen far less often than would appear warranted by the comparative level-of-service data.

As with the network and reported data, the controversy has not been resolved. Also, like that debate, much of the debate on allocated versus reported choice sets revolves around the issue of ability to forecast choice sets and the effects of using alternative definitions for calibration and forecasting, where the two definitions are likely to be inconsistent.

DATA COLLECTION

Strategic and Long-Range Planning

Probably the central data-collection activity involved in support of strategic and long-range planning is the survey of individuals and households to amass information on travel characteristics around the study region. As described in the section on data needs, the primary application of data in this context is for calibrating, validating, updating, and applying travel-forecasting procedures. Traditionally, the mechanism for such data collection has been the home-interview survey. Principally for reasons already discussed in this paper, there is a need to consider improvements to data collection in this area and to determine why some changes have begun to appear on a limited basis. Most instances of the collection of the standard 24-h travel data still rely on the same data-collection methodology that has been used since the 1950s. However, the amount of data collected for each trip is frequently too little for the purposes of current models and policy needs, the home-interview process is too expensive for the budgets available, the sample sizes used in the 1950s and 1960s also are too large for current budgets, and the methods produce too many errors that are no longer so easy to assume away or lose in the aggregation process. Concerns, too, with specific population subgroups in impact analysis have tended to show up deficiencies in much of the traditional data collection, so that the planner finds too little data available about key impact groups, such as the elderly, the handicapped, and the poor. Clearly, change is needed in the procedures, but too little change is evident in the practice.

Those changes that have occurred in this area of methodology are largely by nature of experimental applications of modified or different procedures, and there is as yet no consistent new methodology that has been applied. There are several areas in which such experimental changes have occurred, namely, sampling procedures, sample sizes, survey-instrument design, administration of the survey instrument, and reduction of data to machine-readable form. Although this may seem to embrace all possible areas of survey activity and to cover all areas of survey work, whether strategic, long-range, project, microscale, or operations, the specific applications of these different elements are extremely limited in occurrence and in context area. Those that have been applied in the specific context of strategic and long-range planning are described in this section of the paper, but somewhat briefly, with the idea of illustrating the types of changes that have come about.

The traditional home-interview survey was applied on a systematic or random sample, usually generated from some available list of households in the study region, or by a simple method of field sampling (13). Probably the advent of specialized sampling for the initial research activity in developing behavioral models was responsible for the discovery of alternative sampling methods. Many of the research studies used a technique that was subsequently labeled "choice-based" sampling and introduced sampling notions that departed radically from simple random samples. With this and the development of alternative administration procedures and instruments, as described later in this section, new methods, such as two-stage samples, stratified samples, and cluster samples, began to be used for transportation surveys (14-16). Increasingly, there seems to be a move away from straightforward simple random samples that has grown out of the realization that such samples are not very efficient, particularly if any supplementary information is available about the population from which the sample is to be drawn; this change has been coupled with another change, discussed below.

The second change that is beginning to percolate into transportation surveys is a change in the sample sizes. Several factors are coming together to produce a change in sample size. First, there are economic pressures to reduce sample sizes; it is no longer possible to contemplate undertaking household surveys on the sample sizes that were used in the first generation of long-range transportation-planning studies. It has been suggested that these sample sizes may well have been used simply because the money was available to pay for them and it seemed reasonable to spend the money that way. Now the money is no longer available, but there are perceived needs to gather new data. Therefore, smaller and more efficient samples are needed. Second, there has been a slow, possibly reluctant, recognition that the first generation of major transportation surveys provides supplementary information on which much smaller sample sizes can be calculated (17). This has required the recognition that the large sample sizes (2-6 percent) of the first-generation studies were defined at that size because of ignorance about the inherent variances in the variables of concern. Although model fit may not be the reason for choice of a sample size (which may be far more an issue of available budget), it is still the case that model fit is used to justify the use of a particular sample size. Thus, a frequent justification of the large samples of the 1950s and 1960s was that they were necessary to obtain nonzero estimates in most of the cells of a trip matrix that might contain 500 000 cells (700 by 700 zones). This was considered of paramount importance because it was mistakenly thought that the calibration of the models in the travel-forecasting procedure relied on this trip matrix. This is not the case, although it is still misperceived by most transportation planners. For example, the gravity model of trip distribution is not calibrated on the trip matrix but only on the trip-length distribution. Hence, there is a need to rethink the purposes of the data and to understand better the way in which calibration and forecasting make use of the data.

The third factor in sample-size change is that it has become clear that the disaggregate models do not need the large sample sizes of the aggregate models. Samples as small as 300 individual trips have been found to be very satisfactory for statistically good fits (18). In contrast to the first-generation samples of 20 000 and more households, which made as many as 140 000 trips in a 24-h period, these are indeed small samples. Fourth, it has been recognized that more sophisticated methods of sampling, such as stratified samples, are capable of producing as much information on regional travel as samples of considerably larger size that are based on simple random or systematic sampling (14). Thus, for a combination of reasons, smaller sample sizes are coming into use and there has been a concomitant improvement in understanding of the implications of sample size and recognition of the sampling error.

The third area of change is in the survey instrument designs themselves. Of particular note here is the increasing interest in a travel diary for collecting the traditional 24-h travel data (19). To my knowledge, travel diaries have been used in a few recent surveys, specifically in Broward County, Florida, in Southeast Michigan, and in Honolulu, Hawaii. Although the travel diary is by no means a new technique, there are design differences and differences in the method of administration in these instances that seem to have contributed to a marked change in the success of the travel diary. The primary issues raised by the travel diary are that of recall versus active completion and the question of whether the diary itself may modify travel behavior. A marked difference found in the three applications of the diary noted above is that the proportion of non-home-based trips is much higher than that recorded in recent surveys and is also much higher than would be expected just from the known travel adjustment of increased trip chaining. Traditional recall surveys were known to be low on non-home-based trips, and it was generally necessary to factor these trips upward by as much as 20-30 percent based on screen-line counts. Even after such factoring, it appears that the reporting of non-home-based trips may have been too low, perhaps because many of them are relatively short and would not be picked up by screen-line counts. Nevertheless, it still seems likely that people will omit a certain number of trips, either because they cannot be bothered to give a complete accounting of their trips or because they do not wish to reveal some trips.

Another change that has occurred in survey instrument designs, in a few cases, is the omission of coding blocks, which used to be very much in evidence on many of the traditional survey forms. There are two reasons for this. First, changes in administration, discussed in the next paragraph, have focused more and more on the self-report or self-administered survey. It has been recognized that the existence of coding blocks on such survey instruments is deleterious to response and has a strong negative impact on potential respondents. Second, changes in data-reduction methods, discussed in the succeeding paragraphs of this section, have eliminated the need for coding blocks as an interim measure in the transfer of data from the survey form to the computer. Indeed, it has become clear that a careful redesign of most survey instruments can accommodate the needs of data reduction as easily as they can increase the propensity of potential respondents to complete the survey form. There are some further changes in survey instrument designs that have arisen from increasing use of self-report procedures and that have been made easier by the increasing sophistication and flexibility of printing processes. This should not lead the reader to suppose that all survey instruments are now designed in such ways. It is rather the case that there are a few instances in which such instruments have been used. Unfortunately, there are still too many instances where good instrument design has not found its way into practice; the result is that response rates are often too low and that transportation surveys gain a bad reputation because of the difficulty of completing them and the adverse publicity that accompanies such poor designs.

The primary change in the administration of transportation surveys is in the use of procedures other than the home interview. This is not to say that there is anything inherently wrong in the home interview; it is more the case that the home interview has become too expensive for continued use in transportation surveys and is also an inefficient procedure for very small but widely scattered samples. Whereas early transportation studies for long-range or strategic planning relied totally on the home-interview survey for the major data base on person travel, more recent efforts have used a variety of alternative procedures.

Perhaps the most commonly used procedure that has been introduced more recently is the telephone interview. This may be used either on its own or in conjunction with some other form of survey. For the Bay Area Rapid Transit (BART) studies conducted by the University of California (20), telephone interviews formed the basis of the data collection. There are also some instances in which other types of survey administration have been used. In Southeast Michigan (16), a home interview was used to collect attitudinal and socioeconomic information, whereas a self-administered travel diary was left by the interviewer for subsequent pickup. In Honolulu County, a telephone survey was used as a sampling device and a means to gain cooperation from households and was followed by an extensive mail-out, mail-back survey, which achieved a high response rate of more than 60 percent usable responses (21).

The notion of a telephone survey as a sampling device deserves some elaboration. A random sample can be drawn very easily from a region by using random-digit dialing (RDD). This procedure uses a random-number generator to produce random four-digit numbers that are attached also at random to the three-digit exchange prefixes used by the telephone company in the study area. Various methods exist for making this procedure efficient while preserving randomness, but they are not germane to this discussion. Once these telephone numbers have been generated, each number is called until answered or up to a prespecified number of times. From an interview conducted at that time, details about the household contacted can be determined, and these details can be used to sample households by characteristics for a secondary survey. In the case of Honolulu, for example, an RDD telephone survey was used in which the telephone interview lasted for less than 5 min. The interview ascertained, among other things, the household size, vehicle availability, and mailing address. A mail survey was then sent to households in specific categories of household size and vehicle availability only. A similar administration procedure was used in Broward County, Florida, earlier but with somewhat less success in terms of response rate. Nevertheless, both telephone and mail-back surveys appear to be finding use in transportation surveys for primary data bases of person travel.

Again, these changes can be seen to be linked to a number of the earlier ones. One primary impetus to changing the administrative procedures is the same economic one that has helped to increase consideration of the smaller sample sizes. In turn, smaller sample sizes with a representative geographic distribution generate problems of efficiency with home-interview surveys. The extent to which behavioral travel-forecasting procedures have been the catalyst for these changes is not clear, but there definitely is some relationship, given the changing data needs of the behavioral models and the better understanding of the effects of sample size that have accompanied these models.

Finally, in the area of data reduction, the primary improvements that have come about are related to technological improvements in computer software ahd hardware, which have generally made the 80-column card obsolete as the data medium. Direct-to-disk data entry frees the data-entry task from the limitations of an 80-column format and the need to repeat person or household identifiers on each 80-column card. Instead, it is possible to produce data formats of varying lengths that can usually accommodate an entire survey form. Also, entry grids on CRT displays provide a means to reduce the keypunching error and remove the need to identify for the keypuncher the fields in which data are to be entered. These and similar improvements allow a careful designer to structure a survey form that can be keypunched directly, without any intervening coding step, either on the survey form or to coding sheets. As mentioned earlier, this has led to reducing the clutter of the survey form as well as to improving the accuracy of data recording by removing the coding and transfer steps, each of which adds error to the computer record.

Apart from these various changes, the state of the practice continues to rely on methods of data collection and design that have been in use for more than the past two decades, including such items as roadside interviews, spot counts, and transit patronage estimates derived usually from farebox revenue. As is noted in the next sections of this paper, many of the changes in other aspects of data collection that have been described here are not limited to long-range and strategic planning but are used in other planning applications as well.

Project and Urban-Microscale Planning

In many instances, short-range planning activities--project and urban-microscale planning activities--rely on data bases collected as part of the long-range or strategic planning effort. Relatively little data collection is undertaken directly for these activities unless it is to update an old data base or to provide some much finer detail than is available in the regional data base. In those cases in which some updating may occur, it is likely to take one of two forms--collection of data of an identical format to the long-range data collection but at a more detailed level and in a geographically concentrated area or collection of specialized data from the project area for specific analytical procedures to be used on the local area. In this second case, one is most likely to come across the collection of attitudinal data, as discussed in the section of this paper on data needs.

Similar to the long-range and strategic planning situations, the primary differences likely to be found in short-range planning reside in the sampling procedure, the sample size, the administration of the survey, and the design of the survey instrument. For reasons similar to those discussed in the preceding section, sample sizes are likely to be relatively small and the sampling procedure is unlikely to be a simple random sample. The reasons behind the selection of an alternative sampling strategy are more likely to reside in the unavailability of a suitable sampling frame, restricted to the geographic area of concern or the impact group of concern, and in the ease with which an alternative sampling procedure can be applied. For example, in dealing with a project that might involve changes in bus service, it may be of greatest interest to obtain attitudinal data from those using the existing bus service. Therefore, a sampling device, such as an intercept survey on the bus, is likely to be the sampling and administration mechanism. In another case, it may be desired to sample those people in a specific geographic area where a project is planned such as reserving a freeway lane or undertaking highway widening or upgrading. In such a case, a sampling mechanism might be the selection of those telephone exchange codes that correspond to the geographic area of concern and then an RDD procedure on the telephone numbers in those exchange codes.

Survey administration in such a case is much more likely to use mail, telephone, or other self-reporting techniques for the data collection. For example, in surveys in Florida concerning the impacts of service withdrawal of buses, residents of several localities were contacted by telephone by RDD and by a telephone interview, whereas current bus riders were sampled by using on-board, self-report survey instruments (22).

Other types of project or urban-microscale data collection include various forms of intercept surveys, such as roadside interviews, and interviews at parking locations, places of work, shopping centers, etc. For some of the planning activities for downtown people movers (DPMs), data have been collected from those most likely to use or be affected by the DPM by interviewing or distributing self-administered survey forms at downtown businesses. The state of the practice, therefore, includes a number of specialized data-collection activities that use a variety of administrative procedures. Sampling for these surveys has not changed much in the past decade; the sampling itself relies on random arrivals or simple random selection of sites. Frequently, the attitude is encountered that representativeness is not of great concern because of the specialized nature of the project for which data are being collected. This is a somewhat dangerous position to take and has led to something of a cavalier approach to most aspects of the sample design and sample-size determination for these surveys.

Systems Operations

Although there are a number of different aspects of data collection that may be encountered for systems operations, the principal one discussed in this paper is the collection of data from system users, which may be used to describe system operation or to diagnose problems with the system (23,24). In practice, two primary types of data collection are likely to be found. The first is an intercept survey of system users occasionally, but not usually, backed up by some type of survey of nonusers. The second is a purely observational survey, such as a street-corner bus-passenger count or a fare profile survey. The practice in such surveys has changed little in the past one or two decades. Sample-size determination has become a little more sophisticated; more attention is paid to the possibility that one may be able to expand full system data from a sample that does not cover, for example, all routes in a bus system. Nevertheless, much of the current state of the practice relies heavily on much larger samples than are justifiable from statistical grounds. Collection of data for Section 15 reporting to UMTA still specifies a far larger sample and far more extensive data collection than is warranted from any reasonable assessment of sampling errors and needed accuracy of reporting (25). The form of the survey has also changed very little. The primary method used is still either to hand out to riders a self-administered survey form to be returned on the bus or mailed back later or to use survey personnel to record specific data about the system operation. This is not so much to say that there is anything inherently wrong in these methods as it is to say that the state of the practice in these areas has changed little for some time, and there is no apparent use of some of the more interesting and exciting procedures that have appeared recently in the state of the art (Brög and Ampt in a paper in this Report).

NONRESPONSE

It is somewhat surprising that only very recently has any real concern been expressed by transportation professionals over the potential biases injected in any data-collection effort by nonresponse (1,2,26,27). In past documentation of transportation surveys, it is frequently very difficult, if not impossible, to determine what the nonresponse level was on any particular survey--it simply was not reported. Concerns that were raised with nonresponse were largely to defend a priori a specific choice of survey method, and the nonresponse to a home-interview survey, in particular, was frequently reported incorrectly and far too favorably to the home interview. As noted by Sheskin and Stopher (28), the home-interview survey rarely counted addresses that could not be found, vacant addresses, frequent no-answers, demolished residences, etc., as nonresponses, although all of these categories lead to a nonresponse count in mail-out surveys.

Much more important than this distortion between alternative surveys, however, is the fact that little attention has been paid to determining the extent of nonresponse in any executed survey and then establishing the degree to which there is evidence of a bias caused by nonresponse. Brög and Meyburg (1,2) have provided evidence that nonresponse exists in transportation surveys and that even a very small nonresponse percentage, which may have been dismissed as trivial, may have a profound biasing effect on the data. Stopher and Sheskin (28) have shown that some rather inexpensive designs can be employed in surveys to establish the potential existence of nonresponse bias and to allow some degree of correction for it. Slowly, these ideas are beginning to appear in practice. In Dade County, Florida, calculations were made of the nonresponse bias between two parts of a survey instrument--an on-board form and a mail-back form--and used to modify the expansion factors to expand the data to systemwide application (30). The fact remains, however, that nonresponse is of apparently little concern to most of those involved in transportation data collection, and overt procedures to minimize it and to compute the effects of nonresponse bias on the data are few.

PILOT SURVEYS

A second area that has been neglected in transportation surveys is that of the well-designed pilot survey (29). It has long been a mainstay of good data collection in the social sciences and in statistical survey activities, yet too frequently the agencies involved in transportation planning are in too much of a hurry to do their data collection to allow time for a comprehensive pilot survey and frequently will not allow adequate budget to undertake such an essential element in the design process. It is not the intent of this paper to explore and document the benefits to be gained from a pilot survey. These are well documented in much of the survey literature (29,30) and the specific benefits of some case studies in transportation have already been documented (31). Suffice to say that the interests of collecting the right data for a specific need, to ensure that concepts are being measured accurately and appropriately, to ensure that the profiles and analyses to be obtained are derivable from the data, and to explore the effects of design and questioning on response rate, understandability, etc., can only be served by an adequate pilot survey. In this sense, the pilot survey should be a complete rehearsal of the entire survey activity, not only in terms of administration of the survey instrument, but through the analysis and tabulation steps as well. The pilot survey should also be administered to a sample that is drawn from the same population as the main survey sample and should not be a simple test on people drawn from a totally different population.

Of course, such a pilot-survey effort as is described here requires a considerable amount of additional time and effort beyond that of the fielding of the primary survey. Yet there can be no certainty that the data collected are reasonable and meaningful without it. Therefore it is of the greatest importance to conduct such a pilot survey. Again, this is not the current state of the practice except in a very few instances. To my knowledge, such pilot surveys were conducted for the Dade County on-board bus survey; for the Southeast Michigan regional travel survey; for the surveys in Honolulu, Hawaii, in 1981; for the Baltimore disaggregate data set; and for the data collection in Broward County, Florida, in 1980. However, these appear to be most of the cases in which a careful effort has been undertaken to execute a pilot survey. In contrast, in the same time period, a larger number of transportation surveys have been undertaken in which either no pilot survey was undertaken or such a minimal pilot survey was done as not to warrant the name.

CENSUS DATA

A final area of concern that seems warranted in a paper of this nature is the use of and relationship of planning to the decennial census data. Lengthy treatments of this issue have appeared elsewhere, so only a brief treatment is offered here. First, the census offers an invaluable resource of socioeconomic data that is needed to complement much of the specialized data collected for planning. This is widely recognized and does not need elaboration. However, two recurrent problems arise: the timeliness with which census data are provided (often two or three years after collection for the most basic data and longer for the more intricate tabulations and cross-tabulations) and the suppression of data when the number of units in a census tract, or other unit, becomes small. In many urban areas, where traffic-analysis zones represent subdivisions of census tracts, the suppression of census data for reasons of confidentiality may rob the planner of much data of value.

Second, the transportation data collected in a sample are largely incompatible with traditional transportation planning data and models. This is so despite the repeated attempts of professional planners to inform the Bureau of the Census of the definitions and data items that would be of most value. For example, the census collects data only on the main mode of travel, whereas the transportation planner typically needs information on all modes used but also has a carefully constructed definition of main mode that does not correspond to the census definition. Also, the census collects data only on the average journey to work, whereas the transportation data base contains all journey-to-work data for a survey day. Thus data on second jobs and multiple trips to work are not available from the census. The census provides no information on other activities on the journey to work, such as dropping a child at school, and the census assumes that the journey to work is a home-based work trip. This will not be the case in a number of instances, so the data do not fit into the usual purpose categories used by the transportation-planning process. These are a few of the problems that arise with census data.

The problems with census data are not insolvable but do require a willingness to listen on the part of the designers of the census survey instruments. In the meantime, there is much scope for the creation of survey activities in a census year that can be used to augment the census data and correct some of their shortcomings. Specifically, collection of enriched samples from periodic highway counting programs, running on-board bus surveys, and some limited interview surveys provides the means to create a much richer resource out of census data. This is a direction that has been pursued by some agencies, for example, the Florida Department of Transportation. They mounted a Cenval Project for 1980, which sought to do exactly what has been described in this section. More work in this direction in the future would be highly productive.

CONCLUSIONS

The primary conclusion to be drawn from this paper is that there is an extremely large gap between the state of the practice and current knowledge in the area of data collection and that there has been only a very slow percolation of new procedures and information into transportation planning applications of data-collection procedures. This apart, the paper should serve to raise a number of issues.

First, there are some issues that have not been resolved with specific concern to behavioral models of travel demand. These issues are what data should be collected to support the calibration of such models--reported or network data--and how one should define and collect data on choice sets for these same models.

Second, there is a need to remove much of the complacency or indifference that exist with respect to data collection and the designs attendent on it. Data collection is essential to various aspects of transportation planning. Yet it is also an increasingly expensive activity that must compete for what has been for some time a steadily shrinking budget for planning. It is therefore more critical than ever that advantage be taken of reducing sample sizes by the use of different sampling schemes and by utilizing the information inherent in previous data collection.

Third, it is necessary to recognize that the best and most effective data collection is finely tuned to the principal purposes of that data collection. All-purpose surveys, frequently talked about by transportation professionals, are basically impossible to achieve but are capable of consuming vast amounts of money in the attempts to execute them.

Fourth, there needs to be an awakening to the problems and pitfalls of nonresponse. Transportation planners, in particular, need to recognize that the likely nonrespondent is the least mobile individual. As such, this is the person most likely to be affected by many transportation policies and activities but on whom the effects are unknown because no reasonable attempt was made to gain information from that individual. There are many methods available to deal with nonresponse, but too often the attitude holds that even a 30 percent nonresponse rate indicates nonexistence of nonresponse bias. Finally, there is too little effort accorded to the design and conduct of pilot surveys. Some of this, it is recognized, has arisen from rules and regulations promulgated by the U.S. Office of Management and Budget, where well-meaning rules to prevent repeated and unnecessary surveys also tend to prohibit a well-designed and executed pilot survey. But much still lies at the door of transportation planners who have failed to recognize the benefits to be gained from good pilot surveys and who also persist in viewing pilot surveys as having no purpose other than to test alternative survey instruments. Furthermore, there is too often a lack of adequate time to plan and design a survey. Surveys are undertaken in the context of requiring the entire effort to be concluded in five or six weeks. Such short time frames prohibit adequate design of samples and instruments, prevent the execution of pilot surveys, and do not allow high-quality printing and instrument presentation to be obtained. These are false economies. The effects on data quality of a good survey design are well documented in the survey literature but are studiously ignored by transportation professionals.

Perhaps the most important requirement for good data collection is for the transportation profession as a whole to recognize that there is an extensive discipline of survey design and execution and that undertaking a survey is neither a diversion nor a game. It is a serious concern that has wide-ranging impacts on policy and planning. Surveys also represent a point of contact between the transportation professional and the public at large. In this respect, bad surveys can do irreparable damage to relationships with the public. This, in turn, can undermine the acceptance of the products of planning.

In sum, there is a significant gap to be filled between theory and practice and solid and significant gains to be obtained in transportation planning by closing those gaps in data collection.

Before the conclusion of this paper, it is possibly worthwhile to raise one further issue. In the United States, it is no longer clear what the role of planning is likely to be. New federal approaches to planning seem likely to change that role significantly. If the decision to undertake transportation planning is left to the states and regions alone, it is not clear that there will be much transportation planning in the short-term future in many parts of the United States. In this case, of course, much that has been said here becomes academic. Alternatively, the reasons for planning and the way it is done may come under much closer scrutiny by those outside the profession. In this case, it will become even more important that many of the issues discussed here be dealt with effectively.

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Research Needs

1. Improved documentation of data-collection efforts

2. Forums for information exchange to assure data compatibility and professional understanding

3. Coordination among data collectors at various levels of government (at the federal level would include removal of barriers such as the OMB regulation that prohibits repeat surveys of the same individuals)