TRANSPORTATION RESEARCH

RECORD

No. 1463

Planning and Administration

Travel Behavior Analysis, Telecommuting, and Public Participation

A peer-reviewed publication of the Transportation Research Board

TRANSPORTATION RESEARCH BOARD
NATIONAL RESEARCH COUNCIL

NATIONAL ACADEMY PRESS
WASHINGTON, D.C. 1994

Transportation Research Record 1463
ISSN 0361-1981
ISBN 0-309-06070-2
Price: $23.00

Subscriber Category
IA planning and administration

Printed in the United States of America

Sponsorship of Transportation Research Record 1463

GROUP 1—TRANSPORTATION SYSTEMS PLANNING AND ADMINISTRATION
Chairman: Thomas F. Humphrey, Massachusetts Institute of Technology

Transportation Forecasting, Data, and Economics Section
Chairman: Mary Lynn Tischer, Virginia Department of Transportation

Committee on Traveler Behavior and Values
Chairman: Ryuichi Kitamura, University of California at Davis
Julian M. Benjamin, Chandra Bhat, Elizabeth Deakin, Thomas F. Golob, Konstadinos G. Goulias, David T. Hartgen, Greig W. Harvey, Joel L. Horowitz, Dane Ismart, Peter M. Jones, Lidia P. Kostyniuk, Clarisse V. Lula, Hani S. Mahmassani, Patricia L. Mokhtarian, Alan E. Pisarski, Panos D. Prevedouros, William L. Schroeer, Frank Southworth, Peter R. Stopher, Mary Lynn Tischer, Cy Ulberg, Martin Wachs, Edward Weiner, Jeffrey M. Zupan

Committee on Telecommunications and Travel Behavior
Chairman: Patricia L. Mokhtarian, University of California at Davis
Robert J. Aiken, Moshe E. Ben-Akiva, William N. Feldman, Lewis M. Fulton, Gil E. Gordon, Konstadinos G. Goulias, Edward L. Hillsman, John B. Hopkins, Arto S. Keklikian, Ryuichi Kitamura, Lidia P. Kostyniuk, Hani S. Mahmassani, John S. Niles, Ram M. Pendyala, Joanne H. Pratt, Daniel B. Rathbone, Ed M. Risse, Ilan Salomon, Daniel L. Schierer, Elham Shirazi, Edward K. Uchida, Cy Ulberg, Carina Van Knippenberg, Ellen Williams, Fred L. Williams, William Young

Transportation Systems Planning Section
Chairman: Bruce D. McDowell, U.S. Advisory Committee on International Relations

Committee on Transportation and Land Development
Chairman: Elizabeth Deakin, University of California
G. Bruce Douglas III, Frederick W. Ducca, Robert T. Dunphy, Z. Andrew Farkas, Ralph Gakenheimer, Katherine L. Gerwig, Jonathan L. Gifford, Gideon Hashimshony, Mary R. Kihl, R. Ian Kingham, George T. Lathrop, Roger Laurance Mackett, Norbert Oppenheim, Jeffrey A. Parker, Poulicos Prastacos, Richard H. Pratt, Noreen J. Roberts, Darwin G. Stuart, W. T. Watterson, Debra Ann Whitmore

Committee on Citizen Participation in Transportation
Chairman: Marilyn Skolnick, Port Authority of Allegheny County, Pennsylvania
Secretary: Janet Bell Stromberg, Jefferson County Planning Department
Levi M. Cary, Dawn Doyle, Joel P. Ettinger, Paula J. C. Hammond, Sandra Echols Hayes, John Holtzclaw, Julie Hoover, Robert C. Johns, Florence W. Mills, Marion R. Poole, Heidi J. Stamm, Juhani Tervala, Erskine S. Walther, Lynda S. Webster, Alan C. Wulkan, Alexandra Zetlin; Kathleen E. Stein-Hudson, Liaison Representative

Public Transportation Section
Chairman: Subhash R. Mundle, Mundle & Associates Inc

Committee on Specialized Transportation
Chairman: David L. Lewis, Hickling Corporation
Jon E. Burkhardt, Betsy Buxer, David J. Cyra, Manuel de Alba Perez, E. Philip Doolittle, Douglas B. Gurin, Paul N. Hale, Jr., Patrick H. Hallett, Lawrence J. Harman, Katharine M. Hunter-Zaworski, Jo Ann Hutchinson, F. Ron Jones, Ira Laster, Jr., Barbara Cahill Melendez, Philip R. Oxley, Patrisha Piras, Sandra Rosenbloom, Lalita Sen, Michael K. Shipp, Agneta Stahl, S. Lng Suen, Margaret L. Young

Transportation Research Board Staff
Robert E. Spicher, Director, Technical Activities
James A. Scott, Transportation Planner
Nancy A. Ackerman, Director, Reports and Editorial Services
Naomi Kassabian, Editor

Sponsorship is indicated by a footnote at the end of each paper. The organizational units, officers, and members are as of December 31, 1993.

Transportation Research Record 1463

Contents

Foreword

The papers in this volume focus on work and residential location and work trips, paratransit services and costs, telecommuting, and public participation.

Watterson shows results of high levels of residential and workplace location changes, connections to reductions in home-to-work distances for long work trips, and shifts in the usual travel mode to work, especially out of transit and carpooling and particularly for women workers. Koffman uses two case studies to illustrate three issues connected with recovering the cost of ongoing trips and a cost allocation needed for services to determine fixed and variable components of the costs of eight different types of service.

In the three papers on telecommuting, Lund and Mokhtarian deal with the effects of telecommuting on work trips, Yen et al. discuss employer attitudes and preferences toward telecommuting, and Salomon forecasts telecommuting in Tel-Aviv in 2020.

There are four papers on public participation: Prevedouros et al. focus on the interactive visualization of traffic impacts as a technique for presenting traffic impacts to an audience of nonexperts; Unsworth discusses development of a new process intended to minimize transportation controversies; Hoover reviews progress to date in establishing public participation under the Intermodal Surface Transportation Efficiency Act at the metropolitan level; and Balog et al. review the public participation process under the Americans with Disabilities Act of 1990 (ADA) and the development of an ADA public participation handbook.

Dynamics of Job and Housing Locations and The Work Trip: Evidence from Puget Sound Transportation Panel

W. T. WATTERSON

Residence and workplace locations are the defining elements for the work trip. However, until recently both have been treated in theoretical and empirical research as static determinants instead of being recognized for the numerous locational changes that occur every year. Many such changes can be viewed as adjustments to housing and commuting conditions. Panel surveys can provide data bases suitable for analyzing such adjustments. The Puget Sound Transportation Panel (PSTP) was used to draw household and worker samples for exploring the magnitude of locational changes and their effects on home-to-work travel behavior. Descriptive analysis indicated no strong evidence of bias as a result of panel attrition. Results showed high levels of residence and workplace location changes, connections to reductions in home-to-work distances for long work trips, and shifts in the usual travel mode to work, especially out of transit and carpooling and particularly for women workers. The PSTP data base is evaluated for its ability to support further dynamic demographic analysis.

Researchers in travel behavior have long been interested in residential and workplace locations as the defining elements in the home-to-work commuting distance and the choice of travel mode to work. Similarly, urban economists have sought to explain the spatial structure of metropolitan areas through the choices of residential (and work) locations with respect to the work trip. Both lines of inquiry have continually been frustrated by the theoretical complexities of multiple employment centers and chains of trip purposes and by empirical problems of limited data bases. However, both also suffer from the changes that individual workers are constantly making in their residential locations, their workplaces, and their travel modes. These changes are surprisingly numerous and may be viewed as adjustments to personal and travel conditions faced by the workers on a day-to-day basis.

The relationship between residential location choice and the work trip has long been recognized, analyzed, and modeled; it is the foundation for urban travel modeling. Much of the literature on household moves, however, has been concerned with the reasons for the move (*1*) or economic or public-sector choice variables (*2*). For travel analysis, the residential location was either a static given or a dependent variable to be predicted from travel conditions. Lerman (*3*), McFadden (*4*), and Anas (*5*) started modeling residential location as a joint dependent variable with travel choices. Anas (*6*) has developed dynamic models that incorporate location changes but has found data bases insufficient to make the models operational.

Workplace location and travel behavior have been extensively studied, but more from the perspective of transportation supply (transit service, parking costs) and public policy (demand management) than from a choice perspective (*7–9*). The following are the questions that have been raised: What characteristics of workplace locations are associated with what travel behavior by workers? What changes in those characteristics can induce changes in their behavior? The modeling of workplaces has mostly involved the selection of locations by firms, not by workers. Choice and changes of workplace locations by workers has only begun to surface in the urban economics literature (*10–13*).

There is also the normative issue of the balance between jobs and housing, which is under debate in land use and transportation planning circles. The issue involves using public policy to encourage or force additional housing in areas dominated by jobs, and vice versa, such that more opportunities would exist for shorter commutes and use of nonmotorized modes. It is policy based and begs the theoretical and empirical questions of individual choices of residences, workplaces, and modes. Giuliano (*14*) concluded a review of the jobs housing issue with the assessment that the policy bears only a tenuous relationship to the transportation problems it purports to address.

On the empirical side, most analysis of these questions has been conducted using cross-sectional data from such large-sample surveys as the Census Transportation Planning Package, the American Housing Survey, and the Nationwide Personal Transportation Survey. Much of the working wisdom on trends in work trip lengths, mode choices, and congestion levels derives from analysis of these data bases (*15,16*). These surveys, plus localized worker surveys on travel behavior, often in a before-and-after format, confirm the static or slowly changing travel characteristics that are typical results from repeated cross-sectional surveys (*17*).

Only recently has the perspective of worker changes emerged as a key element in travel behavior research. Zax and Kain (*13*) defined moves and quits as the equilibrating mechanisms for inefficient or suboptimal commutes. Gordon et al. (*18*) used worker changes as the fallback explanation for anomalies in commuting times in a large cross-sectional survey. Commuting is viewed as the critical link in spatial equilibrium for workers. The out-of-pocket costs and time spent in commuting to work absorb money and time that could be used for housing consumption, productive work, or leisure. Inefficient commutes—too long, too short, or by the wrong mode—impose excess costs on workers. Too short a commute is one for which the worker's housing consumption is suboptimal such that a longer commute could improve the worker's utility. Moves to more appropriate residences, changes to more convenient workplaces, and switches to more efficient modes are individual remedies for inefficient commutes.

But to analyze or model such behavior empirically, there must be a data set on individuals' actions over a period of time. Such a data

Watterson West Group, Inc., 1121 23rd. Avenue East, Seattle, Wash. 98112.

set is likely to be drawn from a panel survey, in which observations are made repeatedly from the same sample. Panel surveys have become more common in recent years in transportation planning and analysis. They have been developed for analyzing specific projects, in San Diego (*19*), Honolulu (*20*), and Sacramento (*21*), and for general-purpose data bases for transportation planning in the Netherlands (*22*) and the Puget Sound region of Washington State (*23*). Only with a panel survey can the adjustments over time in residence, workplace location, and modes be logged for the individuals actually making them. Travel panel surveys typically contain a trip diary for one or more days for each individual in a household unit at every survey wave. Changes are thus observed directly and unambiguously. And, as Kitamura (*24*) has emphasized, factors contributing to the travel behavior of a household or individual change almost continuously.

This paper is intended to demonstrate the use of panel data in analyzing the dynamics of locational adjustments to travel conditions. It is exploratory in approach, using primarily descriptive analysis to examine the issues of residential and workplace location changes and mode shifts and the ability of the Puget Sound Transportation Panel (PSTP) data to support such analysis. The paper also builds on preliminary research reported in Murakami and Watterson (*25*). Systematic attention is given to the potentials in the panel survey for biases because of the sample development and its attrition over time.

PUGET SOUND TRANSPORTATION PANEL

PSTP was initiated in 1989 by the Puget Sound Council of Governments, now the Puget Sound Regional Council (PSRC). PSTP is the first (and as-yet only) general-purpose travel panel survey in an urban area in the United States. It was designed to build on the conventional cross-sectional urban travel surveys that have been conducted in the Puget Sound and other metropolitan areas since the early 1960s by adapting elements of such ongoing travel panel surveys as the Dutch National Mobility Panel. PSTP surveys have included telephone interviews, household travel diaries, and attitude surveys.

PSTP survey data collection has taken place at least annually since the fall of 1989. Interviews and diaries were administered in the fall of 1989, 1990, 1992, and 1993. An attitudes-and-values survey, developed by transit marketing and university researchers, was administered to the panel in February 1990, October 1991, and October 1993. Additional contacts for address verifications and corrections, along with new panel member refreshment, also have been made periodically. A number of administrative details on PSTP are documented in Murakami and Ulberg (*26*). Once coded, cleaned, and checked, the panel data have been made available by PSRC for a variety of directed and independent research projects aimed at expanding the stock of information on travel behavior in the Puget Sound region. The result is an ever-increasing body of research using the PSTP data.

The analysis in this paper covers samples drawn from the 1989 and 1990 interviews and diaries, as well as from the 1991 survey. Three wave pairs are developed for this analysis: Wave1-Wave2 (1989–1990), Wave2-Wave3 (1990–1991), and Wave1-Wave3 (1989–1991). In each case, as many continuing households or continuously employed workers as possible were included in the samples for each wave pair. Thus, a household continuing for 1989 and 1990, but dropping out in 1991, could be used only for the Wave1-Wave2 sample. A 1990 replacement household continuing through 1991 could be included in the Wave2-Wave3 sample. Issues related to the validity of these samples are discussed in the next section.

The geographic dimensions of the residential and work location changes are represented by six subregions of the Puget Sound region. The largest county, King (located in the center of the region), is divided into three subregions—the central city of Seattle, plus two large suburban subregions of the county—each containing a population of about 500,000 in 1990. The other subregions are the other three counties in the Puget Sound region, ranging in population from almost 600,000 (Pierce, to the south) to 500,000 (Snohomish, to the north) to just under 200,000 (Kitsap, to the west, by ferry). All three are mainly suburban in composition, with the major exception of the central city of Tacoma in Pierce County (population, 175,000).

PSTP SAMPLES, BIAS, AND WEIGHTING

There are at least two issues in connection with developing samples from the PSTP data, especially ones that involve changes between panel waves. One stems from the stratification of the original PSTP panel by county of residence and by usual travel mode to work. The other involves attrition of panel members between waves and the sample bias this can produce.

Panel Stratification

The original 1989 PSTP was stratified by county and mode so that each county and each of the three major travel modes would contain a statistically valid sample size to permit longitudinal analysis by each stratified subsample. Thus, the original sample of 1,713 households significantly overrepresented households in Kitsap County (12.0 percent versus 6.4 actual, 1990) and Snohomish County (25.4 percent versus 15.6 actual).

For purposes of sample stratification, travel mode was defined on the following usual mode of choice:

1. Households without regular (four one-way trips per week) transit users or carpoolers;
2. Households with regular transit users; and
3. Households with regular (work trip) carpoolers.

Carpooler and nontransit, noncarpool (single-occupancy-vehicle) households were selected using telephone random-digit dialing, which is assumed to replicate reasonably well the proportions of occurrence within the sampled population. As for transit, although some transit-defined households were selected by this means, additional households necessary to overrepresent transit households in PSTP were recruited from transit surveys and on-bus fliers. These are choice-based procedures that present special problems for treatment of otherwise random survey samples.

The original PSTP sample households were defined for mode subsamples as 66.4 percent drive-alone, 22.3 percent transit, and 11.3 percent carpool, thus significantly overrepresenting transit-mode households. Of the 382 transit households in the original sample, 222 had been recruited by random-digit dialing, and 160 had been recruited by the various choice-based methods.

For analysis, the sample needs to represent the regional popula-

tion as closely as possible. To do so, the stratification bias in the original PSTP sample must be corrected with weights. Because the county stratification was based entirely on oversampling through random procedures, the correction weight for each county is the ratio of its actual proportion of households in the region to its PSTP proportion. The 1990 Census was the source of the actual household data. Thus, the King County household sample weight was 1.3849 to compensate for its underrepresentation, the weight applied to Kitsap was 0.5180, to Pierce it was 0.9957, and to Snohomish it was 0.6188.

For the travel-mode sample, the development of the weightings is somewhat more complicated. Pendyala et al. (*27*) have discussed the problem of choice-based samples in panel surveys and developed a system of weights for the PSTP sample to correct for the bias caused by overrepresentation of transit households. The procedure relates the proportions of total households randomly selected, transit households randomly selected, and total transit households in the original sample. The results as applied to the original 1989–1990 sample produced weights of 0.4073 for transit-mode households and 1.1080 for drive-alone and carpool household subsamples.

For households, the weightings changed the original sample means only slightly. Average household size, for example, was reduced from 2.60 to 2.55, whereas the average number of vehicles per household rose from 2.12 to 2.15. By distribution, the proportion of households with children remained at about 35 percent, and the proportion of households with 2+ adults 35–64 years with no children continued at around 28 percent. The weightings had little effect on the distribution of the sample by household income.

For employed workers, the weightings had a somewhat more dramatic effect. The sample means changed only slightly: the average person age rose from 40.0 to 40.8; the average household size dropped from 2.92 to 2.78; the average number of vehicles dropped from 2.48 to 2.44; and the average distance to work remained at about 11.0 mi. But the distribution of usual modes to work shifted to levels more representative of the overall population of the region—77.6 percent drive-alone, 6.3 percent transit, and 12.0 percent carpool, with the remainder in walk, bicycle, and other modes.

Between-Wave Samples

Because this analysis is concerned with samples of households and workers between wave pairs, the important question is the representativeness and consistency of the samples across time periods. Here the issue pertains to attrition of households from the original sample.

Panel attrition is a much-discussed and inevitable aspect of virtually all panel surveys (*28–30*). The risk is that the types of households that fail to continue from wave to wave will be sufficiently concentrated by relevant characteristics as to bias the presumably valid original sample. A related question (at least for panels that use replacement households to refresh the panel) is whether households selected to replace the lost households maintain the panel's representativeness of the population.

In this project, several samples were developed to analyze the amount, type, and impact of residential and workplace relocations in the Puget Sound region over time. Specifically, there were six different samples in this analysis: Wave1-Wave2 (1989–1990), Wave2-Wave3 (1990–1991), and Wave1-Wave3 (1989–1991), each for households and workers. For both 1990 and 1991, the households and workers consisted not only of households still considered part of the panel (those completing travel diaries and indicating willingness to continue), but also those dropping from the panel for whom some relevant information is available. Thus, the households in the Wave1-Wave2 sample include the 1,391 households that stayed in the panel, plus 218 households that dropped out in 1990 but whose 1990 residence locations and some other demographic information were recorded. Similarly, many original households and 1990 replacements dropped out in 1991 but can still be included in the Wave2-Wave3 sample. Any "splits" in households—household members who split to form their own households, through young person new household formation, divorce or separation, roommate splits and so on—are entirely omitted. Only the original household, if it continues as such, is retained for analysis.

The sample enhancement is possible because this analysis needed relatively little information from the travel diaries, which are the defining element for the panel stayers and dropouts. Most of the data for this analysis came from the telephone interviews or follow-ups. The enhancement was not very successful for households in 1991 because no telephone interviews were conducted for demographic data and little follow-up was undertaken. There was more success for workers in 1991 because there were questions on the attitudes-and-values survey that year that completed some employment data.

Nevertheless, there was attrition between each of the wave pairs used for analysis in this project. The question is whether there is serious and relevant bias in this attrition. For an analysis of residential movers and workplace changers, those that drop out of the panel are more likely to have moved than those that stay in the sample—moving is one of the primary reasons for dropping out. But the sample enhancement picks up on a good many of these moves, even out of the region, thus minimizing the number of dropouts. The amount of moving will still be understated. But the important question is how different the lost movers are from the retained movers. Does the between-wave sample still resemble the original sample in its characteristics? Table 1 presents such comparisons for households and workers.

The comparative household and worker demographic characteristics are not substantially divergent across the samples. Even if they were, Hensher (*28*) has argued that nonrandomness in such variables that are exogenous to the analysis at hand are not an important panel attrition bias. The important variables are the endogenous ones—in this case those pertaining to travel behavior. The travel characteristics presented in the tables—work trip length and work-travel mode—do not vary widely across samples. There is some loss of carpool workers, mostly offset by gains in drive-alone workers, but these are relatively small.

Overall, this brief analysis does not find a great deal of evidence that attrition bias is a major problem in the samples developed for this analysis of household movers and workplace changers. There is slightly more such evidence for the Wave2-Wave3 sample than for the Wave1-Wave2. But there is not a prima-facie case for correction of attrition bias, even if there were good data on which to base the correction.

The Wave3 survey in 1991 was not accompanied by the high level of effort in following up and verifying panel household moves and some characteristics connected with these changes. The results for Wave2-Wave3 and Wave1-Wave3 for household residential moves, which are presented in the next section, are significantly degraded by the sample deterioration for 1991.

TABLE 1 Comparison of Household and Worker Characteristics Across Samples: Weighted Observations

Variable	Original	Wave 1-2	Wave 2-3
HOUSEHOLDS:	1713	1609	1722
Average Household Size	2.55	2.54	2.54
Average No. Adults in Household	1.90	1.91	1.89
Average No. Children in Household	0.65	0.64	0.65
Average No. Household Vehicles	2.15	2.17	2.14
Percent by Household Type			
1. Any child <6 yr.	17.7	17.2	17.3
2. All children 6-17 yr.	17.6	17.6	17.2
3. One adult, <35 yr.	4.7	3.8	4.3
4. One adult, 35-64 yr.	9.2	9.0	10.4
5. One adult, 65+ yr.	4.6	4.6	3.8
6. Two+ adults, <35 yr.	6.8	6.2	8.1
7. Two+ adults, 35-64 yr.	27.7	28.9	28.2
8. Two+ adults, 65+ yr.	11.8	12.6	10.6
Percent by Income Level			
1. <$7,500	1.7	1.4	2.1
2. $7,500-$15,000	7.5	7.2	5.9
3. $15,000-$25,000	14.2	13.6	14.4
4. $25,000-$30,000	10.6	10.4	8.4
5. $30,000-$35,000	14.4	14.5	11.0
6. $35,000-$50,000	26.5	27.1	25.6
7. $50,000-$70,000	13.1	13.7	19.6
8. $70,000+	7.5	7.6	11.8
9. Don't Know/Refused	4.7	4.6	1.3
WORKERS:	2034	1878	1487
Average Person Age	40.79	41.01	42.53
Average Household Size	2.78	2.79	2.72
Average No. Household Vehicles	2.44	2.45	2.38
Average Distance to Work (in miles)	10.84	10.96	11.02
Percent by Usual Work-Travel Mode			
1. Drive-Alone	77.6	78.2	79.9
2. Transit	6.3	6.4	6.8
3. Carpool	12.0	11.8	10.1
4. Walk	1.8	1.7	1.4
5. Other	1.6	1.5	1.5
6. Don't Know/Refused	0.8	0.4	0.3

RESULTS OF ANALYSIS

Despite the limitations imposed by the 1991 Wave3 survey, samples were developed for all three wave pairs—Wave1-Wave2, Wave2-Wave3, and Wave1-Wave3—and analysis was conducted. The analysis was intended from the start to be exploratory and descriptive, seeking to develop the best possible samples, to probe what preliminary findings could be drawn from the sample data, and to assess what types of analysis the panel data could support.

The household residential moves and the worker workplace changes are separate analyses, each with three wave pair samples. In each case, the basic comparisons are between location changers and nonchangers. The focus is on explaining the changes through relationships in the data, and on relating the changes to travel and travel behavior. Conclusions are restricted by the data limitations and the analytic methods. But still there are some clear directions emerging from the data.

Change in Residential Location

Overall, approximately 13 percent of the original PSTP households changed their residence location between the first two waves of the PSTP (not counting changes by household members who "split" from main households). This is likely to be an understatement of the total residential mobility during the period because among the 104 households that left the panel and were not able to be followed there was probably a higher rate of moving than within the sample. On the other hand, the rate of residential location change in the Wave2-Wave3 sample was markedly lower, and within the 2-year Wave1-

Wave3 sample the moving was not correspondingly as high. The known data deficiencies at Wave3 suggest a greater reliance on the Wave1-Wave2 findings than for the other samples.

The rates of household residential moves by county and subregion were near the regional rate for all wave pairs. In each pair, the move rates for the central city of Seattle were the highest, and those for East/North King County suburban areas were the lowest. By mode sample, the household move rates tended to be highest for the transit-rider sample, but there was no consistent pattern.

Within these geographic and mode samples, demographic characteristics were clearly the dominant factors in household move rates. Households that changed their residential location did not differ much from nonmovers in average household size, but the movers in all three wave samples clearly were young adult households—single adults, adult couples, or families with preschool children. Households with below-median incomes were more likely to move their residence than those with above-median incomes. Although the housing tenure of households was not collected, many more renter households have below-median than above-median income. Renters have been shown to relocate more frequently than owners (*1*). There was little correlation between household moves and the number of employed persons, licensed drivers, or motor vehicles in the household. Households that moved, however, were far more likely than nonmovers to have experienced a change in the household size during the period, especially to a smaller size.

As for the geographical patterns of the household moves, the strongest tendency was for movers to stay within the same subregion, as might be expected from literature on residential search. But there were large variations among the subregions—85 percent of the Kitsap County moves and 75 percent of the Pierce County moves stayed within those counties, whereas only 40 percent of Eastside King County and 50 to 60 percent of the Seattle and South King County suburban movers remained in those subregions. Seattle, South King County, and, surprisingly, suburban Snohomish County were net losers in the residential relocations. Not included were moves from outside the region into the various subregions. But almost 12 percent of the moves from within the region were to locations outside the region (Wave1-Wave2 only). A full 25 percent of the mover households from Eastside King County moved to locations outside the region.

A question of considerable interest is whether household residential moves are used to reduce the home-to-work commuting distance. To examine this, the individual worker work trip distances were summed for the household for both ends of the wave pairs, and the differences were taken. The distribution of these changes is shown in Table 2, along with the mean of all the changes. Trip distances, calculated directly from networks, were used in this analysis.

On the basis of the between-wave changes in home-work distances for households, there is a clear and consistent pattern in all

TABLE 2 Home-Work Distance Changes for Movers by Prior Wave Distance

Original Distance	Less Distance	More Distance	Same Distance	Total	Average Change
WAVE 1-2					
0-5 miles	41.1	30.8	27.8	100.0	1.3 mi.
5-10	54.6	36.5	8.9	100.0	0.9 mi.
10-15	50.6	38.2	11.1	100.0	-1.3 mi.
15-20	66.2	18.4	15.3	100.0	-3.0 mi.
20-30	57.5	23.5	19.0	100.0	-6.6 mi.
30-50	78.6	16.1	5.3	100.0	-13.5 mi.
50+	68.7	17.4	14.1	100.0	-34.9 mi.
Total	54.3	29.5	16.2	100.0	-3.7 mi.
WAVE 2-3					
0-5 miles	41.0	43.7	15.3	100.0	3.8 mi.
5-10	51.9	35.5	12.6	100.0	-0.6 mi.
10-15	78.5	16.4	5.1	100.0	-7.0 mi.
15-20	85.8	14.2	0.0	100.0	-9.8 mi.
20-30	71.3	19.6	9.1	100.0	-9.8 mi.
30-50	95.7	4.3	0.0	100.0	-28.4 mi.
50+	100.0	0.0	0.0	100.0	-52.4 mi.
Total	67.5	24.5	8.0	100.0	-8.2 mi.
WAVE 1-3					
0-5 miles	29.4	46.4	24.2	100.0	3.2 mi.
5-10	57.1	34.7	8.2	100.0	1.7 mi.
10-15	75.6	12.6	11.8	100.0	-3.9 mi.
15-20	80.1	19.9	0.0	100.0	-9.9 mi.
20-30	86.2	4.4	9.5	100.0	-14.5 mi.
30-50	95.0	5.0	0.0	100.0	-22.9 mi.
50+	87.8	12.2	0.0	100.0	-58.4 mi.
Total	66.5	23.4	10.2	100.0	-7.6 mi.

Note: Values are sums of home-work distances within households (in percentages).

three samples. Above the range of 10 or 15 mi total work trip distance, the residential moves are serving to reduce the trip length and by rather substantial amounts at the high end. However, 60 percent or more of the household moves occur with households having a total work trip distance of less than 15 mi.

Change in Workplace Location

Although a change in residence location affects all members of a household, changes in work location must be examined for particular workers within the household. As with households, the samples of workers were constructed with the maximum number of persons reporting "employment outside the home" in both ends of each wave pair, for whom geographic and demographic information was collected. For example, of the 2,034 persons reporting being employed in Wave1, a total of 1,878 qualified for the continuing sample of Wave1-Wave2.

A change in workplace location was determined using information from both the travel diaries and self-reporting in interviews and survey instruments (especially in Wave3). By these measures, 20.7 percent of the continuing workers changed work locations between Wave1 and Wave2, 19.1 percent changed between Wave2 and Wave3, and 35.7 percent changed in the 2-year period between Wave1 and Wave3.

Workers from the carpool sample had a consistently lower rate of work-location change, whereas those from the transit sample had a somewhat higher level of change. However, the age of the worker was the primary demographic characteristic that distinguished workplace changers from nonchangers. Workers in younger ages were much more likely to change locations between the waves, although there was a substantial amount of change even among the older workers. In the Wave1-Wave2 sample, for example, 36.2 percent of the workers 15 to 24 years old changed workplace, whereas 26.7 percent of the workers 25 to 34 years old changed, and 15.7 percent of the workers 45 to 54 years old changed. The disparities were even greater over the 2-year Wave1-Wave3 period.

The overall rate of workplace change tended to be close to the regional rate in most subregions, with the notable exceptions of consistently low rates of change for workers in Kitsap County and high rates in Eastside King County. Most of the work location changes took place within the same subregion, although with considerable variation among subregions. For example, in the Wave1-Wave3 period, 86 percent of the Pierce County changers stayed in the county, whereas only 54 percent of the Seattle changers stayed in Seattle, and 55 percent of the Eastside King County changers stayed in that subregion. This pattern suggests that at least in King County potential labor market areas are perceived to encompass more than one defined subregion, whereas in Pierce and Kitsap Counties the county defines the labor market area.

There were significant net shifts of workers among subregions. For Seattle in the Wave1-Wave3 sample, there were 100 Wave1 workers changing location, with 54 remaining in the city, less 46 relocating out of the city, plus 28 relocating into the city, for a net loss of 17 or 17 percent. For Eastside King County, there were 45 Wave1 workers changing location, with 25 remaining in the subregion, less 20 relocating out, plus 36 relocating into the subregion (mostly from Seattle), for a net gain of 16 or 35 percent. Pierce County was also a major net gainer of workers, gaining 22 percent, mostly from South King County.

As with the household residential location changes, there were consistent effects in the work location changes of decreasing the workers' home-to-work trip distance, at least for those with distances greater than 10 to 15 mi. Table 3 shows the distribution of these trip distance changes by prior home-to-work distance, along with the average amount of the changes.

Even though the data from the Wave2-Wave3 pair are not as smooth, the work trip distance changes provide consistent evidence of workers using workplace location changes to reduce their commute distances, especially those with longer work trip lengths. It should be noted, however, that the majority—over 60 percent—of the workers changing locations started with work trip distances under 15 mi. But clearly those with the longer distances were using such changes to shorten the work trip.

A final aspect of workplace location changes is changes in travel mode to work. In the PSTP, the mode to work was reported in two different ways: (*a*) identification of the "usual mode" to work for each household member in the telephone interview or questionnaire, and (*b*) a record in the trip diaries of the actual mode taken by each household member on the 2 assigned days for each wave (Wave1 and Wave2 only). The identified usual mode is the basis for the results presented next. Table 4 contains transitions in travel mode between waves for workers changing job locations.

Among workers changing work locations, there was a high degree of shifting their usual travel mode to work, especially out of transit and carpooling, with most of these going to driving alone. But there were correspondingly large shifts by workplace changers into transit and carpooling, so that the net shifts for such workers were about nil. These shifts suggest workplace changes to locations with good transit service and perhaps closer to the workplaces of spouses or other friends.

The surprising result of the PSTP mode transition data was the degree of instability in carpooling, for both those who changed job locations and those who did not. Even for the nonchangers, the carpool retention rate ranged from 40 to just over 50 percent in the three wave pairs. And, among the workplace changers, for the Wave1-Wave3 period there seemed to be deterioration in the gains made by carpooling over the 2-year period. For transit users in Wave1 who switched to driving alone by Wave3, over 60 percent had changed job locations, probably out of places with good transit service. But for carpoolers in Wave1 who had switched to driving alone (well over half of the Wave1 carpoolers), only 30 percent had changed job locations; all the others just shifted mode with the same workplace.

Gender Characteristics

In light of literature that suggests differences in travel behavior between men and women workers, the worker sample was further disaggregated by worker sex. A total of 45.7 percent of the continuing workers between Wave1 and Wave 2 were women. Change of workplace rates for both men and women were comparable: 20.4 percent for men and 21.2 percent for women. The only significant sample difference was a greater predominance of driving alone to work for men and more transit to work for women.

As for workplace changers, women were markedly younger than men. Almost 48 percent of the women who changed were under 35 years, versus 33 percent of the men. In life cycle stage, there were similar relative proportions in each stage, except that single women

TABLE 3 Home-Work Distance Changes for Workers by Prior Wave Distance

Original Distance	Less Distance	More Distance	Same Distance	Total	Average Change
WAVE 1-2					
0-5 miles	8.1	79.6	12.3	100.0	6.3 mi.
5-10	38.4	48.3	13.3	100.0	2.3 mi.
10-15	56.6	42.4	1.0	100.0	2.2 mi.
15-20	66.5	29.0	4.5	100.0	-3.7 mi.
20-25	73.7	16.9	9.4	100.0	-4.7 mi.
25-30	72.0	28.0	0.0	100.0	-7.2 mi.
30+	86.6	13.4	0.0	100.0	-20.8 mi.
Total	40.6	50.2	9.2	100.0	1.0 mi
WAVE 2-3					
0-5 miles	27.3	61.5	11.1	100.0	4.2 mi.
5-10	38.5	56.2	5.3	100.0	2.5 mi.
10-15	65.9	33.6	0.5	100.0	-0.9 mi.
15-20	57.1	40.4	2.5	100.0	0.7 mi.
20-25	53.8	39.5	6.8	100.0	-2.6 mi.
25-30	43.2	37.4	19.4	100.0	-2.5 mi.
30+	63.5	28.7	7.8	100.0	-11.1 mi.
Total	45.8	47.6	6.6	100.0	0.6 mi.
WAVE 1-3					
0-5 miles	25.9	64.3	9.8	100.0	5.2 mi.
5-10	42.9	52.1	5.0	100.0	1.8 mi.
10-15	59.5	40.1	0.4	100.0	-1.6 mi.
15-20	64.1	33.8	2.1	100.0	-2.5 mi.
20-25	80.0	15.5	4.5	100.0	-9.5 mi.
25-30	79.1	12.4	8.5	100.0	-11.6 mi.
30+	84.2	15.8	0.0	100.0	-17.8 mi.
Total	49.8	45.1	5.1	100.0	-0.8 mi.

Note: Values are in percentages.

under 35 years were far more likely than comparable men to change workplaces during the year. Women workplace changers were more likely to stay within the same subregion and more likely to suburbanize. All women workers were more likely than men to live and work in the same subregion. This characteristic was reinforced by the workplace location changes.

Women workers in general lived closer to work than men. Except for the workplace changers, a full 73 percent lived less than 10 mi from work (before the change), compared with 52 percent of the men who changed. Only 15 percent of the women had work trip distances greater than 15 mi, whereas 33 percent of the men who changed did. But the average changes in work trip distance were similar for both groups.

As for work trip mode, the mode shifts for women who changed workplaces were dramatic—and devastating for transit and carpool use in work trips. Only 40 percent of the transit users and 35 percent of the carpoolers remained in those modes to work after their workplace changes. Transit mode share dropped from 9.5 percent to 6.5 percent. For men who changed workplaces, the transit mode share increased by 65 percent. Enough women who changed shifted into carpools to keep the same overall share, but for men who changed so many previously solo drivers shifted to carpools that the mode share doubled from 7 to 14 percent over the year.

SUMMARY AND CONCLUSIONS

Summary of Findings

Although this project was exploratory and descriptive in its approach and the data from the 1991 Wave3 do not support extensive analysis, there still are some clear and consistent results from the tabulations. There was a high rate of both residential and workplace change among the panel members. Almost 14 percent of the households moved their residences during the best 1-year period (Wave1-Wave2); the other wave periods have apparent data deficiencies. This figure may be lower than the true rate because of moving households lost to the panel. Continuing workers changed work locations at a rate of about 20 percent each year. These changes were dominated by young adult households and younger workers, although there were a considerable number of changes by others as well. Women who changed tended to be younger than men. The youthful bias also correlates with relatively low incomes, renter tenure, and transit ridership.

Geographically, there were some variations in rates of change across the six subregional areas: residential moves tended to be low in Pierce County and Eastside King County and high in Seattle, whereas workplace changes were very low in Kitsap County and

TABLE 4 Mode-to-Work Transitions by Wave Pair: Workers Changing Workplaces

WAVE 1-2	*Wave 2 Mode*				
Wave 1 Mode	Drive Alone	Transit	Carpool	Walk/ Other	Total
Drive-Alone	224	10	19	3	256
Transit	8	10	2	1	21
Carpool	10	0	13	0	23
Walk/Other	2	0	2	4	8
Total	244	20	36	8	308

WAVE 2-3	*Wave 3 Mode*				
Wave 2 Mode	Drive Alone	Transit	Carpool	Walk/ Other	Total
Drive-Alone	176	7	15	8	206
Transit	3	9	2	1	15
Carpool	13	1	9	1	24
Walk/Other	5	0	0	3	8
Total	197	17	26	13	253

WAVE 1-3	*Wave 3 Mode*				
Wave 1 Mode	Drive Alone	Transit	Carpool	Walk/ Other	Total
Drive-Alone	273	7	9	11	301
Transit	12	10	3	3	28
Carpool	21	4	7	0	31
Walk/Other	4	2	0	1	7
Total	310	23	19	15	367

high in Eastside King County. Residential moves tended to be within the same subregion, but with an outward bias away from Seattle to suburban King County and toward Pierce County. Workplace changes in King County were less likely to be in the same subregion, again with an outward direction from Seattle. Kitsap and Pierce County changes were mostly within the same county.

Both residential and workplace changes were strongly connected with reductions in home-to-work distances for those households and workers with prior distances greater than 15 mi, and the greater the distance, the larger the average reduction in distance after the change. Workplace changes brought about shifts in the workers' usual travel mode to work, especially out of transit and carpooling. But there also were significant shifts by workplace changers into transit and carpooling, suggesting changes to locations with better transit service and perhaps closer to workplaces of spouses or other friends. Carpooling in general appears to be unstable, for both those who change job locations and those who do not.

When disaggregated by worker gender, however, more dramatic shifts appear. Women who change workplaces tend to start from relatively short work trip lengths, and the change leads to substantial shifts out of transit and carpool modes. Although transit mode share of women changers dropped by a third, the men who changed increased their transit and carpool use by large amounts.

A Final Word

Despite the negative comments on the quality of the 1991 PSTP data base and its implications for the ability of the PSTP to support dynamic demographic analysis of travel behavior, the results from this work indicate bright prospects for such analysis. First of all, the findings support the hypothesis that there is a great deal of change occurring in demographics and travel behavior, such as residential and workplace mobility and mode shifts. Second, the demographic changes seem to bear significantly on the observed changes in travel behavior by urban residents. Third, such changes suggest a dynamic process of adjustment on the part of households and workers to their needs. Finally, the panel data base seems ideally suited to empirical research on emerging theory of individual adjustments to inefficient commutes.

This work has also pointed up some important deficiencies in the PSTP data bases and some limitations in the amount and type of research that they can support. This will always be the case with real-world panel surveys and the data they produce. But the PSTP is the first general-purpose travel panel survey in the United States, and the more its data are used, the more will be known for better panel survey design and administration. There is great potential through such surveys for major breakthroughs in research and expanding knowledge of the way urban areas and their residents behave. Change is the foundation of life, and the panel design is well suited to analysis of that change.

ACKNOWLEDGMENTS

Much of this research was conducted under a contract with the Puget Sound Regional Council. PSTP data base and technical support for this research were provided by the Regional Council.

REFERENCES

1. Quigley, J. M., and D. H. Weinberg, Intra-Urban Residential Mobility: A Review and Synthesis. *International Regional Science Review,* Vol. 2, No. 1, 1977, pp. 41–66.
2. Watterson, W. T. *Econometric Analysis of Residential Choice.* Ph.D. dissertation. University of Pennsylvania, Philadelphia, 1983.

3. Lerman, S. R. Location, Housing, Automobile Ownership and Mode to Work: A Joint Choice Model, In *Transportation Research Record 610,* TRB, National Research Council, Washington, D.C., 1977, pp. 6–11.
4. McFadden, D. Modeling the Choice of Residential Location. In *Transportation Research Record 673,* TRB, National Research Council, Washington, D.C., 1978.
5. Anas, A. *Residential Location Markets and Urban Transportation.* Academic Press, New York, 1982.
6. Anas, A., and L. S. Duann. Dynamic Forecasting of Travel Demand, Residential Location and Land Development. In *Advances in Urban Systems Modelling* (B. Hutchinson and M. Batty eds.), North-Holland, Amsterdam, 1986.
7. Ben-Akiva, M., S. Lerman, W. A. Jessiman, R. L. Albright, and R. E. Nestle. *A Behavioral Analysis of Automobile Ownership and Modes of Travel,* Vol. 1–4. FHWA, U.S. Department of Transportation, 1976.
8. Shoup, D. C. *Free Parking as a Transportation Problem,* U.S. Department of Transportation, Washington, D.C., 1980.
9. Ulberg, C., and G. Etchart. Parking Tax in Washington State. In *Transportation Research Record 1305,* TRB, National Research Council, Washington, D.C., 1991, pp. 31–35.
10. Hamilton, B. W. Wasteful Commuting *Journal of Political Economy,* Vol. 90, No. 5, 1982, pp. 1035 –1053.
11. White, M. J. Urban Commuting Journeys Are Not 'Wasteful.' *Journal of Political Economy,* Vol. 96, No. 5, 1988, pp. 1097–1110.
12. Cropper, M., and P. Gordon. Wasteful Commuting: A Re-Examination. *Journal of Urban Economics,* Vol. 29, No. 1, 1991, pp. 2–13.
13. Zax, J. S., and J. F. Kain. Commutes, Quits, and Moves. *Journal of Urban Economics,* Vol. 29, No. 2, 1991, pp. 153–165.
14. Guiliano, G. Is Jobs-Housing Balance a Transportation Issue? In *Transportation Research Record* 1305, TRB, National Research Council, Washington, D.C., 1991, pp. 305–312.
15. Pisarski, A. E. *Commuting in America.* Eno Foundation for Transportation, Westport, Conn., 1987.
16. Pisarski, A. E. *Travel Behavior Issues in the 90's.* U.S. Department of Transportation, Washington, D.C., 1992.
17. Duncan, G. J., F. T. Juster, and J. N. Morgan. The Role of Panel Studies in Research on Economic Behavior. *Transportation Research A,* Vol. 21A, No. 4/5, 1987, pp. 249–264.
18. Gordon, P., H. W. Richardson, and M-J. Jun. The Commuting Paradox: Evidence from the Top Twenty. *Journal of the American Planning Association,* Vol. 57, No. 4, 1991, pp. 416–420.
19. Supernak, J. C., and R. Kitamura. The Reversible Carpool Roadway in San Diego: Perception and Reality. Presented at 5th World Conference on Transport Research, Yokohama, Japan, July 1989.
20. Guiliano, G., and T. F. Golob. *Evaluation of the 1988 Staggered Work Hours Demonstration Project in Honolulu.* Institute of Transportation Studies, University of California, Irvine, 1989.
21. Kitamura, R., K. Goulias, and R. M. Pendyala. *Telecommuting and Travel Demand: An Impact Assessment for the State of California Telecommute Pilot Project Participants.* Research Report UCD-TRG-RR-90-8. Transportation Research Group, University of California, Davis, 1990.
22. van Wissen, L. J. G., and H. J. Meurs. The Dutch Mobility Panel: Experiences and Evaluation. *Transportation,* Vol. 16, No. 2, 1989, pp. 99–119.
23. Murakami, E., and W. T. Watterson. Developing a Household Travel Panel Survey for the Puget Sound Region. In *Transportation Research Record 1285,* TRB, National Research Council, 1990, pp. 40–46.
24. Kitamura, R. Panel Analysis in Transportation Planning: An Overview, *Transportation Research A,* Vol. 24A, No. 6, 1990, pp. 401–415.
25. Murakami, E., and W. T. Watterson. The Puget Sound Transportation Panel After Two Waves. *Transportation,* Vol. 19, No. 3, 1992, pp. 141–158.
26. Murakami, E., and C. Ulberg. Current Status of the Puget Sound Transportation Panel. Presented at 1st U.S. Conference on Panels for Transportation Planning, Lake Arrowhead, Calif., Oct. 1992.
27. Pendyala, R. M., K. G. Goulias, and R. Kitamura. *Development of Weights for a Choice-Based Panel Survey Sample with Attrition.* Puget Sound Regional Council, Dec. 1991.
28. Hensher, D. A. Longitudinal Surveys in Transport: An Assessment. In *New Survey Methods in Transport,* (E. Ampt, A.J. Richardson, and W. Brög, eds.), VNU Science Press, Utrecht, Holland, 1985.
29. Kitamura, R. and P. H. L. Bovy. Analysis of Attrition Biases and Trip Reporting Errors for Panel Data. *Transportation Research A,* Vol. 21A, No. 4/5, 1987, pp. 287–302.
30. Hensher, D. A. An Assessment of Attrition in a Multi-Wave Panel of Households. In *Urban Dynamics and Spatial Choice Behaviour.* (J. Hauer et al., eds.). Kluwer Academic Publishers, The Hague, Holland, 1989.

Publication of this paper sponsored by Committee on Traveler Behavior and Values.

Telecommuting and Residential Location: Theory and Implications for Commute Travel in Monocentric Metropolis

JAY R. LUND AND PATRICIA L. MOKHTARIAN

A simple partial equilibrium model was used to estimate the long-term effect of telecommuting on work trip vehicle distance traveled and residential location for households located in a monocentric metropolitan area and for workers employed in the metropolitan center. Although based on very simple assumptions, the model illustrates some aspects of the complexity of the effects of telecommuting on residential location and commute travel. Although telecommuting reduces the number of work trips, the long-term effects of telecommuting are likely to include change in residential location farther from the workplace, diminishing the reduction in commute distance traveled per year from telecommuting. This effect of residential relocation is most pronounced for metropolitan areas with flatter spatial variation in land prices—the trend in most metropolitan areas in recent decades.

Telecommuting is often suggested as a way to decrease traffic congestion, energy consumption, and air pollution by reducing commuting travel (*1–3*). Some critics have argued that these benefits are likely to be somewhat reduced because of higher nonwork travel, more local work-related trips, and shifts in mode of travel. It has also been argued that benefits to the transportation system from telecommuting might be diminished further by an increased flexibility in residential location.

This flexibility is expected to encourage residential location farther from the traditional workplace, thereby inducing additional travel on days when the employee travels to the traditional workplace. In the worst case, commute distance traveled after relocation could exceed commute distance traveled before (*4–7*).

On the basis of several studies, empirical evidence to date has found relatively positive transportation impacts of telecommuting. Nonwork travel has not increased and vehicle distance traveled, peak-period trips, fuel consumption, and emissions have all decreased as expected (*8–13*). However, evidence on the residential relocation effects of telecommuting is scanty because of the short-term duration of most evaluation efforts.

In his evaluation of the 2-year state of California pilot project, Nilles (*14*) found that 6 percent of the telecommuters indicated that they had moved or were considering moving, 72 km or more (45 mi or more) farther from work since they began to telecommute. However, no significant differences in number or length of work trips existed between actual moves of the telecommuters and those of a control group. In a study of San Diego telecommuters, Mokhtarian (*15*) found a small proportion of respondents reporting that the ability to telecommute was prompting consideration of moves two and three times farther away from the workplace than were their current residential locations. Such moves, if they occurred and if the frequency of telecommuting remained constant for those respondents, would certainly result in higher levels of commute travel than before.

This short paper presents a simple theoretical examination of residential relocation induced by telecommuting, for monocentric metropolis for commuters working in the metropolitan center. The theory provides quantitative and qualitative estimates of the importance of residential location effects in reducing the transportation system benefits of telecommuting. Although the residential location effects of telecommuting can be significant, they appear to detract only moderately from the effectiveness of telecommuting at reducing commuter-related urban travel.

SIMPLE THEORY OF RESIDENTIAL LOCATION WITH TELECOMMUTING

An Alonso model of residential location would hold that households are located to minimize the summed cost of housing and travel (*16*). For a monocentric metropolis, this cost is expressed simply as

$$C(d) = h + AR(d) + c_T T d/r \quad (1)$$

where

- $C(d)$ = total location cost as function of distance from metropolitan area's center,
- h = cost of dwelling,
- A = land area desired (and assumed constant),
- $R(d)$ = cost of unit of land as function of location,
- c_T = unit cost of commuting (cost per unit of distance traveled),
- d = location's distance from workplace at metropolitan center,
- r = real discount rate, and
- T = number of one-way commuting trips taken per year.

Because households are assumed to minimize this cost in their locational decisions,

$$\frac{dC(d^*)}{dd} = 0 = A\frac{dR(d^*)}{dd} + \frac{c_T T}{r} \quad (2)$$

or

$$\frac{dR(d^*)}{dd} = -\frac{c_T T}{A} \quad (3)$$

Department of Civil and Environmental Engineering and Institute of Transportation Studies, University of California, Davis, Calif. 95616.

where the derivatives are evaluated at d^*, the least-cost residential location. Because land prices tend to decrease with distance from the metropolitan center, $dR(d^*)/dd < 0$.

So long as this relationship holds and because telecommuting lessens the number of work trips per year ($T_1 < T_0$),

$$\left[\frac{dR(d^*)}{dd}\right]_{T_0} < \left[\frac{dR(d^*)}{dd}\right]_{T_1} < 0 \tag{4}$$

Assuming that land prices follow a conventional exponential decay (*17,18*),

$$R(d) = R_0 e^{-kd} \tag{5}$$

where R_0 is the land price at the metropolitan area center and k is a decay constant. Therefore,

$$\frac{dR(d)}{dd} = -R_0 k e^{-kd} \tag{6}$$

Combining Equations 3 and 6 yields

$$R_0 k e^{-kd^*} = \frac{c_T T}{Ar} \tag{7}$$

where d^* is the least-cost location. This simplifies to

$$e^{kd^*} = \frac{ArR_0 k}{c_T T} \tag{8}$$

or

$$d^* = \frac{\ln\left(\frac{ArR_0 k}{c_T}\right)}{k} - \frac{\ln(T)}{k} \tag{9}$$

Note that this relationship consists of a constant that does not vary with commuting trips per year minus a term that increases logarithmically with the number of annual commuting trips.

CHANGE IN EQUILIBRIUM LOCATION WITH TELECOMMUTING

How should residential location change with the onset of telecommuting? Here it is assumed that telecommuting is only partial. The employee remains at home or works nearby some fraction of the work days but must commute to work physically for the remaining work days.

To examine this case, define the change in least-cost location, $\Delta d^* = d^*(T_1) - d^*(T_0)$. Replacing Equation 9 into this definition yields

$$\Delta d^* = \frac{\ln(T_0) - \ln(T_1)}{k} = \frac{\ln(T_0/T_1)}{k} \tag{10}$$

Note that this change in equilibrium location is affected only by the change in commuting trips and the decay constant of land prices. Other factors entering into the initial locational decision do not affect the magnitude of change in the equilibrium least-cost location.

EFFECTS OF TELECOMMUTING ON ANNUAL WORK-RELATED DISTANCE TRAVELED

Define annual vehicle-kilometers traveled as $VKT(T) = Td^*$. The change in vehicle-kilometers traveled with the onset of some level of annual posttelecommuting trips T_1 relative to some prior annual number of trips T_0 is then

$$\Delta\, VKT\,(T_1) = VKT\,(T_1) - VKT\,(T_0) = T_1\, d_1^* - T_0\, d_0^* \tag{11}$$

where d_0^* and d_1^* are the least-cost locations before and after the onset of telecommuting. Noting that $\Delta d^* = d_1^* - d_0^*$, this expression can be changed to the following form:

$$\Delta\, VKT(T_1) = T_1\, \Delta d^* + d_0^*(T_1 - T_0) \tag{12}$$

Combining Equations 10 and 12 yields

$$\Delta\, VKT\,(T_1) = T_1 \frac{\ln(T_0/T_1)}{k} + d_0^*\,(T_1 - T_0) \tag{13}$$

as a final predictive equation for changes in annual vehicle-kilometers traveled to work in the metropolitan core.

EXAMPLE

Some implications of this simple theory are illustrated by the following example. Consider a household initially located 10 km from the metropolitan center ($d_0^* = 10$) where 400 one-way commuting trips are made annually ($T_0 = 400$). Land prices decay exponentially at a constant rate ranging from 5 to 50 percent per kilometer ($k = 0.05$ to 0.5/km). For this case, Figure 1 shows the change in equilibrium residential location and Figure 2 shows the change in annual VKT with number of commuting trips for this range in decay constants for metropolitan land prices. Figure 3 shows the ratio of annual commute VKT after telecommuting to that before telecommuting.

Figures 2 and 3, indicate that for the steeper rates of decay ($k \geq 0.1$), VKT with telecommuting and after residential relocation is still lower than that without telecommuting, for all levels of telecommuting. For the flattest rate of decay, however ($k = 0.05$), VKT after beginning to telecommute and after residential relocation is higher than that before at all but the greatest frequencies of telecommuting. For example, the person presently living 10 km from the center who begins telecommuting half of the time ($T_1 = 200$) will find a new equilibrium residential location about 24 km from the center (nearly 2.5 times farther away than before), and annual commute VKT will increase 19 percent (from 4000 to nearly 4800 km).

Increasing the decay constant of land prices (to levels above 0.1/km) increases the reduction in VKT, as shown in Figure 2. As k decreases, the spatial variation in land prices decreases, and the effect of telecommuting on least-cost location becomes more pronounced. This, in turn, diminishes the reduction in work trip VKT from telecommuting. This effect may be fairly important, given the long-term trend toward relatively flat urban land markets.

However, the total cost function in the neighborhood of the least-cost location is very flat. There are many near-least-cost locations in the neighborhood of the least-cost location. The spatial breadth of the near-least-cost region increases with the flatness of the land

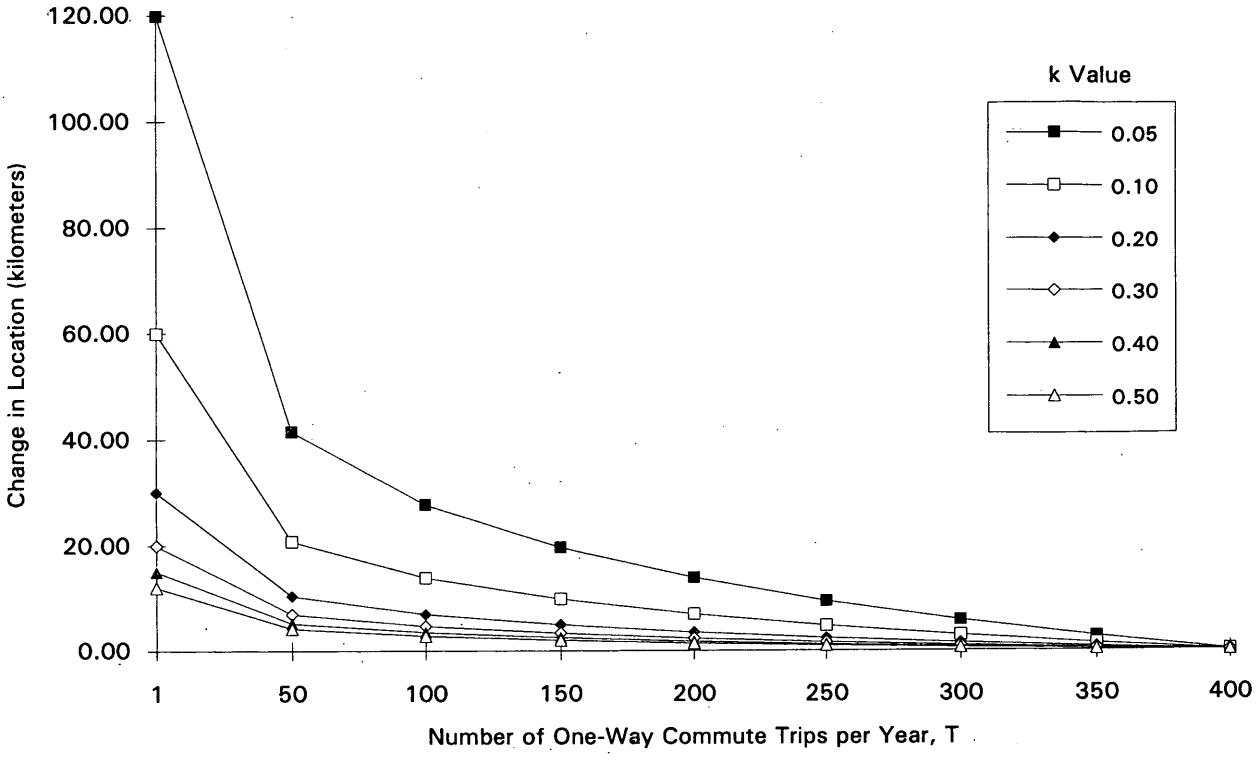

FIGURE 1 Change in equilibrium residential location with telecommuting for example case.

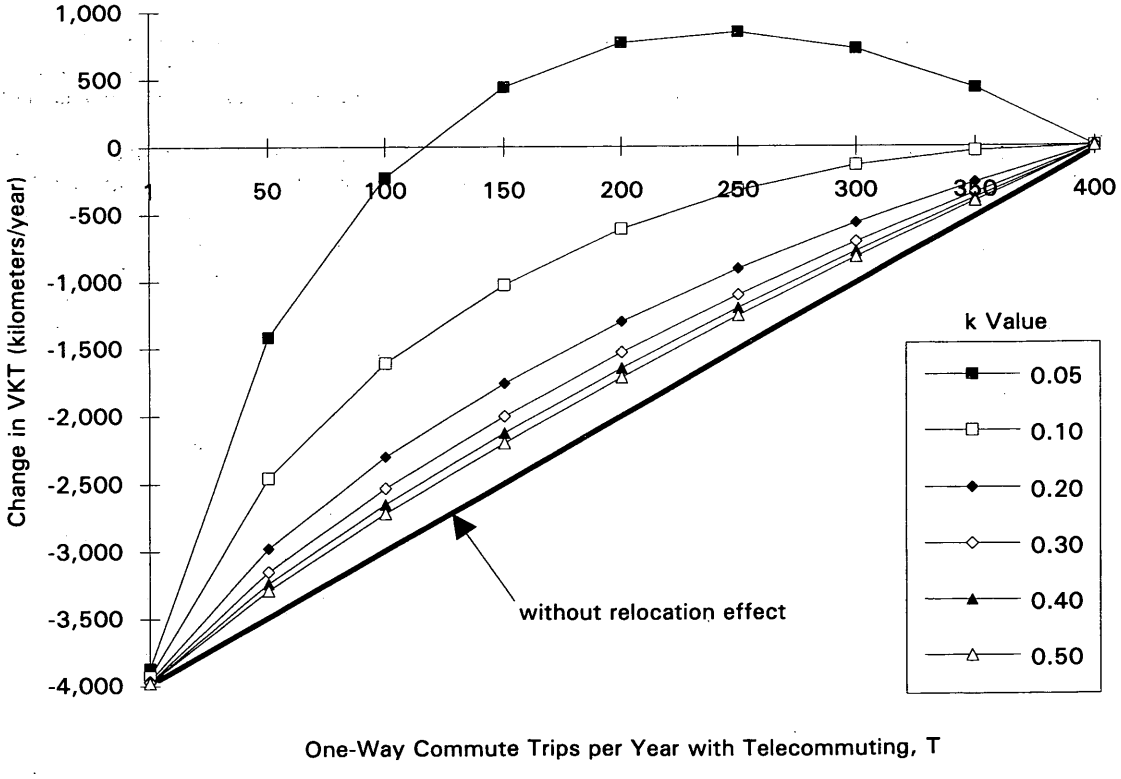

FIGURE 2 Change in VKT after telecommuting for example case.

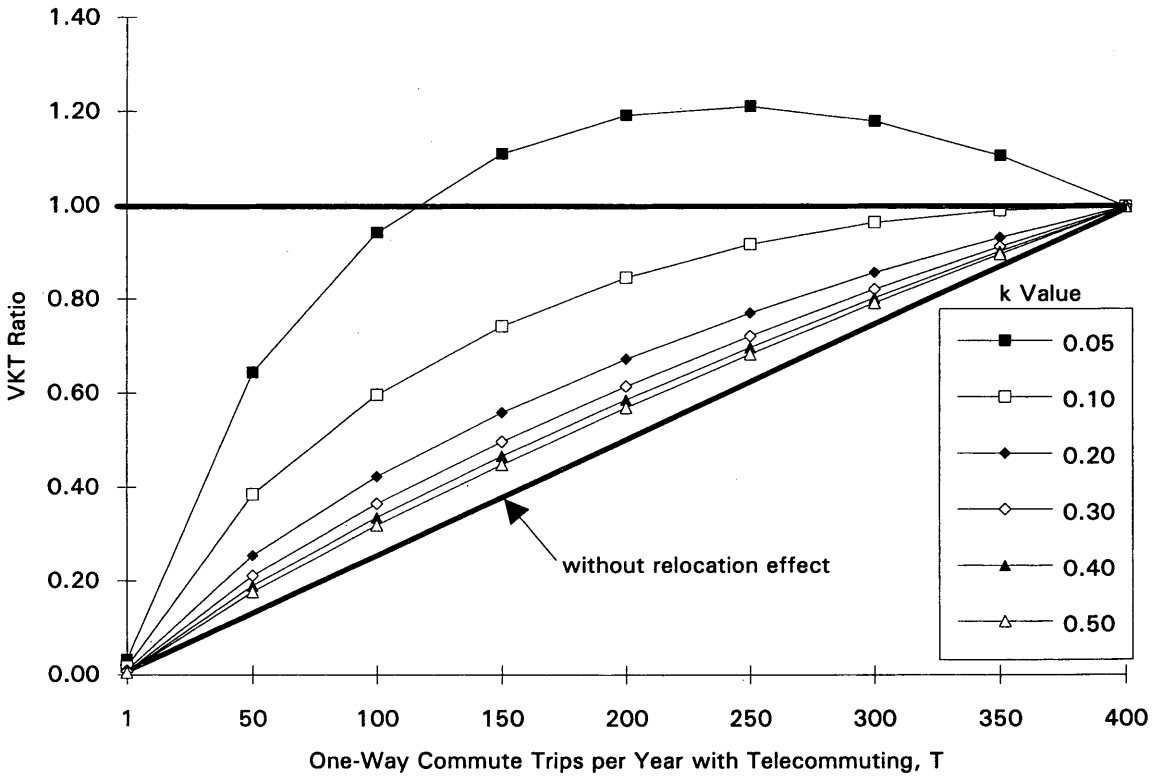

FIGURE 3 Ratio of work trip VKT after telecommuting to before telecommuting for example case.

price decay rate. This wide area of near-optimal locations is likely to increase the role of other locational factors (such as amenity and local neighborhood effects). Nevertheless, the net effect of telecommuting is to induce an outward location of residences from traditional centrally located workplaces.

CONCLUSIONS

The effect of residential relocation in diminishing the transportation benefits of telecommuting has been explored with the aid of a simple economic model. The magnitude of this effect is greatest for intermediate levels of telecommuting in metropolitan areas characterized by relatively flat declines in land prices from the metropolitan center.

Most telecommuting today occurs at relatively low frequencies: 1 or 2 days a week on average (*19*). At those levels, work trip VKT will usually still be lower than it was previously after telecommuting begins and residential relocation takes place. It is plausible that the average frequency of telecommuting will increase over time, however, as individual telecommuters adapt to the concept, as managers grow more comfortable with the idea, as technology improves to permit more types of work to be done cost-effectively remotely, and as telecommuting centers close to home become more commonplace. Thus, for metropolitan areas with flatter land price contours, increasing telecommuting might increase total vehicle commute travel until high levels of telecommuting are achieved.

Residential relocation is likely to be partially self-regulating: many people may choose not to move very far away unless they can telecommute often enough to reduce their vehicle commute travel. For some people, however, other reasons to move (e.g., scenic or recreational opportunities at the new location) may more than outweigh commute considerations.

The effects discussed here are entirely divorced from any effects of telecommuting on local, near-home trips and trip-chaining behavior. Many other factors are also neglected, such as short-term resistance to moving and imperfect behavioral assumptions in the pure Alonso model. The model also does not directly assess the change in work trip travel for households both located and employed in suburban locations. However, the same economic effect should exist for households located farther from the metropolitan center than the traditional workplace.

Nevertheless, this simple model illustrates one mechanism that can somewhat detract from the beneficial transportation impacts of telecommuting. This same mechanism also has implications for land use policies because the encouragement given by telecommuting for movement to the metropolitan periphery could increase pressure for land development on the periphery.

REFERENCES

1. South Coast Air Quality Management District. *Regulation XV: Trip Reduction/Indirect Source.* Diamond Bar, Calif. Adopted Dec. 11, 1987; amended Dec. 12, 1992.
2. *Chapter 202, Laws of 1991 (Transportation Demand Management).* State of Washington, 1991.
3. *Transportation Implications of Telecommuting.* U.S. Department of Transportation, April 1993.
4. Salomon, I. Telecommunications and Travel: Substitution or Modified Mobility? *Journal of Transport Economics and Policy,* Vol. 19, 1985, pp. 219–235.

5. Salomon, I. Telecommunications and Travel Relationships: A Review. *Transportation Research A,* Vol. 20A, 1986, pp. 223–238.
6. Garrison, W. L., and E. Deakin. Travel, Work, and Telecommunications: A View of the Electronics Revolution and Its Impacts. *Transportation Research A,* Vol. 22A, No. 4, 1988, pp. 239–245.
7. Mokhtarian, P. L. A Typology of Relationships Between Telecommunications and Transportation. *Transportation Research A,* Vol. 24A, No. 3, 1990, pp. 231–242.
8. Pendyala, R. M., K. G. Goulias, and R Kitamura. Impact of Telecommuting on Spatial and Temporal Patterns of Household Travel. *Transportation,* Vol. 18, No. 4, 1991, pp. 383–409.
9. Hamer, R., E. Kroes, and H. van Ooststroom. Teleworking in the Netherlands: An Evaluation of Changes in Travel Behavior. *Transportation,* Vol. 18, No. 4, 1991, pp. 365–382.
10. Hamer, R., E. Kroes, and H. van Ooststroom. Teleworking in the Netherlands: An Evaluation of Changes in Travel Behavior—Further Results. In *Transportation Research Record 1357,* TRB, National Research Council, Washington D.C., 1992, pp. 82–89.
11. Quaid M., and B. Lagerberg. *Puget Sound Telecommuting Demonstration Executive Summary.* Washington State Energy Office, Olympia, Nov. 1992.
12. Sampath, S., S. Saxena, and P. L. Mokhtarian. The Effectiveness of Telecommuting As a Transportation Control Measure. *Proc., of ASCE Urban Transportation Division National Conference on Transportation Planning and Air Quality,* Santa Barbara, Calf., July 28–31, 1991, pp. 347–362.
13. Mokhtarian, P. L. Telecommuting and Travel: State of the Practice, State of the Art. *Transportation,* Vol. 18, No. 4, 1991, pp. 319–342.
14. Nilles, J. M. Telecommuting and Urban Sprawl: Mitigator or Inciter? *Transportation,* Vol. 18, No. 4, 1991, pp. 411–432.
15. Mokhtarian, P. L. The Transportation Impacts of Telecommuting: Recent Empirical Findings. In *Understanding Travel Behaviour in an Era of Change,* Pergamon Press, in press.
16. Alonso, W. A Theory of the Urban Land Market. In *Papers and Proceedings of the Regional Science Association,* Vol. 6, 1960, pp. 149–157.
17. Muth, R. F. The Spatial Structure of the Housing Market. *Papers and Proceedings of the Regional Science Association,* Vol. 7, 1961, pp. 207–220.
18. Coulson, N. E. Really Useful Tests of the Monocentric Model. *Land Economics,* Vol. 67, No. 3, 1991, pp. 299–307.
19. Handy, S. L., and P. L. Mokhtarian. *Technical Memo 1: Current Levels of Telecommuting in California.* Institute of Transportation Studies, University of California, Davis, Aug. 1993.

Publication of this paper sponsored by Committee on Transportation and Land Development.

Employer Attitudes and Stated Preferences Toward Telecommuting: An Exploratory Analysis

JIN-RU YEN, HANI S. MAHMASSANI, AND ROBERT HERMAN

The adoption of telecommuting involves two principal categories of decision makers: the employee and the employer. Employee participation in telecommuting programs is in general considered to be voluntary; however, approval from supervisors is required. The employer's decision therefore plays a decisive role in the initiation of a telecommuting program. An exploratory analysis of executives' attitudes and stated preferences toward telecommuting, which are essential to the employer's adoption of telecommuting, are presented. The results indicate that management issues such as employees' productivity, executives' abilities to supervise telecommuters, and data security remain barriers to the employer's adoption of telecommuting. The comparison between the stated preferences of executives and those of employees also shows that executives are more reluctant than employees to adopt telecommuting.

Telecommuting continues to receive attention as a promising transportation demand management strategy that may possibly eliminate a portion of the work trips in peak hours and therefore reduce energy consumption and air pollution. Telecommuting has also been advocated as offering the potential to increase social welfare by providing job opportunities to parents with young children or workers with disabilities who may not be able to work otherwise. Other advantages and disadvantages incurred by both participants and their employers also have been identified in the literature, either as a result of speculation or on the basis of the experience acquired through various pilot projects (*1–3*).

A growing number of researchers have been involved in telecommuting projects, primarily motivated by the promising results from experiments on the west coast of the United States (*4,5*); however, several important issues remain to be addressed. Critical among these is the extent to which telecommuting might be adopted, as this would largely determine the eventual impact of telecommuting on transportation and business. To address this issue, it is important to understand the telecommuting adoption process, which is a key determinant of the existence and success of telecommuting programs. Two principal categories of decision makers are involved in this adoption process; the employee and the employer (*6*). An investigation of the employees' decision process and of the key factors that influence their attitudes and stated preferences toward telecommuting has been conducted (*6*). The present study is a complementary effort to address issues regarding the other major decision maker in the adoption process.

The employer makes decisions from the organization's viewpoint about whether to let employees telecommute, as well as the conditions and features of the particular program offered to employees. The complexity of the employer's adoption process is evident as decision processes differ among organizations, depending on the organization's culture, structure, and other characteristics, such as type of business activities. Some organizations may have only one decision maker, the chief executive officer, whereas others may have a decision team consisting of various executives. In addition to the variation of decision rules among organizations, different processes may occur within the same organization. Regardless of the size of the decision group and the underlying decision mechanism, the executives' opinions will strongly affect the organization's adoption of telecommuting, thereby providing the motivation for investigating executives' attitudes and stated preferences toward telecommuting.

This study addresses the employer's telecommuting adoption process using data supplied by executives in response to a telecommuting survey conducted in three cities in Texas. First, the survey method is described and characteristics of the executives and their organizations are summarized. Then executives' responses to attitudinal questions are analyzed, including a confirmatory factor analysis to validate the underlying logic of the questionnaire design, a discussion of the implications from the responses, and a statistical test to identify essential characteristics that affect executives' attitudes toward telecommuting. This is followed by an analysis of executives' stated preferences toward alternative telecommuting scenarios. In addition, results are compared with employees' preferences described in a previous paper by the authors (*6*). Concluding remarks are presented in the last section.

SURVEY METHOD

Data used in this study are from a survey conducted in three Texas cities: Austin, Dallas, and Houston. Both employees and executives were targeted by the survey, with different questionnaires for each group. The details of the survey procedure and the analysis of the employee data were presented in a previous paper (*6*). This paper presents an analysis of the executives' responses to a questionnaire that consists of four sections. The first section is intended to capture the general characteristics of the executives and their organizations. These include the executive's job title, management-related information such as the number of subordinates directly supervised by the executive (span of management), and methods of supervision. Also included is the current availability of telecommunications and computer networking facilities in the company. The second section addresses the executives' attitudes, measured by Likert's five-score, bipolar scales (*7*), toward telecommuting in terms of management concerns such as productivity, morale, absenteeism, and data secu-

Department of Civil Engineering, The University of Texas at Austin, Austin, Tex. 78712.

rity. The third section seeks to elicit executives' preferences for supporting a telecommuting program in the organization under different program scenarios. The last section regards respondents' sociodemographic characteristics, such as gender, age, and educational levels.

Questionnaires were sent to selected organizations and distributed to their executives through personnel officers. A total of 68 organizations representing various firm sizes and business activities were sampled and 397 questionnaires were mailed for distribution. Among these, 83 usable questionnaires were received from 31 organizations. Table 1 lists the sample distribution by city across the business activity of the responding organizations.

CHARACTERISTICS OF RESPONDING EXECUTIVES AND ORGANIZATIONS

Executive Characteristics

The characteristics of the sampled executives and their organizations are illustrated in Table 2. Most of the respondents (77 percent) were men, and 71 percent were between 31 and 50 years of age. About 97 percent of the executives had achieved a high level of educational attainment, with 89 percent completing college or university, and 36 percent attaining a master's degree or Ph.D. Compared with the employees surveyed in the same organizations (*6*), the executives in general had attained higher educational levels, and a greater fraction of them were men.

As expected, the majority of sampled executives were presidents or vice presidents (24 percent) and general managers (52 percent). Other reported job titles include accountant/attorney (19 percent), agent (1 percent), engineer/researcher (2 percent), and general employee (1 percent). To the extent that managerial characteristics are believed to affect executives' preferences toward initiating a telecommuting program, related questions were also included in the survey. The span of management, for example, varied from none to 145 employees, with a mean of 16.8 and a standard deviation of 23.2. In terms of the methods of supervision, review meetings (88 percent), completed task review (84 percent), on-site supervision (78 percent), and written reports (74 percent) were mentioned by most executives, whereas activity logs (33 percent) were indicated by relatively fewer respondents.

Because telecommuting is not widespread in Texas, it is suspected that executives' limited familiarity with telecommuting might influence their attitudes or preferences. Only 16 percent of the executives reported being very familiar with telecommuting, although 61 percent were somewhat familiar, suggesting that a substantial number of the sampled executives may have only limited

TABLE 1 Number of Executive Questionnaires Sent and Received, by Business Sector, by City

Primary Activity	# of organizations selected				# of questionnaires delivered				# of questionnaires received			
	A	D	H	T*	A	D	H	T	A	D	H	T
Accounting	1	2	3	6	5	7	66	78	3	3	10	16
Advertising	1	1	2	4	5	30	6	41	4	10	1	15
Architecture	0	1	1	2	0	2	11	13	0	0	7	7
Banking	0	0	1	1	0	0	4	4	0	0	0	0
Computer/software	4	3	3	10	17	8	21	46	4	0	4	8
Engineering	1	2	0	3	5	8	0	13	1	6	0	7
General consultant	1	0	1	2	3	0	4	7	0	0	0	0
Government	0	1	1	2	0	2	6	8	0	2	0	2
Hospital/medical	2	1	0	3	8	30	0	38	2	6	0	8
Insurance	1	2	3	6	1	16	8	25	1	0	1	2
Law	1	2	1	4	2	37	1	40	0	3	0	3
Manufacturing	1	1	2	4	2	5	8	15	0	0	1	1
Oil	0	2	3	5	0	8	9	17	0	0	1	1
Publishing/translating	2	0	0	2	7	0	0	7	6	0	0	6
R & D	3	0	0	3	15	0	0	15	0	0	0	0
Real estate	1	1	0	2	2	2	0	4	1	0	0	1
Stocks	1	1	1	3	4	3	2	9	1	1	0	2
Telecommunications	1	1	2	4	1	3	7	11	1	0	1	2
Travel	1	1	0	2	5	1	0	6	2	0	0	2
Total	22	22	24	68	82	162	153	397	26	31	26	83

* A: Austin
D: Dallas
H: Houston
T: Total

TABLE 2 Executive and Organizational Characteristics

Characteristics	Categories	Relative frequency (%)
Gender	Male	77.1
	Female	22.9
Age	Under 30	21.7
	31-40	32.5
	41-50	38.6
	51-60	6.0
	above 60	1.2
Educational level	Finished high school	2.4
	Some college or university	4.8
	Finished college or university	53.0
	Master	31.3
	Ph.D.	4.8
	Other	3.6
Familiarity of telecommuting	very familiar	16.0
	somewhat familiar	60.5
	not familiar	23.5
Awareness of someone who telecommutes	yes	36.6
	no	63.4
Number of subordinates directly supervised	0-5	34.6
	>= 6	65.4
Methods of supervision (check all that apply)	review meetings	87.7
	written reports	74.1
	activity logs	33.3
	on-site supervision	77.8
	time-sheets	64.2
	review completed task	84.0
Number of personal computers available to the staff	0	6.2
	1-4	40.7
	>= 5	53.1
Number of dedicated word processors available to the staff	0	55.6
	1-4	30.8
	>= 5	13.6
Number of mainframe terminals available to the staff	0	55.6
	1	16.0
	2	3.7
	>= 3	24.7
Number of terminals interconnected through an internal network	all	45.8
	more than 75%	15.7
	less than 50%	20.5
	none	18.1
Existence of employees who telecommute in the organization	yes	16.9
	no	66.3
	not aware	16.9
Existence of flex-time programs in the organization	yes	31.7
	no	67.1
	not aware	1.2

appreciation of telecommuting. However, no explicit questions were included to test the extent of familiarity. In addition, about 40 percent of the respondents knew someone who telecommutes.

Organizational Characteristics

With respect to the penetration of the technologies normally associated with telecommuting, about 53 percent of the executives indicated that at least five personal computers were available to their staff, with 35 percent indicating at least 10; 44 percent of the executives reported the availability of at least one mainframe terminal and 28 percent reported at least two. Statistically, the average number of personal computers among sampled organizations was 18.9, and 4.3 for mainframe terminals. Additionally, on a per-employee basis, the average number of personal computers per supervised staff member was 1.1 across the surveyed organizations, which dropped to 0.2 for mainframe terminals. In terms of the current

availability of optional work arrangement in the organization, 32 percent of the executives mentioned that there was a flexible work schedule program, and about 17 percent reported that some employees telecommuted at least on a part-time basis.

In addition to statistics based on individual executives, information from each organization as a unit was also analyzed. Among the sixteen organizations with only one executive questionnaire received, three indicated a flex-time program (FTP) and four reported that telecommuting is available in the organization. Within the other fifteen organizations with more than one questionnaire, six had a consensus on the availability of a FTP among the sampled executives, with only one indicating yes and five indicating no; there was consensus among all sampled executives in seven organizations that telecommuting is not available. For organizations without agreement among the responding executives, six had more than half of the responding executives answering yes to the availability of an FTP and three had more than half of the responding executives answering no; two had more than half of the executives answering yes to the availability of telecommuting, and six had more than half answering no. The results revealed that only about half of the organizations with more than one sampled executive had a consensus on the company's current offering of an FTP or telecommuting, and the consensus was overwhelmingly on the lack of availability of such programs. Further investigation showed that six organizations had inconsistent responses from their executives on both questions; all of them had more than 200 employees, indicating that the inconsistency may result from the relatively large size of the organization.

EMPLOYER ATTITUDES TOWARD TELECOMMUTING

This section discusses executives' responses to questions intended to capture their attitude towards telecommuting. First, the logic underlying the design of the attitudinal questions is validated by a confirmatory factor analysis of the responses. A discussion of the responses is presented next, followed by statistical tests aimed at identifying the principal characteristics of the executives and their organizations that influence the executives' attitudes.

Question Design Logic and Confirmatory Factor Analysis

Twelve attitudinal questions included in the executive survey are indicated in Table 3. Those questions were designed to measure four general attitudes that are believed to affect the employer's likelihood of adopting telecommuting. These attitudes pertain to the effects of a telecommuting program on the following:

1. Telecommuting workers and public image of the organization (Questions 1, 2, 5, and 8);
2. Nontelecommuting workers (Questions 3 and 6);
3. Workers overall (Questions 4 and 7); and
4. Managerial effectiveness and related concerns (Questions 9, 10, 11, and 12).

TABLE 3 Responses to Attitudinal Questions

Questions	Responses (relative frequency, in %) 1 *very negative*	2	3 *neutral*	4	5 *very positive*
Suppose your staff were part of a voluntary telecommuting program in which eligible employees worked from their homes twice a week. What effect do you think such a telecommuting program would have on:					
1. the firm's ability to retain and recruit employees ?	4.9	11.1	29.6	39.5	14.8
2. telecommuting employee productivity ?	18.3	31.7	31.7	13.4	4.9
3. non-telecommuting employee productivity ?	16.0	28.4	48.1	7.4	0.0
4. overall staff productivity ?	17.1	30.5	30.5	20.7	1.2
5. telecommuting employee morale ?	8.6	4.9	19.8	50.6	16.0
6. non-telecommuting employee morale ?	11.1	32.1	45.7	11.1	0.0
7. overall employee absenteeism ?	11.0	13.4	52.4	18.3	4.9
8. the firm's public image ?	12.2	17.1	45.1	20.7	4.9
9. your ability to manage your workload ?	19.5	36.6	23.2	13.4	7.3
10. your ability to communicate with your staff ?	20.7	37.8	30.5	8.5	2.4
11. your ability to supervise your staff ?	29.3	40.2	24.4	4.9	1.2
12. security of data and information ?	14.6	25.6	50.0	4.9	4.9

A confirmatory factor analysis using the SAS CALIS procedure (*8*) was performed to verify whether the variation of responses to those twelve questions could be explained by the four general attitudes. The measured variables in the factor analysis model corresponded to the responses to these questions. Formal testing indicated significant correlation between responses to the questions (*9*). Therefore, a factor analysis was appropriate.

The specified factor pattern and estimated results are indicated in Table 4. Correlations between factors are also specified in the model. The results in Table 4 indicate that all loadings were significantly different from 0 at the 0.01 level. In addition, ten variables loaded on the specified factors with values greater than 0.60, usually considered a high loading, whereas no variable had a loading less than 0.30, a low loading. Statistics such as the goodness-of-fit index (GFI = 0.86) and adjusted GFI (0.77) and inspection of the residual correlation matrix indicated that the models fit the observed data well and therefore support the design structure.

Discussion of Responses

Executives' responses to the attitudinal questions are summarized in Table 3. With respect to the possible effects of a telecommuting program on telecommuters and the image of the organization, 26 percent of the executives believed that the effect on the image would be positive, but about the same fraction believed that the effect would be negative (Question 8). However, more than half of the executives (54 percent) believed that instituting a telecommuting program would help the organization retain and recruit employees (Question 1). Interestingly, whereas 67 percent of the respondents indicated that the effect on the telecommuting workers' moral would be positive (Question 5), only 18 percent believed that telecommuters would increase their productivity (Question 2). This result clearly reflects the executives' concerns about the telecommuters' work performance.

Executives generally expected a telecommuting program to exert a negative influence on workers who do not telecommute. In response to Questions 3 and 6, 44 percent of the executives believed that the effect would be negative on both the productivity and morale of nontelecommuting workers, whereas only about 10 percent thought it would be positive in both cases. In addition, about 50 percent of the executives expected a negative effect on overall staff productivity, whereas only 22 percent expected a positive effect (Question 4). The effect on overall employee absenteeism is believed to be neutral, with 24 percent indicating positive and an equal fraction indicating negative impacts (Question 7).

Management issues have long been considered to be the major barrier to an employer's adoption of telecommuting. The responses to related questions (9 through 12) indicate that more than half of the executives thought telecommuting would have negative effects on their ability to manage the workload (56 percent), their communications with the staff (59 percent), and their supervision (70 percent). Additionally, more executives (40 percent) believed that telecommuting would have a negative effect on data security than did executives (10 percent) who thought the effect would be positive. These findings confirm widely expressed thoughts in the literature that some managers are reluctant to adopt telecommuting because of serious concerns about their ability to retain proper management control.

Cross-Tabulated Tests

To identify the factors that influence executives' attitudes toward telecommuting, the responses to each attitudinal question were cross-tabulated with the characteristics of the executives and their organizations listed in Table 2 to examine their independence. Because of the relatively small executive sample, Fisher's exact tests (*10*), instead of the commonly used chi-squared test, were performed for the test. Table 5 summarizes the test results for seven of

TABLE 4 Estimated Factor Pattern from Confirmatory Factor Analysis

Variables	Factor 1	Factor 2	Factor 3	Factor 4
1	0.62(5.8)			
2	0.85(8.9)			
3		0.98(8.2)		
4			0.88(8.7)	
5	0.62(5.9)			
6		0.65(5.6)		
7			0.58(5.4)	
8	0.62(5.8)			
9				0.68(6.6)
10				0.85(8.9)
11				0.90(9.8)
12				0.40(3.5)

* The t values are listed in the parentheses.

TABLE 5 Results of Fisher's Exact Tests of Responses to Attitudinal Questions

Variables	Attitudinal questions											
	1	2	3	4	5	6	7	8	9	10	11	12
job title									*			
number of subordinates directly supervised	#	+			*				*			
method of supervision		+							#	*		
familiarity with telecommuting		*			+					*	*	
awareness of someone who telecommutes		#	#	*			*			*		*
penetration of telecommunications and computing technologies				+							*	
presence of telecommuters in the organization			*						*	*	*	#

+ : significant at the 0.10 level, but not at the 0.05 level

* : significant at the 0.05 level, but not at the 0.01 level

: significant at the 0.01 level

null hypothesis: The responses to attitudinal questions are independent to the variables listed in the first column.

the above variables that have statistically significant effects on the responses to at least one question. In marked contrast to the data on employees (*6*), none of the executives' socioeconomic characteristics appeared to exert significant effects on their attitudes toward telecommuting. Instead their attitudes were primarily influenced by management-related characteristics and the availability of telecommunications facilities in the organizations.

The executive's expectation of the effect of telecommuting on his/her ability to manage the workload was influenced by the job title: fewer presidents or vice presidents (5 percent), who generally possess greater power in the decision process than others (20 percent), believed the effect is positive. As expected, executives with fewer subordinates were more likely to have positive attitudes than others: 29 percent of the executives with less than six subordinates, traditionally the recommended span (Group 1), felt that telecommuters would increase their productivity, a feeling shared by only 13 percent of other executives (Group 2). Similarly, about 32 percent of the executives in Group 1 expected a negative effect on the telecommuter's productivity, whereas 58 percent in Group 2 had the same expectation. Apparently, spans of management also affected the executives' attitudes toward the influence of telecommuting on their workload. Whereas less than half (46 percent) of the executives in Group 1 thought that this influence would be negative, more than half (60 percent) of the executives in Group 2 thought so.

The test results indicate that methods of supervision affect the executives' attitudes as well: 58 percent of the executives who rely on "reviewing completed tasks" as a way of supervising subordinates felt that telecommuting would negatively affect their communications with the staff, whereas a larger portion (69 percent) of executives not using this method had the same expectation. In addition, whereas only 22 percent of executives who use "written reports" but not "on-site supervision" believed that telecommuters would decrease their productivity, about 55 percent of the other executives believed so. Clearly, executives who supervise employees by reviewing the final accomplishment, and not by looking over their shoulders during work hours, are more inclined to report positive attitudes toward telecommuting.

To the extent that telecommuting has not been widely adopted in Texas, the executives' awareness of telecommuting is expected to affect their attitudes. The test results are consistent with this hypothesis. In general, fewer executives who were familiar with telecommuting (Group 1) than others (Group 2) expected a negative effect from telecommuting: 53 percent of the executives in Group 1 expected a negative effect on their communication with staff, compared with 84 percent in Group 2. Extremely, almost all executives (95 percent) in Group 2 believed their ability to effectively supervise would be negatively affected. This percentage, however, dropped to 62 percent for respondents in Group 1. In addition, among executives who know someone who telecommutes, more respondents (33 percent) believed that telecommuters' productivity would increase than did respondents (23 percent) who believed that productivity would decrease. On the other hand, among executives who are not aware of someone who telecommutes, a large fraction (67 percent) believed that the productivity would decrease, whereas only about 10 percent believed that productivity would increase.

The penetration of relevant technologies within the organization has positive impacts on executives' attitudes. About 38 percent of the executives in organizations with more than five personal computers and two mainframe terminals believed that telecommuting would increase the productivity of staff overall, whereas only 19 percent of the other executives had the same expectation. In addition, whereas only 38 percent of the executives in organizations with technology penetration thought that telecommuting would have a negative effect on their ability to supervise, 75 percent of the other executives thought so. Executives in organizations with a telecommuting program (Group 1) are more likely to exhibit posi-

tive attitudes as well: in this group, more respondents (43 percent) believed that the effect on their workload would be positive than respondents (36 percent) who believed it would be negative. In addition, about 72 percent of the respondents in organizations without such a program (Group 2) believed that the effect on their ability to supervise would be negative, whereas only 43 percent in Group 1 had the same expectation. Different attitudes between the two groups were also manifested with respect to the influence of telecommuting on data security. In Group 2, 48 percent thought the influence would be negative and only 2 percent thought it would be positive. On the other hand, 36 percent of the executives in Group 1 expected a negative effect, and an equal percentage expected a positive effect.

STATED PREFERENCES FOR TELECOMMUTING ALTERNATIVES

This section discusses responses to questions about the executives' willingness to support a telecommuting program in an organization under various program scenarios. After a discussion of the responses to each scenario, an exploratory analysis of some of the underlying factors influencing these responses is presented.

Discussion of Responses

Table 6 lists the executives' responses to nine different telecommuting program scenarios, defined on the basis of who assumes the additional costs of telecommuting and the corresponding salary changes to telecommuting employees. For each scenario, executives were asked to state their willingness to support such a telecommuting program in the organization from one of the following responses: 1, yes; 2, possibly; and 3, no.

Scenario 1 was designed as the cost-neutral "status quo" from the employer's standpoint: the employee's salary (ES) remains the same and the employer incurs no additional costs. Under this scenario, about 67 percent of the executives would support the telecommuting program. Keeping the ES fixed, this percentage decreases as the costs incurred by the employer increase. This is confirmed by the results of Questions 2 and 3: the percentage decreased to 51 percent under Scenario 2 (some costs assumed by the em-

TABLE 6 Responses to Stated Preference Questions for Telecommuting Program Scenarios

Telecommuting and Program Scenario	Responses (relative frequency, in percent) 1 *Yes*	2 *Possibly*	3 *No*
1. Employee's salary stays the same; employer incurs no costs	33.3 (35.5)	33.3 (29.0)	33.3 (35.5)
2. Employee's salary stays the same; employer assumes some costs	25.9 (25.8)	24.7 (19.4)	49.4 (54.8)
3. Employee's salary stays the same; employer pays all costs	25.9 (32.3)	14.8 (12.9)	59.3 (54.8)
4. Employee's salary decreases 5%; employer incurs no costs	8.8 (0.0)	31.3 (38.7)	60.0 (61.3)
5. Employee's salary decreases 5%; employer assumes some costs	5.0 (0.0)	28.8 (22.6)	66.3 (77.4)
6. Employee's salary decreases 5%; employer pays all costs	7.5 (0.0)	15.0 (16.1)	77.5 (83.9)
7. Employee's salary increases 5%; employer incurs no costs	7.5 (9.7)	15.0 (16.1)	77.5 (74.2)
8. Employee's salary increases 5%; employer assumes some costs	7.5 (9.7)	8.8 (9.7)	83.8 (80.6)
9. Employee's salary increases 5%; employer pays all costs	8.8 (9.7)	7.5 (6.5)	83.8 (83.9)

Note: Numbers in parentheses are relative frequency in terms of responding organizations. Responses were received from executives in 31 organizations.

ployer) and further to 41 percent under Scenario 3 (all costs are paid by the employer).

A priori, Scenario 4 (the ES decreases 5 percent and the employer incurs no additional cost) was thought to dominate all others from the employer's point of view. However, the results do not support this assumption. Compared with Scenario 1, the percentage of telecommuting supporters dropped to 40 percent under Scenario 4, to 34 percent under Scenario 5 (the ES decreases 5 percent and the employer assumes some costs), and to 23 percent under Scenario 6 (the ES decreases 5 percent and the employer pays all costs). Apparently, a 5 percent decrease in the employee's salary does not stimulate executives' willingness to support telecommuting. On the contrary, it appears to decrease the percentage of supporters by about 20 percentage points (when the organization does not incur additional costs). This somewhat unexpected finding suggests that executives probably recognize that it would be unfair to penalize employees who wish to telecommute if they continue to perform the same job duties. Furthermore, executives undoubtedly recognize that a program that reduces employees' salaries will not be viewed favorably by the employees and would therefore lead to poor public image. Results from Scenarios 4 through 6 also exhibit the tendency noted earlier of decreasing support for telecommuting by executives as the additional costs incurred by the employer increase.

Although executives in general do not seem inclined to reduce telecommuters' salaries, they certainly do not believe that telecommuters should receive a salary increase. The latter appears to be even less tolerable than the former. Under Scenario 7 (the ES increases 5 percent and no additional cost to the employer), the percent of telecommuting supporters dropped to 23 percent and further dropped to 16 percent if the employer was required to assume some or all costs (Scenarios 8 and 9, respectively). Again, the tendency of telecommuting support to decrease as the employer's additional costs increase remains.

With these results it is possible to estimate the percentage of "hard-core" telecommuting supporters (executives who answered yes to every scenario) at less than 10 percent and those who would not support telecommuting under any circumstances at over 35 percent. Compared with employees' results, about 15 percent for both extremes (*6*), the present result implies that executives are more reluctant to adopt telecommuting than are employees. However, because voluntary telecommuters require the approval of their supervisors, the executive's attitudes and preferences play a decisive role in the initiation and adoption of a telecommuting program (*11*). The implication from these results is that an effort to remove management barriers would be essential to encourage a telecommuting adoption.

The stated preferences for telecommuting program scenarios are also summarized on the basis of the responding organizations and are listed in Table 6 (in parentheses, below the percentage of executives). Overall, the relative frequency distributions are comparable to those based on the individual executive's responses. For organizations with more than one sampled executive, the organizational response to each question is represented by the majority of its sampled executives. Further investigation of the responses within these organizations indicates that most of the inconsistencies appear to be in responses to the first three scenarios.

Cross-Tabulated Tests

Responses to alternative telecommuting scenarios were also cross-tabulated using Fisher's procedure with respect to the same variables considered in the analysis of the executives' attitudes. Only four variables, indicated in Table 7, were found to significantly affect the executives' stated preferences toward telecommuting. Variables that did not affect the executives' attitudes have no bearing on their preferences either.

TABLE 7 Results of Fisher's Exact Tests of Responses to Stated Preference Questions

	Stated preference questions								
Variables	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
job title	#	*	*						
number of subordinates directly supervised	#	*	+						
method of supervision									
familiarity with telecommuting									
awareness of someone who telecommutes	+			+			*	#	#
telecommunications technology adoption	*	+	+		*				
existence of telecommuters in the organization									

+ : significant at the 0.10 level, but not at the 0.05 level

* : significant at the 0.05 level, but not at the 0.01 level

: significant at the 0.01 level

Null hypothesis: The responses to attitudinal questions are independent to the variables listed in the first column.

Consistent with the attitudinal results, executives with less power in the decision-making process exhibited a stronger preference for supporting a telecommuting program: whereas relatively few presidents or vice presidents indicated their support under the first three scenarios (30, 25, and 15 percent, respectively), more than 50 percent of other executives indicated such support (78, 58, and 50 percent, respectively). Spans of management affect executives' preferences as well. A large fraction of executives with less than six subordinates would support telecommuting (89 percent, 67 percent, and 55 percent for the first three scenarios, compared with 54, 40, and 31 percent, respectively, of other executives). As expected, the executive's awareness of someone who telecommutes increases his or her support for telecommuting: about 79 percent of such executives would support telecommuting under the first scenario, whereas 59 percent of the other executives would.

The penetration of related technologies is the only organizational characteristic that significantly influences executives' preferences. Again, these effects are manifested mainly under the first three scenarios. The percentage of telecommuting supporters drops from 69, 69, and 62 percent (for Scenarios 1 through 3, respectively) of executives whose organizations have more than five personal computers and two mainframe terminals (Group 1) to 65, 45, and 35 percent, respectively, of the other executives (Group 2). Another interesting result appears from this analysis. Although the percentage of telecommuting supporters in Group 1 remains approximately the same from Scenarios 1 through 3, the corresponding percentage drops substantially in Group 2 as the additional costs incurred by the organization increase. As indicated earlier, most of the effects of these four variables are exhibited by the executives' preferences under the first three scenarios. This may result from the fact that considerably fewer executives would support telecommuting under the other scenarios, especially the last four.

COMPARISON OF EMPLOYEE AND EXECUTIVE STATED PREFERENCES FOR TELECOMMUTING ALTERNATIVES

Data obtained from both employees and executives in the same organizations provide an opportunity to compare their respective preferences toward telecommuting. The responses from five organizations with at least three sampled executives were selected for this comparison. Again, the Fisher's exact test was used for independence tests because of the small executive sample in each selected organization.

Test results (Table 8) of the responses to six scenarios asked of both employees and executives clearly reveal that employees have stronger preferences for telecommuting than executives. Among all respondents, for example, most employees (88 percent) would like to telecommute under Scenario 3 (employee salary remains the same and employer pays all costs), whereas only 41 percent of the executives would support such a program. The divergence between the responses from the two groups is maximal under Scenario 6, theoretically the best scenario for employees and the worst for executives (employee salary increases 5 percent and employer pays all costs). Whereas about 87 percent of the employees would like to telecommute under this scenario, only 16 percent of the executives would support it.

Similar results were found within individual organizations. For example, a dominant majority of employees (95 percent) from the publishing firm would like to telecommute under Scenario 3, but only 40 percent of the executives would support it. The difference within the architectural firm is also dramatic: about 83 percent of its employees desire to telecommute under Scenario 6, supported by only 29 percent of its executives. These results are confirmed by Kendall's tau-b measures (*10*), as listed in Table 9, most of which

TABLE 8 Results of Fisher's Exact Tests of Responses from Employees and Executives to Various Telecommuting Program Scenarios

	Scenario					
Organizations	**1**	**2**	**3**	**4**	**5**	**6**
1 accounting firm [07;3]						
2 advertising firm [17;4]			#			*
3 architects firm [12;7]		*				+
4 computer software firm [28;3]					*	#
5 publishing firm [109;5]			#		+	#
6 all firms [695;83]	#		#	#	#	

Note 1: Numbers in brackets are [# of employee responses received; # of executive responses received].

Note 2 (scenarios)

1: employee salary: the same	employer: some costs (employee: a new telephone number)
2: employee salary: the same	employer: some costs (employee: a personal computer)
3: employee salary: the same	employer: all costs
4: employee salary: - 5%	employer: all costs
5: employee salary: + 5%	employer: some costs
6: employee salary: + 5%	employer: all costs

Note 3
+ : significant at the 0.10 level, but not at the 0.05 level
* : significant at the 0.05 level, but not at the 0.01 level
# : significant at the 0.01 level

TABLE 9 Results of Kendall's TAU-B Measures of Responses from Employees and Executives to Various Telecommuting Program Scenarios

Organizations	Scenarios 1	2	3	4	5	6
1 accounting firm [07;3]	.27 (.24)		.59 (.16)	.32 (.13)	.59 (.16)	.66 (.18)
2 advertising firm [17;4]	.42 (.14)	.32 (.15)	.57 (.12)		.45 (.11)	.51 (.12)
3 architects firm [12;7]			.34 (.21)		.24 (.22)	.27 (.24)
4 computer software firm [28;3]				.24 (.07)	.41 (.11)	.52 (.13)
5 publishing firm [109;5]	.11 (.09)		.29 (.11)		.19 (.06)	.26 (.08)
6 all firms [695;83]	.11 (.04)		.30 (.04)	.12 (.03)	.31 (.03)	.37 (.03)

Note 1: Numbers in brackets are [# of employee responses received; # of executive responses received].

Note 2 (scenarios)

1: employee salary: the same	employer: some costs (employee: a new telephone number)
2: employee salary: the same	employer: some costs (employee: a personal computer)
3: employee salary: the same	employer: all costs
4: employee salary: - 5%	employer: all costs
5: employee salary: + 5%	employer: some costs
6: employee salary: + 5%	employer: all costs

Note 3 : Standard error estimates for 95% confidence intervals are listed in parentheses.

are positive and significantly different from 0 at the 5 percent level. For the given measure design (for respondents: 1 if an employee and 2 if an executive; for responses: 1 if yes, 2 if possibly, and 3 if no), positive measures indicate that executives are more likely to answer no than employees.

CONCLUSION

It has been at least two decades since the notion of telecommuting emerged in the United States. However, information and evidence about the adoption of telecommuting programs by employers are still limited. This paper has presented an exploratory analysis of the responses to a detailed survey of the attitudes and stated preferences of executives toward telecommuting in selected organizations in three Texas cities. The goal was to develop a better understanding of the decision processes and factors underlying the adoption process. The results of this study have confirmed some speculation in the literature that management issues constitute the major barrier against greater support of telecommuting programs by executives. The results also indicate that executives' awareness of telecommuting substantially reduces this barrier, suggesting that as the concept of telecommuting becomes more familiar to executives, more adoption of telecommuting may be expected. The responding executives were not inclined to support telecommuting programs in which the participating employee's salary would be reduced. This finding should alleviate some employee concerns because the financial aspects of telecommuting programs have been found (*6*) to be a major concern of most employees.

The survey results also strongly indicate that executives are overall more reluctant than employees to support telecommuting. To the extent that public policy objectives favor greater adoption of telecommuting, it appears that there should be a greater effort to inform executives, especially those in the upper echelons of the decision-making process, such as presidents or vice presidents. In addition, management concerns about employees' productivity, executives' ability to supervise telecommuters, and security of data need to be alleviated.

Although the results from this study are undoubtedly limited by the relatively small sample, the analysis yielded useful insights into factors most likely to influence an employer's adoption of telecommuting. In addition to their direct substantive interest and policy relevance, these insights provide useful guidelines for the development of formal mathematical models of adopting telecommuting for both employees and employers and the subsequent development of a predictive capability in this regard.

ACKNOWLEDGMENTS

This paper is based on a study sponsored by the state of Texas Governor's Office (Oil Overcharge Funds) through the Region 6 U.S. Department of Transportation Southwest Region University Transportation Center. The authors are grateful to Mark A. Sullivan for his contribution to the telecommuting survey. Gorge Joji, undergraduate research assistant, performed most of the computer data entry. Thanks are also due to respondents who participated in the survey.

REFERENCES

1. Katz, A. I. The Management, Control, and Evaluation of a Telecommuting Project: A Case Study. *Information and Management,* Vol. 13, 1987, pp. 179–190.
2. DeSanctis, G. Attitudes Towards Telecommuting: Implications for Work-At-Home Programs. *Information and Management,* Vol. 7, 1984, pp. 133–139.
3. Salomon, I. and M. Salomon. Telecommuting: The Employees' Perspective. *Technological Forecasting and Social Change,* Vol. 25, 1984, pp. 15–28.
4. *The Telecommuting Phenomenon: Overview and Evaluation.* Transportation Planning Department, Southern California Association of Government, 1985.
5. Kitamura, R., K. Goulias, and R. M. Pendyala. *Telecommuting and Travel Demand: An Impact Assessment for State of California Telecommute Pilot Project Participants.* Research Report UCD-TRG-RR-90-8. Transportation Research Group, University of California, Davis, 1990.
6. Mahmassani, H. S., J.-R. Yen, R. Herman, and M. A. Sullivan. Employee Attitudes and Stated Preferences Towards Telecommuting: An Exploratory Analysis. In *Transportation Research Record 1413,* TRB, National Research Council, Washington, D.C., 1993, pp. 31–41.
7. Fishbein, M., and I. Ajzen. *Belief, Attitude, Intention and Behavior: An Introduction to Theory and Research.* Addison-Wesley, Reading, Mass., 1975.
8. *SAS/STAT User's Guide,* Version 6. SAS Institute, Inc., 1990.
9. McDonald, R. P., *Factor Analysis and Related Methods.* Lawrence Erlbaum Associates, New Jersey, 1985.
10. Schlotzhauer, S. D., and R. C. Littell. *SAS System for Elementary Statistical Analysis.* SAS Institute Inc., 1987.
11. *Implementation Plan: Telecommuting Pilot Project for the Southern California Association of Governments.* Southern California Association of Governments, 1986.

The views expressed in this paper are those of the authors and do not necessarily reflect those of the project sponsors.

Publication of this paper sponsored by Committee on Telecommunication and Travel Behavior.

How Much Telecommuting Should We Count On? A Forecast for Tel-Aviv in 2020

ILAN SALOMON

Telecommuting is suggested as one of a series of transportation demand management measures designed to reduce commuting trips. In the process of planning the transportation system for the Tel-Aviv metropolitan area for the year 2020, it became necessary to forecast the extent to which trip tables can be reduced as a consequence of expected levels of telecommuting. In the absence of an appropriate behavioral model to forecast the demand for telecommuting, a simple modeling approach is presented. This model is based on the assumption that, for telecommuting to take place, certain conditions must be met: jobs must be amenable, employers must agree, employees must desire to telecommute, and so on. The simple model assumes the probability that each of these conditions will be satisfied and calculates the number of potential telecommuters and trips eliminated on the basis of the joint probability of the necessary conditions.

Transportation planners are increasingly searching for ways to curb the growth of the demand for travel, particularly of the drive-alone mode. The high direct costs of road construction, the high social costs of automobile ownership and use, in both developed and developing countries, is of increasing concern. Among the variety of means considered, there is a growing interest in the potential substitution of travel by telecommunications (*1–4*). With commuting trips being at the heart of the congestion problems in many urban areas, the options of performing remote work, substituting for commuting, are of particular interest.

Telecommuting is the substitution of commuting by work done at home or in a remote (neighborhood) work center, for part or full time, that has positive effects on congestion. Although at present there is only limited adoption of formal telecommuting arrangements, it is nevertheless desirable to assess the potential of this option in the long term.

The forecasts of telecommuting have largely overestimated the pace of growth of its adoption. Most forecasts have assumed that the potential elimination of unpleasant and costly commuting trips, as well as the flexibility involved in many telecommuting arrangements are so attractive that the option to telecommute will be widely requested. Few forecasts are based on analytical approaches, and even those often fall short of addressing all the relevant issues. Only recently have behavioral modeling approaches been offered (*5*). Formal models at this point are primarily contributing to a conceptual understanding of the role various factors play in the decisions associated with working at home; however, because they are based primarily on self-selected samples, the validity of these factors for forecasting purposes is limited.

As part of the transportation planning for the metropolitan area of Tel-Aviv for the year 2020, a forecast of telecommuting was called for. Specifically, the question posed was the extent to which a reduction in the growth of trip tables can or should be taken into account by planners.

This paper presents the results of a simple approach that provides some forecasts of telecommuting. The second section presents the rationale and essence of the simplified approach. The third section discusses the details of the forecast for the Tel-Aviv metropolitan area and the major findings. Finally, the fourth section presents some conclusions drawn from this study.

SIMPLIFIED APPROACH TO FORECASTING TELECOMMUTING

How much telecommuting will take place in the future is a question of relevance to a number of policy makers, including those involved in the planning of the infrastructure of telecommunications, transportation, real estate, and other social services. In the area of transportation, the specific question is how much substitution can be expected and, hence, to what degree could future trip tables (origin-destination matrices) be reduced?

A variety of forecasting techniques have been used by researchers, producing a very wide range of forecasts (*2*). For example, Nilles (*4*), adopting a technological substitution approach, produced a range of forecasts that may not be sufficiently narrow for planning purposes. The main shortcoming of forecasts presented to date is that they fall short of accounting for the complexity of the telecommuting phenomenon.

A number of studies that attempt to develop behavioral models of telecommuting are under way (*5,6*). However, these are still in their infancy and cannot provide the long-term forecasts necessary for current planning practice.

The approach presented here is a very simple one that relies on an elimination process. It is based on the identification of seven conditions, five of which must be satisfied for telecommuting to take place. On the basis of the likelihood that these conditions will be met, a calculation of the number of trips that can be expected to be eliminated in the future is presented.

In most metropolitan areas, the introduction of new corridors is not a viable option. Increasingly, planners are concerned with the environmental problems of a city and with the consequences of growing congestion on the economy of the metropolitan area. Consequently, the current effort to develop a long-range transportation plan, with 2020 as its target year, has included telecommuting as an option that needs to be considered as a measure to mitigate the growth of commuter traffic in the city.

Very long-range forecasting is subject to numerous limitations, most notably the inability to forecast the values and norms to prevail in future generations. Very clearly it is already possible to observe how today's children assimilate computers differently from

Department of Geography, The Hebrew University of Jerusalem, 91905, Israel.

most adults. However, because forecasts are needed now, some assumptions must be made, in lieu of factual information. To produce a usable forecast, the following forecasting approach makes specific assumptions about these necessary and supporting conditions.

The rationale of a simplified approach involves the following attributes. First, it entails reliance on available data. Second, only a simple "back-of-the-envelope" calculation method is used. In the following example, the calculations were performed on a spreadsheet program. Explicit assumptions are crucial in this approach, as in any other. All of the above attributes result in a quick turnaround, which allows for "sensitivity analyses" to examine the implications of the assumptions integrated in the analysis. The process as applied here consists of a number of stages, as depicted in Figure 1. The model assumes that five conditions must be satisfied, that is, they must have nonzero probability. The conditions are assumed to be independent, and thus the model uses a multiplicative form of joint probability. The model may be used with various levels of detail, depending on the particular need and available resources.

Necessary Conditions for Telecommuting

Seven conditions that enable telecommuting were identified. Five of the seven are necessary conditions that must be satisfied, whereas the remaining two are supporting conditions. They are (schematically) indicated in Figure 1. Each will be briefly discussed.

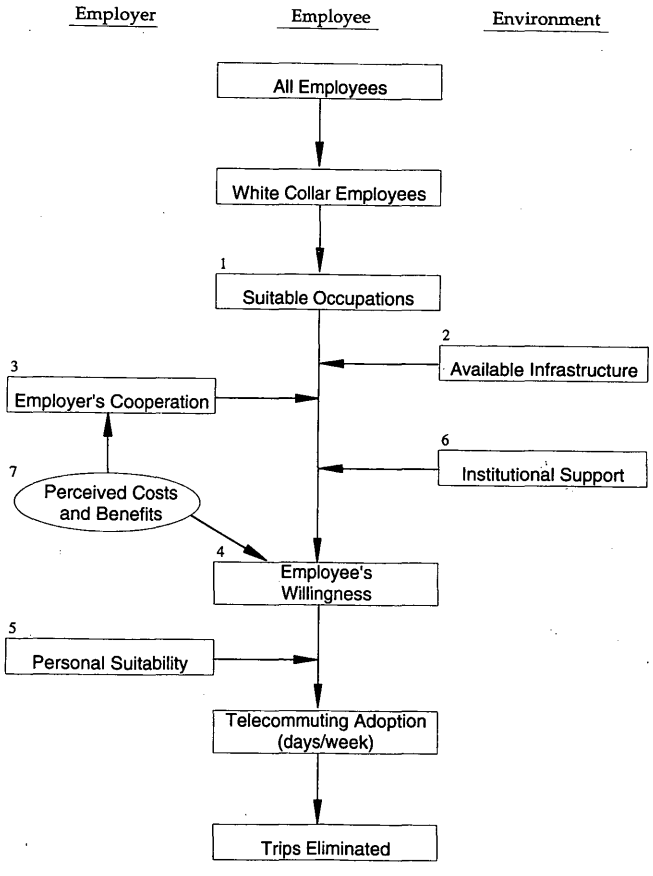

FIGURE 1 Screening process: conditions for telecommuting.

Condition 1: Job Suitability

Not every job can be done from a remote location. Clearly some occupations require on-site performance, as in the case of operation of equipment or personal interaction with the public. Occupations vary in the degree to which they are suitable for remote performance, and it is necessary to identify, for each job description, the extent to which it is amenable for remote operation. This condition will be further elaborated.

Condition 2: Infrastructure Availability

Working from a remote location requires that certain facilities be available to the worker, including such instruments as a telephone, a terminal or a computer, and a modem, but not necessarily all of them.

Condition 3: Employers' Willingness

Workers cannot unilaterally adopt telecommuting. It is necessary that such arrangements be accepted by the employers. Employers' support consists of the organization's stand on telecommuting and to some extent on the attitude of the individual manager who supervises the telecommuter. Both are necessary and may not always coincide. Employers are likely to weigh a number of factors before they engage in supporting telecommuting, such as the following:

1. An expectation that remote work will bring about cost savings, particularly with regard to space requirements. The potential for such savings is not quite clear. On the one hand, the cost of office space is known to be an important factor in office location. On the other hand, in many U.S. cities there seems to be an over supply of office space, resulting in attractive offers by the real estate industry. Moreover, if a large share of the labor force will in fact telecommute, office space costs are likely to decrease and offers may become even more attractive. Another related issue is the question of how much space can, in fact, be saved if employees telecommute only 1 to 3 days a week and hence still require a space in the office. Thus, employers' support on the basis of cost savings may be more of wishful thinking than actual savings.
2. Productivity gains should be expected, or at least no decrease should occur. Numerous reports indicate that the flexibility to work at home does in fact result in productivity gains. Consequently, employers are likely to view telecommuting as a positive measure.
3. There should not be any damage to the employer's image. Some employers may be concerned that having an "invisible" workforce may not contribute to the image of the organization. Moreover, if telecommuting may emerge to have a gender bias, the additional effects on the image may play a role.
4. There will be no opposition on behalf of related institutions, namely the government and the labor unions. This condition is separately discussed, but it is noted here because it may affect the employer's position.
5. The employers are to have the right to decide which employee may engage in telecommuting. One can expect that employers will not allow all employees automatically to engage in such arrangements, on the basis of job requirements, whether real or perceived by particular managers, and on the basis of the individual worker's characteristics.

6. At the managers' level, the question is whether they feel that they can successfully perform their own jobs if their subordinates are not present.

In summary, the employer's position is expected to be based on a series of factors, each of which can be assessed differently by individual employers.

Condition 4: Employees' Willingness

Research on employees' attitudes toward telecommuting and their willingness to engage in such arrangements can be divided to two types. The first emphasizes the benefits side, such as the time and cost savings and the potential increase in family time. This research type is often based on responses to direct questions presented to individuals. In general, these studies suggest a wide-ranging demand for telecommuting arrangements. The second type presents a more critical view, noting that along with the benefits there may also be some costs, such as slower promotion, responsibility for equipment, and social isolation. Thus, this type of research attempts to emphasize a more balanced, some may argue skeptical, perspective.

The decision of individuals of whether to adopt telecommuting is not yet quite understood, and empirical evidence at this point is too limited to identify the likely behavior. It can reasonably be assumed that the market consists of numerous segments, each of which assigns different weights to the variety of benefits and costs associated with telecommuting. In any case, it is unanimously accepted that telecommuting is a voluntary arrangement; hence Condition 4 is defined as being the employee's willingness to engage in telecommuting.

Condition 5: Personal (Employee) Suitability

Personality attributes affect the ability of some people to work by themselves with little or no supervision, whereas others need the office environment to help them execute their tasks. These attributes refer to self-discipline, level of organization, and other factors. Hence, not all people can perform telecommuting satisfactorily (from the employer's perspective and possibly even from their own). Employers require the right to determine who can take part in telecommuting. Some telecommuting consultants who have interviewed candidate telecommuters report that about 70 percent of the candidates can be considered suitable from a personality perspective (*7*). There are no other sources to substantiate this figure.

Supporting Conditions

In addition to the necessary conditions, there are at least two supporting conditions, which, if fulfilled, will strongly encourage the wide-scale adoption of telecommuting. For the long-term forecast, it is assumed that people will be aware of the telecommuting option (*6*), and therefore it is not defined as a condition.

Condition 6: Institutional Support

Working at home in formal arrangements requires that some legal issues be attended to: for example, liability, insurance, and employee rights. Both governments and labor unions need to at least agree to if not support such working arrangements, if these are to be offered to employees.

Condition 7: (Perceived) Costs and Benefits of Telecommuting

Both major actors in the adoption process, the employers and the employees perceive the costs and benefits of telecommuting in ways that do not necessarily reflect the actual costs and benefits. However, it is the perceived value that affects their decision to undertake telecommuting.

Telecommuting is "marketed" on the basis that individuals will enjoy significant savings from the elimination of commuting trips. Common notions on commuting describe it as a cost imposed, particularly on suburban residents, who must spend much time and costs traveling to work. An increase in commuting costs will certainly encourage more individuals to consider the alternative offered by telecommuting. However, telecommuting may not be the single alternative for coping with rising commuting costs. An individual may make a variety of adjustments to reduce commuting costs, such as a change of departure time, a change of mode, use of a more comfortable car, and so on. Thus, telecommuting is just one option of a very wide range of coping strategies (*2*; unpublished data).

Forecasting Potential of Telecommuting for Tel-Aviv

The Tel-Aviv metropolitan area is the largest in Israel. It lies along the Mediterranean coast, with about 1 million inhabitants presently living in it. Most of the current population growth is in the outer ring of metropolitan communities. Consequently, Tel-Aviv is already suffering from severe congestion on the major corridors leading to the central city. At present, Tel-Aviv has only one rail link serving it from the north; thus almost all workers must rely on buses and automobiles for commuting. Tel-Aviv is clearly the greatest center of employment and commercial activities in Israel.

Step 1: Forecasting Total Employment for 2020

The data in Table 1 are for the total labor force in Israel because data at a comparable level of detail for Tel-Aviv are not available. The next step is to determine the share of workers in the Tel-Aviv metropolitan area. The metropolitan area is defined by the Central Bureau of Statistics (CBS) to include the district of Tel-Aviv and some parts of the central district, as shown in Figure 2. In 1989 there were 598,700 employees working in the Tel-Aviv metropolitan area and 683,000 in the central district (including those within the metropolitan part of the district).

The total employment in the Tel-Aviv metropolitan area was forecast under a separate task of the long-range planning process (*9*). The employment forecasts are for three very broadly defined economic sectors: commercial, services, and manufacturing. Assuming that white-collar occupations fall primarily in the second group, the growth assumptions for the 2020 distribution of jobs (Table 2) are based on the growth projected in the study by the Israel Institute for Transportation Planning and Research (IITPR).

TABLE 1 Number of Workers in Job Categories Suitable for Remote Work, 1989 (*8*)

CBS Code		Occupation	Number of employees	Percent Female
0		Scientific and Academic		
	02	Engineers & Architects	27000	12
	05	Lawyers	10000	27
	06	Academics,in Social science[1]	11300	45
	07	Academics in Humanities[2]	6400	78
	0x	Others[3]	4000	--
1		Professional and Technical		
	11	Accounting	8700	14
	12	Authors, artists & Journalists	22500	49
	18	System An. & Programmers	12500	36
	19	Others[4]	6700	16
2		Managers		
	all	Managers	83700	16
3		Clerical		
	30	Supervising Clerks	15800	42
	31	Accounting clerks	75700	66
	32	secretaries and typists	56500	98
	34	Communications workers	5200	(80)[5]
	37	General office clerks	36100	80
	38-9	Other clerks	27000	60
4		Sales workers		
	43	Insurance workers	9700	15

[1] This category includes a variety of occupations who are university graduates and not included in other classifications.

[2] This class includes a large share of teachers.

[3] This includes other employees in class 0 whose jobs are suitable.

[4] Out of this figure, 3000 are in para-engineering (code 176) of whom we assumed 55% may be suitable for remote work.

[5] Low statistical reliability.

Step 2: Forecasting Share of White-Collar Employment

The share of white-collar employment in the Tel-Aviv district is slightly higher than the national average (50.0 percent compared with 46.6 percent). For the target year it has been assumed that the share of white-collar employment in the metropolitan region will remain at 50 percent. This is assumed to be a conservative figure, biased upwards, because it is likely that further suburbanization of employment will disperse these and other jobs to the exurban areas in the central district.

Step 3: Identifying Job Suitability

This step is aimed at the identification of the fulfillment of Condition 1, namely, the job suitability. It involves two stages: one for the current situation and one for the forecast date.

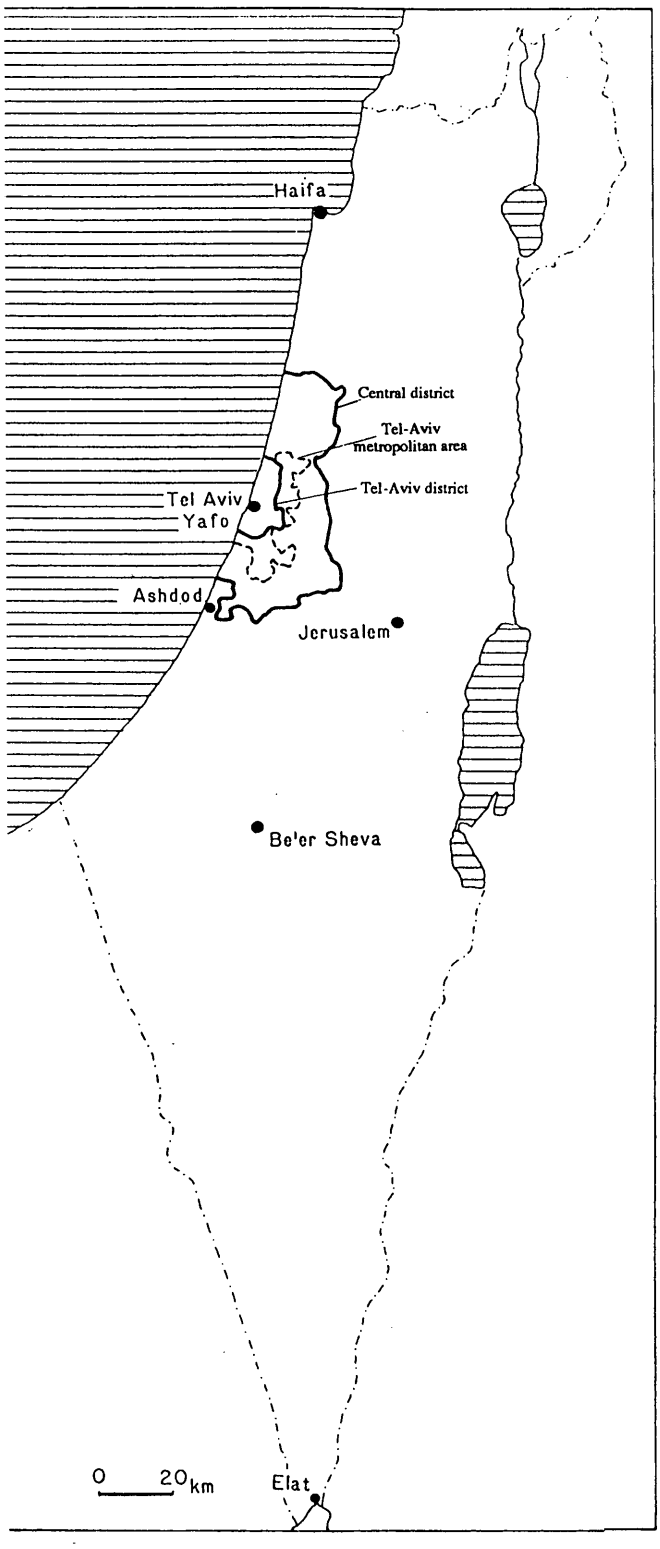

FIGURE 2 Tel-Aviv and central districts of Israel.

Current Job Distribution. For each job type an assumption was made about the share that could perform work from a remote location. Two considerations were taken into account. First, the share of employees assumed to be involved primarily in data or information manipulation, as part of their routine performance. The second criterion was the extent to which the physical presence at the work place is considered important or vital for the performance of the job. For example, whereas in principle teachers could teach from a remote location, at least by present norms, their physical presence at the work place is considered crucial.

Table 1 presents the job categories and the numbers of workers assumed suitable for remote work in Israel for 1989. The table presents the two-digit job classification of the CBS for those occupations whose jobs seem suitable for remote work. The assumptions made on the basis of the two-digit classification may be judged as crude, and a finer analysis of job content on the basis of more detailed classification may be in place. However, for the present context, we accept these assumptions as sufficiently detailed.

The above data represent 51 percent of all employees in the occupation Codes 0 through 4, but there are wide variations. Specifically, in Category 0, the 124,400 employees represent 47 percent of all in that category. In Categories 1 through 4, the respective shares are 22, 100, 86, and 8 percent.

Table 1 also denotes the share of women in each category. Clearly, some occupations are so-called pink occupations in which the share of women is predominant. This point should be considered because the introduction of telecommuting may have differential impacts along gender lines if some occupations are more likely than others to be offered for telecommuting.

Forecasting Occupational Distribution for 2020. This step focuses on the question of whether the distribution shown in Table 1 will change toward the target year. One possible approach to respond to that issue is to adopt a general assumption that Israel will follow a trend evident in other, more advanced economies.

A comparison of the occupation structure in Israel (1989) and the United States [1986 data, based on U.S. Bureau of Census (*10*)] is complicated by the differences in definitions. However, some categories are comparable. For example, the share of systems analysts and programmers is similar in both countries, whereas the share of secretaries and typists in Israel is only 3.86 percent of the labor force compared with 4.82 percent in the United States. This figure indicates that Israel does not lag in information-related occupations but is probably lagging in the level of service in white collar work because of the lower numbers of secretaries.

On the basis of the U.S. forecasts of occupations (*10,* Table 626), the labor force will grow by 19 percent between 1986 and 2000 (intermediate growth assumption), but secretarial and clerical jobs will grow by 7 and 20 percent, respectively. Typists and data entry clerks will increase by 16 and 14, respectively. Systems analysts and computer programmers are expected to increase their share and reach 1 percent of the labor force by the end of the decade.

It can be assumed that in the time horizon considered for this forecast, technological development in machine-readable data entry will reduce the number of jobs in simple clerical and data entry positions. Notably, these are precisely the types of jobs that, from a job suitability perspective, are most amenable for telecommuting.

In Israel, clerical jobs have grown by only 10 percent in the decade between 1980 and 1990 (*11*), whereas professional and technical occupations have grown by 34 percent and managers have grown by 66 percent. To an extent, this growth may be attributed to changes in definitions (which may permit salary increases) but also to the sharp decrease in the number of accounting clerks, which

TABLE 2 Forecasts of Telecommuting by Occupation, 2020

Optimistic Scenario							
A	B	C	D	E	F	G	H
Code	Title	1989	Growth 2020	Emp 2020	% Suitable	Poten. 2020	Poten. 1989
02	Engineers	14108	2.50	35269	70	24688	9875
05	Lawyers	5225	2.40	12540	70	8778	3658
06	Soc.Sci	7054	2.30	16224	80	12979	5643
07	Humanit	3344	2.22	7424	80	5939	2675
0*	Other 0	2100	2.20	4620	50	2310	1050
11	Account	4546	2.35	10683	60	6410	2727
13	Artists etc	11756	2.30	27039	85	22983	9993
18	Compu.pro	6531	3.20	20900	65	13585	4245
19	Other 1	3501	2.40	8402	60	5041	2101
2	Managers	43733	2.40	104960	50	52480	21867
30	Sup. Clerk	8256	2.30	18988	30	5696	2477
31	Accnt.Cls	39553	1.40	55375	60	33225	23732
32	Typists	29521	1.03	30407	75	22805	22141
34	Commun.	2717	2.75	7472	30	2242	815
37	Gen. Clerk	18862	2.45	46213	30	13864	5659
38-9	Oth.Clerk	14108	2.45	34563	40	13825	5643
43	Insurance	5068	2.35	11910	50	5955	2534
Total		219983	2.06	452987		252805	126834
Minimalist Scenario							
A	B	C	D	E	F	G	H
Code	Title	1989	Growth 2020	Emp 2020	% Suitable	Poten. 2020	Poten. 1989
02	Engineers	14108	2.50	35269	40	14108	5643
05	Lawyers	5225	2.40	12540	40	5016	2090
06	Soc.Sci	7054	2.30	16224	30	4867	2116
07	Humanit	3344	2.22	7424	30	2227	1003
0*	Other 0	2100	2.20	4620	25	1155	525
11	Account	4546	2.35	10683	20	2137	909
13	Artists	11756	2.30	27039	40	10816	4703
18	Compu.pro	6531	3.20	20900	40	8360	2613
19	Other 1	3501	2.40	8402	20	1680	700
2	Managers	43733	2.40	104960	25	26240	10933
30	Sup. Clerk	8256	2.30	18988	5	949	413
31	Accnt.Cls	39553	1.40	55375	30	16612	11866
32	Typists	29521	1.03	30407	30	9122	8856
34	Commun.	2717	2.75	7472	10	747	272
37	Gen. Clerk	18862	2.45	46213	10	4621	1886
38-9	Oth.Clerk	14108	2.45	34563	15	5185	2116
43	Insurance	5068	2.35	11910	20	2382	1014
Total		219983	2.06	452987		116224	57658

in turn may be attributed to the increasing role of computers in this area.

Among clerical workers, there was a very slight increase in the number of typists and secretaries and a very significant increase (81 percent) in the number of "general office clerks" (Code 37) between 1986 and 1989. This figure may be indicating an increase in the number of office workers whose work is more complex than simple secretarial work and consequently may be less amenable to telecommuting.

In summary, the expected changes in the distribution of occupations seem to develop in two contradictory trends: on the one hand, an increase in computer-related occupations and on the other hand, a decrease in the number of simple clerical occupations.

Step 4: Defining Range of Conditions Tested

In this step, assumptions are made about the levels of Conditions 2 through 7. In this particular forecasting effort, these levels were collapsed into one step. However, on the basis of the judgment of the forecaster, as to the desired or affordable level of detail, each condition can be treated as a separate step.

Given the nature of the current effort, it was decided that the forecast should lean toward optimistic conditions. Hence, the following was assumed:

1. Condition 2, regarding the availability of the infrastructure, will be set at 100 percent; that is, the infrastructure does not impose any constraint on the adoption of telecommuting. This is an optimistic assumption not because of the availability of the necessary technology but more so because of the treatment of costs, implied in this assumption. Costs are assumed not to hinder telecommuting.
2. Condition 3, the employers' support, is assumed to be satisfied and set to 100 percent. This again means that there will be no opposition on behalf of the employers. This optimistic assumption is adopted on the basis of assumed governmental and public pressure to adopt as many Transportation Demand Management (TDM) measures as possible, telecommuting being one of them. Thus, the assumed high level of employer support is based, in turn, on the assumption that employers wish to take a "politically correct" position.
3. Condition 4 addresses the employees' standing with respect to telecommuting. Here two assumptions were set: one that tends to be more optimistic and a second that tends to be a minimalist position. At present, there is no clear indication of how many employees really would like to telecommute. In response to the simple question, Would you like to work at home?, a simple affirmative response is often given. It is also unclear to what extent the current studies reflect the general population of white-collar employees or just a narrow group of self-selected individuals. More elaborate studies that attempt to model the choice of telecommuting are under way but still do not provide forecasting of this choice. The assumptions made here are thought to refer to the total white-collar segment, including the large number of individuals who work as what may be labeled "manual information workers," that is, they are employed in tasks of information processing that do not require intellectual involvement. The assumption is that these workers may place greater weight on the social interaction at the workplace (*12*), and hence a lower desire to telecommute. The optimistic assumption was set to 80 percent of the employees wishing to work from their homes, and the minimalist assumption was set to 50 percent.
4. Condition 5, personal suitability, was set to 70 percent, on the basis of reports by telecommuting consultants involved in the process of screening individuals at organizations (*7*).
5. Condition 6 refers to institutional support. Again, under the desire to identify the upper bounds of potential trip savings, it was assumed that there is 100 percent support. Government and labor unions are assumed here not to impose any restrictions on the adoption of telecommuting.
6. Condition 7 refers to the perceived costs (and benefits) of telecommuting to the employer and the employee. Given the assumed complete support of employers, their perception is not addressed here and only the employees' perception is discussed here. In the face of increasing congestion, an individual may consider a wide set of responses for coping with these rising costs (*2*; unpublished data). These strategies include a change in departure time, a change of mode, relocation of home or workplace, telecommuting, and although they are last, two unrecognized approaches are seemingly popular coping strategies. The first is the acceptance of costs; that is, individuals adjust by accepting the costs of congestion as a given and lower their expectations and anxiety associated with traveling on congested systems. The second is lowering the costs by improving the amenities during travel—more comfortable cars, air conditioning, better sound systems, cellular telephones, and so on—instruments that effectively lower the costs of the time lost traveling. Other, long-term coping strategies may also be employed. In fact, Gordon et al. (*13*) report that despite claims of rising congestion in American cities, actual commuting travel times do not substantiate the common notions. This may be a reflection of the fact that, although more facilities are congested more hours per day, individuals have adjusted in ways so that similar travel times are maintained. If this is a correct interpretation, then the likelihood of switching to telecommuting because of congestion is somewhat diminished.

In Israel, where it is believed (although not tested by research) that the car serves as a status symbol, the latter strategy is attractive because it fulfills two objectives simultaneously. Hence, rising congestion costs experienced (and expected to continue in the future) in the Tel-Aviv metropolitan area are likely to affect individuals primarily in the direction of a solution that does not necessarily move people out of their cars. The assumption adopted here does not necessarily support telecommuting.

Step 5: Calculations

The results of the simple calculations of the trip reductions are indicated in Tables 2 and 3. The former is the calculation of the distribution of suitable occupations for the Tel-Aviv metropolitan area for the target year (2020). The latter is the actual calculation of trips eliminated by each occupation.

Table 2 is based on the share of employment in the occupations listed in Table 1, and Column C presents the data for 1989 (the deviation from 50 percent is attributed to the inclusion of the city of Ashdod in the metropolitan area in this forecasting effort). Data in Column D are the assumed occupation-specific growth rates that were derived by judgment on the basis of the overall growth rate produced by IITPR (*9*). The resulting number of workers in each category in 2020 are shown in Column E.

As noted earlier, Table 1 includes all workers in each class whose job description is, in principle, a candidate for telecommuting. However, not all employees in these jobs can perform work from a

TABLE 3 Forecast of Trip Reduction as a Result of Telecommuting

Optimistic Scenario							
A	B	C	D	E	F	G	H
Code	Title	1989	Emp 2020	Poten. 2020	Time Away(%)	Screen-ing	Trips Saved
02	Engineers	14108	35269	24688	60	0.56	8295
05	Lawyers	5225	12540	8778	70	0.56	3441
06	Soc.Sci	7054	16224	12979	70	0.56	5088
07	Humanit	3344	7424	5939	70	0.56	2328
0*	Other 0	2100	4620	2310	60	0.56	776
11	Account	4546	10683	6410	70	0.56	2513
13	Artists etc	11756	27039	22983	80	0.56	10297
18	Compu.pro	6531	20900	13585	60	0.56	4565
19	Other 1	3501	8402	5041	60	0.56	1694
2	Managers	43733	104960	52480	50	0.56	14694
30	Sup. Clerk	8256	18988	5696	40	0.56	1276
31	Accnt.Cls	39553	55375	33225	70	0.56	13024
32	Typists	29521	30407	22805	85	0.56	10855
34	Commun.	2717	7472	2242	40	0.56	502
37	Gen.Clerk	18862	46213	13864	25	0.56	1941
38-9	Oth.Clerk	14108	34563	13825	25	0.56	1936
43	Insurance	5068	11910	5955	25	0.56	834
Total		219983	452987	252805			84058
Minimalist Scenario							
A	B	C	E	E	F	G	H
Code	Title	1989	Emp 2020	Poten. 2020	Time Away(%)	Screen-ing	Trips Saved
02	Engineers	14108	35269	14108	25	0.35	1234
05	Lawyers	5225	12540	5016	25	0.35	439
06	Soc.Sci	7054	16224	4867	20	0.35	341
07	Humanit	3344	7424	2227	25	0.35	195
0*	Other 0	2100	4620	1155	25	0.35	101
11	Account	4546	10683	2137	20	0.35	150
13	Artists	11756	27039	10816	50	0.35	1893
18	Compu.pro	6531	20900	8360	40	0.35	1170
19	Other 1	3501	8402	1680	20	0.35	118
2	Managers	43733	104960	26240	20	0.35	1837
30	Sup. Clerk	8256	18988	949	20	0.35	66
31	Accnt.Cls	39553	55375	16612	25	0.35	1454
32	Typists	29521	30407	9122	50	0.35	1596
34	Commun.	2717	7472	747	20	0.35	52
37	Gen. Clerk	18862	46213	4621	20	0.35	323
38-9	Oth.Clerk	14108	34563	5185	20	0.35	363
43	Insurance	5068	11910	2382	20	0.35	167
Total		219983	452987	116224			11499

remote location. Column F presents the assumed share of workers in each category who can telecommute. For example, under the optimistic scenario, it is assumed that 80 percent of the workers in social sciences and humanities (Codes 06 and 07) can become candidates for telecommuting from a job suitability perspective. Similarly, only 30 percent of the supervising clerks can do so because their jobs require much more social presence. Column G presents the number of workers in each category who are defined as candidates, from the job suitability perspective. The total numbers for 2020 are 252,805 and 116,224 workers for the optimistic and minimalistic scenarios, respectively.

Table 3 is a continuation spreadsheet, in which Column E is identical to Column G in Table 2. The next assumption relates to the amount of time each category of telecommuters can stay at home. These assumptions are presented in Column F of Table 3. For example, it is assumed that telecommuting engineers can work from home 60 percent of the time, although general clerks can do so only 25 percent of the time. These assumptions are based on judgments.

Column H in Table 3 presents the screening factor composed of two conditions. First, the personality condition, in which the 70 percent suitability has been assumed for both scenarios, although one may argue that this is an optimistic figure. The second is the employee's willingness condition, which in the optimistic scenario is assumed to be 80 percent and in the minimalistic scenario is assumed to be 50 percent. The product of both conditions is presented in Column G. Finally, in Column G the number of trips eliminated is presented. Under the optimistic scenario this amounts to 84,058 person trips and in the minimalistic scenario only 11,499 trips are eliminated.

IMPLICATIONS AND CONCLUSIONS

The numbers derived from the calculations presented earlier, 84,058 and 11,499 person trips for the optimistic and minimalistic scenarios, respectively, can be challenged on a number of grounds. However, before doing so, it is necessary to translate these figures into policy-making inputs.

First, these numbers represent 5.6 and 0.8 percent of the total number of work trips in the year 2020. Because these are person trips, they must, for planning purposes be translated into vehicle trips. If under an optimistic assumption only car trips are considered and a 1.1 occupancy rate is assumed, then the figures are reduced by about 9 percent. However, a more likely situation is that many of these trips will be diverted from transit because transit is a priori perceived as a less convenient mode of travel and therefore more likely to be traded off for telecommuting; then the numbers are reduced even further.

Although the numbers are relatively small and do not seem to be of a magnitude that justifies a change in the 2020 trip tables, one could refine the assumptions and argue that because congestion is more severe on the radial corridors to Tel-Aviv, the reductions mentioned earlier will not be uniformly distributed in the metropolitan area but are more likely to be realized on congested facilities.

These numbers can also be challenged on the grounds that they are based on either too optimistic or too pessimistic assumptions. Although such arguments are legitimate on the basis of persuasion, it is believed that the two scenarios provide the range of likely outcomes, and for each argument in one direction, a counter argument can be suggested. One particular optimistic assumption that was not explicitly mentioned is that for telecommuting to take place, all parties involved, and in particular the employer and employee, must agree on such arrangements simultaneously. If that fails, the forecasts presented earlier will be significantly lower. The aforementioned assumption that the conditions are independent is also a simplification of reality. It is very likely that some of the conditions are intertwined, and thus the multiplicative form may distort some of the probabilities assumed earlier.

Forecasting a phenomenon with which little empirical experience exists and that carries much hope for relieving problems that cannot be miraculously solved by any single measure is a serious challenge. The simple approach presented in this paper provides an order of magnitude of what can be expected. However, it is necessary to move ahead to behavioral models that can better explain under what circumstances individuals are likely to choose telecommuting in one of the many forms in which it may be offered. Such studies will provide input into the design of policies to encourage trip elimination. An important by-product of such studies will be the explanation of trip generation behavior in situations in which trips need not be made (*14*).

ACKNOWLEDGMENT

Comments by Ilan Gilor and Tomer Gudovich of IITPR and Eran Feitelson of the Hebrew University are gratefully acknowledged.

REFERENCES

1. Boghani, A., E. Kimble, and E. Spencer. *Can Telecommunications Help Solve America's Transportation Problems?* Arthur D. Little, Cambridge, Mass., 1991.
2. Salomon, I. Studying Telecommuting As a Complex Solution. Presented at University of California, Irvine, Conference on Telecommuting—A New Way to Work, 1991.
3. Mokhtarian, P. Defining Telecommuting. In *Transportation Research Record 1305,* TRB, National Research Council, Washington D.C., 1991, pp. 273–281.
4. Nilles, J. Traffic Reductions by Telecommuting: A Status Report. *Transportation Research A,* Vol. 22A, No. 4, 1988, pp. 301–317.
5. Bernardino, A., M. Ben-Akiva, and I. Salomon. A Stated Preference Approach to Modelling the Adoption of Telecommuting. In *Transportation Research Record 1413,* TRB, National Research Council, Washington, D.C., 1993, pp. 22–30.
6. Mokhtarian, P., I. Salomon, S. Saxena, and S. Sampath. *Modeling the Choice of Telecommuting: Setting the Context.* Research Report UCD-ITS-RR-92–12. Institute of Transportation Studies, University of California, Davis, 1992.
7. Nilles, J. Panel Discussion at University of California, Irvine, Conference on Telecommuting—A New Way to Work, 1991.
8. *Labor Force Survey.* Special Report 894. Central Bureau of Statistics, Jerusalem, 1990.
9. *Tel-Aviv Metropolitan: A Forecast of Socio-Economic Characteristics for 2020.* Working Paper. Israel Institute for Transportation Planning and Research, Tel-Aviv, 1992 (in Hebrew).
10. *Statistical Abstract of the United States.* U.S. Bureau of the Census, Washington, D.C., 1988.
11. *Statistical Abstract of Israel-1990.* Central Bureau of Statistics, Jerusalem, 1991.
12. Shamir, B., and I. Salomon. Telecommuting and the Quality of Working Life. *Academy of Management Review,* Vol. 10, 1985, pp. 455–463.
13. Gordon, P., H. Richardson, and M. J. Jun. The Commuting Paradox, Evidence from the Top Twenty. *APA Journal,* Vol. 57, No. 4, 1991, pp. 416–420.
14. Jones, P., and I. Salomon. Technological and Social Developments and Their Implications for In Home/Out of Home Interactions. In *Europe on the Move.* P. Nijkamp (ed.), Avebury, Aldershot, England, 1992, pp. 95–113.

Publication of this paper sponsored by Committee on Telecommunication and Travel Behavior.

Development of Interactive Visualization Tool for Effective Presentation of Traffic Impacts to Nonexperts

PANOS PREVEDOUROS, DAVE BRAUER, AND RANDOLPH J. SYKES

The effective presentation of traffic impacts to a broad range of public and private constituencies is an essential part of the approval process for proposed improvements to transportation infrastructure. The increased sophistication of audiences and demand for greater participation by the public in decision-making processes makes effective public education an essential component of transportation planning efforts. A tool was developed for the interactive visualization of traffic impacts (IVTI) that offers clear, comprehensive, and effective views of proposed transportation enhancements. IVTI is essentially a tool for visualizing and organizing the output of traffic engineering models. Its main advantages compared with those of existing traffic simulation and animation programs are that IVTI does not require any training for users to understand the displayed results; roadway layouts and vehicles are photorealistic instead of simplified geometric representations; and adjacent land uses are in full display, which permits a more direct assessment of the consequences of the proposed traffic plans. The traffic model currently employed by IVTI is TRANSYT-7F. The IVTI system has two primary components: a development system and a delivery system. The development system generates a template of the presentation into which the audio, video, and image assets are captured in digital form and integrated into the general presentation framework. The TRANSYT-7F analysis results are imported into IVTI and converted into data structures (e.g., roadways and vehicles), resulting in a photorealistic visualization of the underlying model. The delivery system, a scaled-down, portable version of IVTI equipped with video projection capabilities, enables interactive presentations of the visualizations of the subject transportation improvement to an audience.

This paper presents the development of an original computer-driven tool focused on the interactive presentation of traffic impacts. The development of the tool arose from the need for effective presentations to decision makers and to the general public so that planned transportation improvements can achieve a level of support (both in citizen sentiment and in funding allocations) leading to successful implementation. The goal of the project was to develop a turnkey hardware and software system enabling the Hawaii Department of Transportation (HDOT) to visualize the results of planned traffic improvements using multimedia imagery and visualization techniques.

The resulting tool is called IVTI, acronym for interactive visualization of traffic impacts. IVTI visualizations and presentations are developed for a Macintosh. IVTI is driven by the results of TRANSYT-7F (T7F), which is a widely used traffic simulation program. The ultimate vision for IVTI is to be able to present results from a variety of engineering and planning computer applications. T7F runs on a personal computer (PC) host, and output reports are transferred to the IVTI system in file format.

IVTI combines T7F outputs with corresponding visual and audio information to create technically effective and aesthetically appealing presentations. IVTI is capable of providing multimedia visualizations from both the "bird's eye" view (i.e., 1 mi = 1 screen) and "over intersection" view (i.e., 100 ft = 1 screen) of the section of roadway under analysis. Traffic on the roadway is represented either as simulated traffic (individual cars) or as symbolic flows (color-coded arrows), depending on user preference and the volume of traffic being modeled. At a minimum, visualized data include the information contained in the summary reports output by the traffic model. The user can call up detailed numeric reports of traffic flow at each intersection as well as explanatory media such as audio, video, graphics, and text. Furthermore, the presenter can use IVTI interactively to answer questions from the audience.

The need for effective presentations (primarily to nonexperts of the fields of traffic and transportation engineering or planning) was the driving force behind the development of IVTI. This need is discussed in the next section, followed by a detailed presentation of IVTI in another section. The fourth Section presents T7F, the underlying traffic simulation program, as well as a case study done for IVTI. Finally the fifth section summarizes the presentation, appraises the achievements so far, and discusses planned and potential future enhancements.

NEED FOR EFFECTIVE PRESENTATIONS

General

In his book Guerilla Marketing, Jay Conrad Levinson states that "every type of entrepreneurial enterprise requires marketing. There are no exceptions. It's not possible to succeed without marketing." Few engineers and transportation planners consider themselves to be entrepreneurs, let alone marketing professionals. In fact, few planners in government think in private-sector terms, such as competition, results orientation, and customer-driven objectives. In the era of re-inventing government, however, well-focused marketing of public works projects can mean the difference between public acceptance or lack of funding.

The result of one's failure to market proposals for public works projects convincingly has been an increase both in the number of projects that remain unfunded as well as in the success of special interest organizations at being able to stop projects from proceeding as planned. In not promoting the benefits of and in communi-

P. Prevedouros, Department of Civil Engineering, University of Hawaii at Manoa, 2540 Dole Street, Suite 383, Honolulu, Hawaii 96822. D. Bauer, Pacific International Center for High Technology Research, 2800 Woodlawn Drive, Suite 180, Honolulu, Hawaii 96822. R. J. Sykes, Statewide Transportation Planning Office, Department of Transportation, State of Hawaii, 600 Kapiolani Boulevard, Suite 306, Honolulu, Hawaii 96813.

cating inadequately the risks associated with many projects, government agencies have not provided requisite infrastructure to ensure that problems such as congestion are well managed for the common good.

The effective presentation of traffic impacts to a broad range of public and private constituencies has become an increasingly essential part of the approval process for proposed improvements to transportation infrastructure. Examples abound of transportation projects that have not materialized because of lack of public support. The failure of the Honolulu rapid transit system is the most recent of a long line of transportation improvements in Hawaii that have failed despite the compelling need for congestion relief. Each of these initiatives, had they proceeded as planned, would have provided a substantial long-term benefit in the form of added transportation capacity.

What caused these initiatives to fail was, in large part, the lack of good marketing. Government did not provide the public with a clear picture of the benefits of and alternatives to these projects in a way that made it clear that the associated costs were both justified and reasonable. The case can be made that lack of an effective presentation of the impacts of planned infrastructure improvements and related alternatives analyses was responsible in great measure for the demise of these and other projects in Honolulu and elsewhere. Although the means of disseminating information to broad cross sections of the public have grown tremendously during the past 20 years, government entities have been slow to adopt new techniques for delivering ideas about public works improvements and even slower to recognize the increased sophistication of the public with respect to its understanding of issues.

With the advent of the Intermodal Surface Transportation Efficiency Act of 1991, state and metropolitan planning organizations are now mandated to provide opportunities for public involvement in all phases of transportation planning. In the eyes of many planners, this requirement underscores the need for better tools to educate the public about transportation and public works issues. As the public increases its participation in analyzing transportation deficiencies, its knowledge base will increase exponentially, as will its ability to understand a range of solutions and considerations much broader than what otherwise may have been envisioned. It will be increasingly difficult to sell engineering-defined solutions to traffic problems without effective marketing.

Presentations to Decision Makers

Elected and appointed officials make funding decisions about complex public transportation projects on the basis of their individual understanding of the project as well as on a range of political and other considerations. From a transportation planner's perspective, it is essential that these decision makers have the benefit of the essential engineering analyses underlying a project. Often, the planner's access to the decision maker is limited, and opportunities to explain the intricacies of alternatives may be lacking. Transportation engineers, by their training and professional standards, traditionally respond to public works needs with analyses that result in "correct" solutions. Such linear problem solving often does not lend itself to the dynamic world in which politicians operate. Frequently there is a communications gap that can result in unrealistic expectations on the part of the public and inadequate resources to carry out the project as the engineers have envisioned.

Transportation planners must market their ideas to decision makers every bit as effectively as they do to the public. Given the constraints that have been identified, it is clear that a presentation tool is necessary to ensure that the essential information about a project is communicated as effectively and efficiently as possible. Ideally, such a tool should have the ability to

- Define the scope of the project,
- Delineate the alternatives that have been considered,
- Provide all relevant information concerning risks,
- Establish costs and contingency factors, and
- Give a clear picture of the improvements resulting from the project.

In addition, the tool should be able to mitigate the effects of any public-speaking deficiencies that an individual planner may have.

IVTI Concept

IVTI has been developed as a tool for delivering a clear, comprehensive, and effective view of proposed transportation enhancements. The system has been structured to provide a flexible, low-cost marketing platform that meets the needs of government planners to answer questions about transportation initiatives by both decision makers and the public. It meets this need in two ways:

- IVTI helps deliver the before-and-after visual impact of planned improvements to an audience on the basis of computer-supported analyses of alternatives, costs, and benefits.
- IVTI can be used either as an interactive component of a live presentation or in a stand-alone, kiosk-type delivery mode so that the public can interact with the system directly.

As opposed to other forms of audiovisual presentation assistance, IVTI's flexibility allows the presenter to tailor the information to the needs of each audience. Individuals witnessing the presentation see real-life roadways and simulations on the basis of analyses done by computer-based models. The aerial and driver-level views that IVTI provides make it possible for persons in the audience to understand otherwise complex mathematical outputs quickly and to weigh the pros and cons of various alternatives on the basis of these visualizations. Questions from the audience may be answered by reference to any of the menu-driven screens containing underlying data about the proposed transportation improvement.

IVTI SYSTEM

System Overview

Significant benefits could be realized if multimedia visualization capabilities were developed for the data contained in a T7F final report (*1*). T7F operates strictly in batch mode so truly interactive modeling and simulation of a traffic network, with a multimedia front end for visualization, would not be possible using this package. However, a DOT traffic engineer or planner could use T7F to develop several different options for a given traffic network, saving each report as a separate ASCII text file. A multimedia visualization of the traffic network for each option examined could be developed using IVTI. The T7F report files would be used as input for setting up the parameters of the multimedia visualization. Each

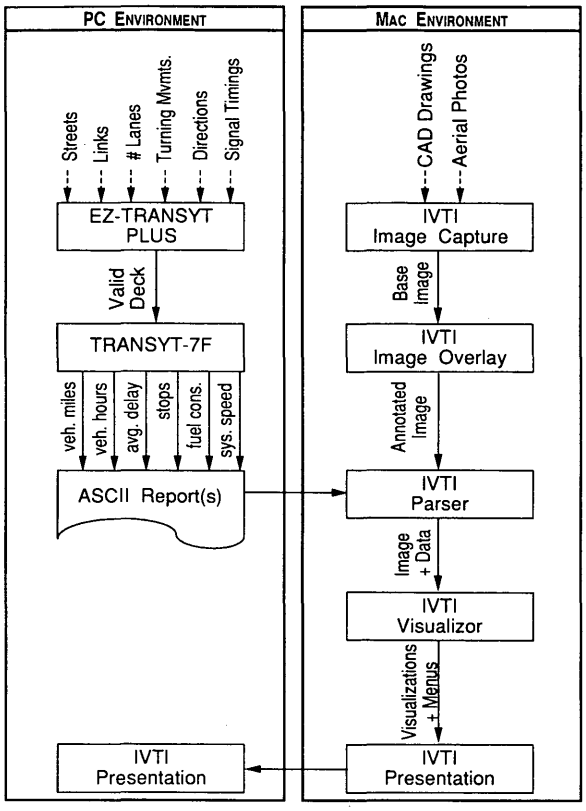

FIGURE 1 IVTI system overview.

option for the traffic network could be "visualized" and then organized as a single presentation showing the before, during, and after effects for a proposed roadway improvement. The overview of this system is shown in Figure 1.

Suppose, for example, that a traffic engineer was developing new signal plans for the recently widened portions of a highway. The first step would be to collect all data necessary for running T7F. The next step is the input of data for use by T7F. This can be done by using either the T7F input module or one of several available user-friendly data manager and preprocessing software; EZ-TRANSYT has been used in the IVTI applications so far (*2*). The traffic engineer would use T7F to output the report files for the existing conditions and for the planned improvements, including the best settings for traffic signals.

Simultaneous with these analyses, a multimedia visualization of the highway would be developed using IVTI. A graphical, overhead view of the highway would be produced using either digitized aerial photographs or computer-assisted drawings. The highway traffic network would be overlaid on the aerial view using tools provided within IVTI to identify objects modeled within T7F, such as intersections, linkages, and turning movements.

Once the multimedia visualization was complete, the report files from T7F would be imported into IVTI. The user would use an option within IVTI to set up a master menu for the visualization, identifying each report file and annotating it with some explanatory text (e.g., Hwy_1: Existing traffic conditions on the recently widened highway, Hwy_2: Traffic signals optimized for morning rush hour).

The multimedia visualization could be used to present the various options for traffic signal timings on the highway. The IVTI user would select an option from the main menu and would be treated to a bird's eye view of the highway. The traffic flow would appear as individual cars moving down the highway or as color-coded symbolic "flows" with numbers, starts, stops, and turns consistent with the T7F report. The user could zoom in on particular intersections for a closer view or request actual numbers/graphs on traffic flow instead of animated graphics.

Top-Level Design

The top-level design of the IVTI system is presented in Figures 2 and 3. Figure 2 shows the flow of data into and out of IVTI from external systems. Ideally, the presentation script and storyboard would be developed by a "production manager" (public affairs officer, etc.) and provided in hard-copy form to guide the logic of the presentation. Video, music, audio, photos, photo logs, and computer graphics (hereafter referred to as assets) would be collected and cataloged in their native form by a "production specialist." The production specialist or a computer specialist would then use the IVTI development system to convert these assets into the proper digital form for use by the computer. A traffic engineer would be responsible for performing the necessary T7F analysis and providing the output files to the computer specialist for conversion into IVTI. The logic of the presentation would then be developed by the computer specialist using the script and storyboard as a guide. The assets would then be integrated into a single, executable, digital IVTI presentation file, which could be run on either the development system or the smaller, portable presentation system.

Figure 3 depicts the top-level block diagram of the IVTI development system. In general, an IVTI presentation is generated by first creating an outline followed by the production of a template. The audio, video, and image assets for the presentation are then captured in digital form and integrated into the general presentation framework. The T7F analysis results are imported into IVTI and converted into data structures. Aerial images are manipulated to link parts of the image to the data structures (e.g., roadways and vehicles). The visualizations are then merged into the overall presentation.

A brief narrative of each of the major system functions identified in Figure 3 follows. All operations are activated via on-screen menus.

1. *Outline IVTI presentation:* In the presentation mode, the user activates the outline option and selects the major headings to be used, identifying the screens and layouts to be used within each major heading. Once the outline is completed, a template of the presentation is generated. This template is an executable version of the final presentation with placeholder material instead of actual assets. Saved templates may also be selected directly, without the creation of an outline file, for immediate use in creating a presentation.

2. *Capture digital audio:* In the presentation mode, the user activates the assets option and selects the audio icon. An audio capture tool is launched that allows the user to digitize voice or music in the appropriate format and save the result in a file. The file is saved in the audio assets list.

3. *Capture digital video:* In the presentation mode, the user activates the assets option and selects the video icon. A video capture tool is launched that allows the user to digitize video and sound in the appropriate format (Apple Quicktime) and save the result in a file. The file is saved in the video assets list.

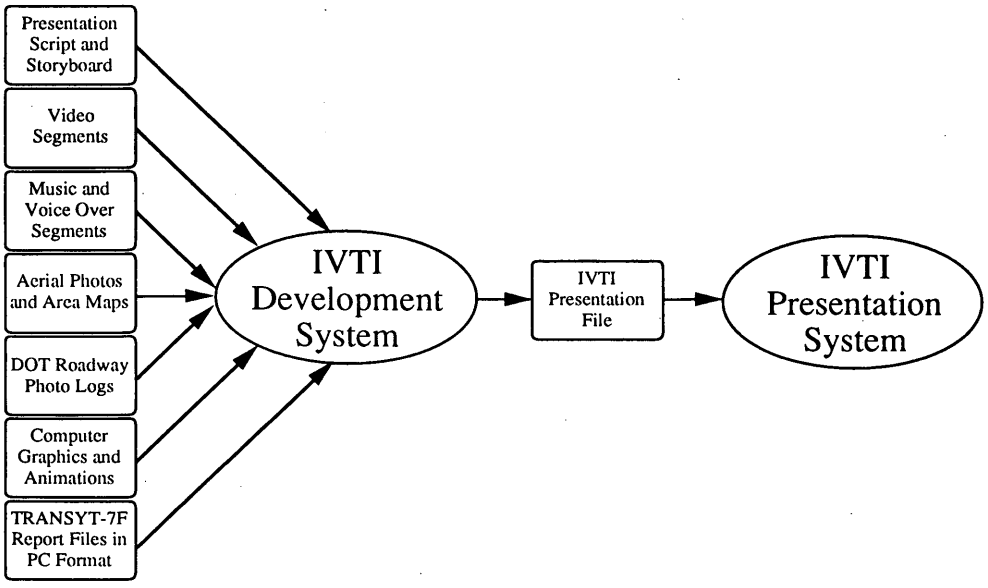

FIGURE 2 External inputs and outputs.

4. *Capture scanned images:* In the presentation mode, the user activates the Assets option and selects the image icon. An image capture tool is launched that allows the user to digitize flat art or photos in the appropriate format and save the result in a file. The file is saved in the image assets list.

5. *Convert image formats:* In some cases, images and computer graphics already may be provided in digital form. It may be necessary to convert these images into the proper format. The user activates the assets option and selects the image icon. A tool is launched that determines the original file format and converts it to the appropriate format for use in IVTI. The same capabilities are provided for audio and text.

6. *Construct general IVTI presentation:* The process for constructing the IVTI presentation proceeds after a template has been generated or selected (Process 1) and the appropriate assets have been collected (Processes 2 through 5). The user activates the template option and then steps through the presentation using the rewind, back step, play, step, and stop buttons in the control menu and replaces filler material in the template with proper selections from the assets lists.

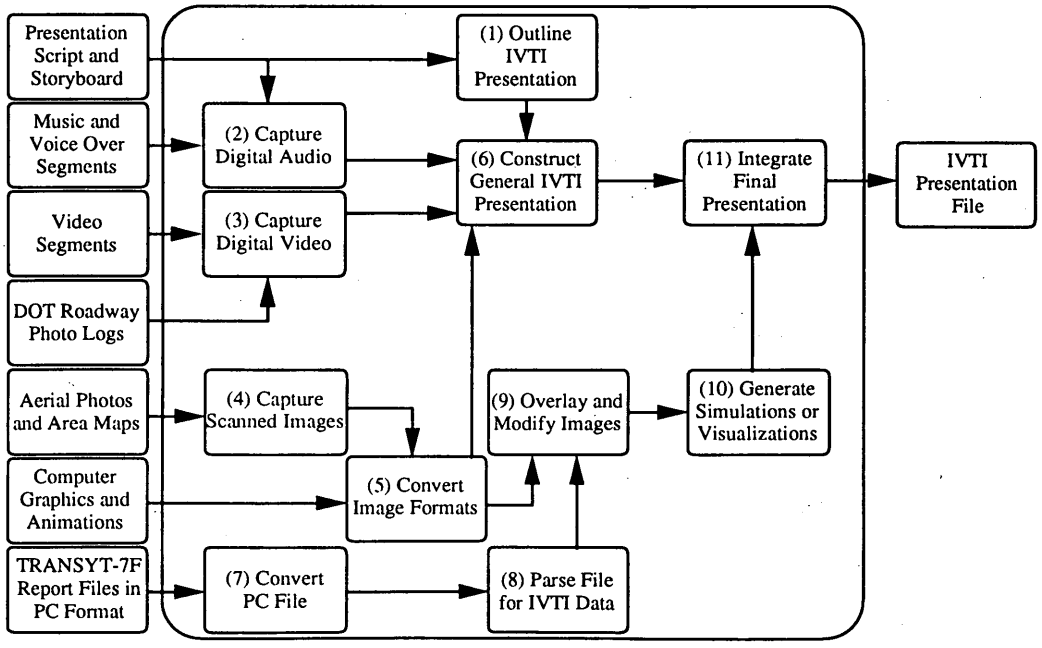

FIGURE 3 IVTI development block diagram.

7. *Convert PC file:* In visualization mode, the report file generated by T7F is converted into Macintosh format using Apple file exchange conversion tools.

8. *Parse file for IVTI data:* In visualization mode, the user activates the data file option and then selects the parse option. The user identifies the file to be parsed and provides a name. The IVTI system automatically generates a T7F data file for use in the visualization.

9. *Overlay and modify images:* In visualization mode, the user activates the Overlays option. To create an overlay, a view and an associated data file must first be selected. Menu commands and graphical tools are invoked to select vehicle samples for use in the visualization. Other menu selections are used to overlay vehicle paths and turning movements on the image. The overlay is then named and saved for use in the generation process.

10. *Generate visualizations:* The T7F data file and its associated view and overlay files are used to generate automatically a separate visualization file that shows a complete cycle of traffic movement for the given visualization.

11. *Integrate final presentation:* The general presentation (with assets incorporated in Process 6) is linked with the visualization files developed in Process 10. The user employs menu selections to create a stand-alone presentation file and directory for playback on the IVTI delivery system.

System Hardware

The block diagram of the IVTI development system is indicated in Figure 4. The principal component is a NuBus-based Macintosh computer (such as a IIci) with 8 MB of main memory and 200 MB hard disk drive. Incorporated within the Macintosh IIci machine is a card for audio and video capture (*3,4*). Two monitors are provided to facilitate development. A flatbed or slide scanner is used to capture graphics. External video devices (camera or videocassette

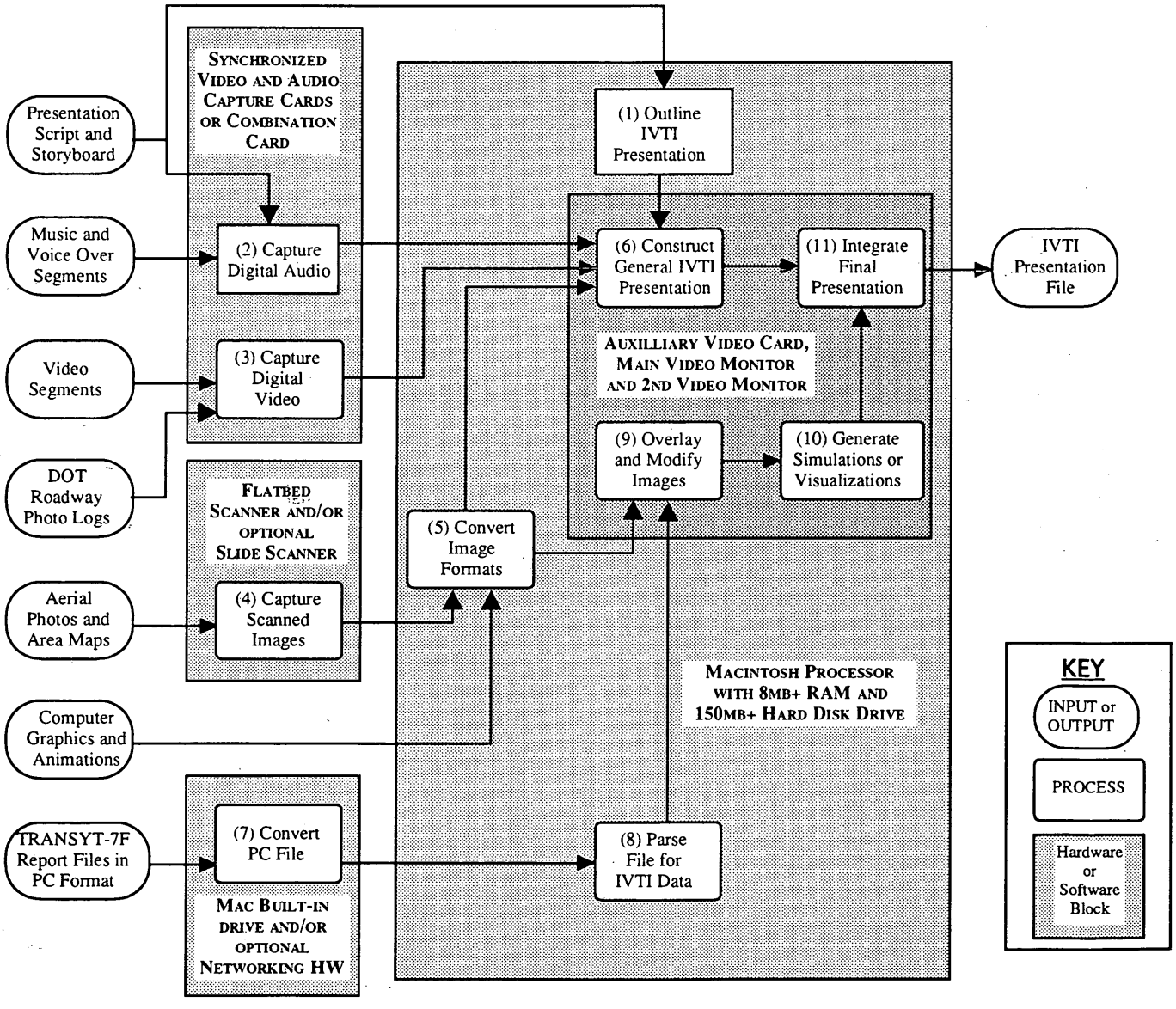

FIGURE 4 IVTI hardware block diagram.

recorder) can be attached to the audio and video capture card for input of video assets. Networking hardware is included to allow the IVTI development system to access local area networks for files.

The hardware for the IVTI delivery system is a Macintosh IIci identically equipped with the same audio and video playback card as those of the development system. Portable Macintosh notebook computers were considered, but they currently do not support the audio quality desired. The system includes a card to provide quality stereo audio output and to drive the external projection device. Amplified stereo speakers and a liquid crystal display (LCD) panel (for overhead projector) are provided to facilitate presentation to large audiences.

System Software

IVTI custom software for the development system assumes that information to be incorporated in an IVTI presentation already has been converted into the appropriate digital format using commercial off-the-shelf software. The functions implemented by the IVTI custom software for the development system are shown in Figure 5. The IVTI main program has two modes of operation. In the presentation mode, an IVTI presentation is developed. An outline of the presentation is created, from which a presentation template is generated. Asset files in the appropriate digital format are then integrated into the template. Asset files may include graphics, audio, and video, as well as simulations or visualizations output from the simulation mode.

From the IVTI main program, the IVTI simulation mode is accessed to create simulations or visualizations from T7F data files and associated aerial photos or maps. A simulation is created for intersections or aerial views where movements of individual vehicles are desirable. A visualization is created where individual vehicle movements are inappropriate—for example, if the area of coverage is so large that individual cars cannot be seen, or if the number of vehicles to be simulated is too large for processor capacity. Visual-

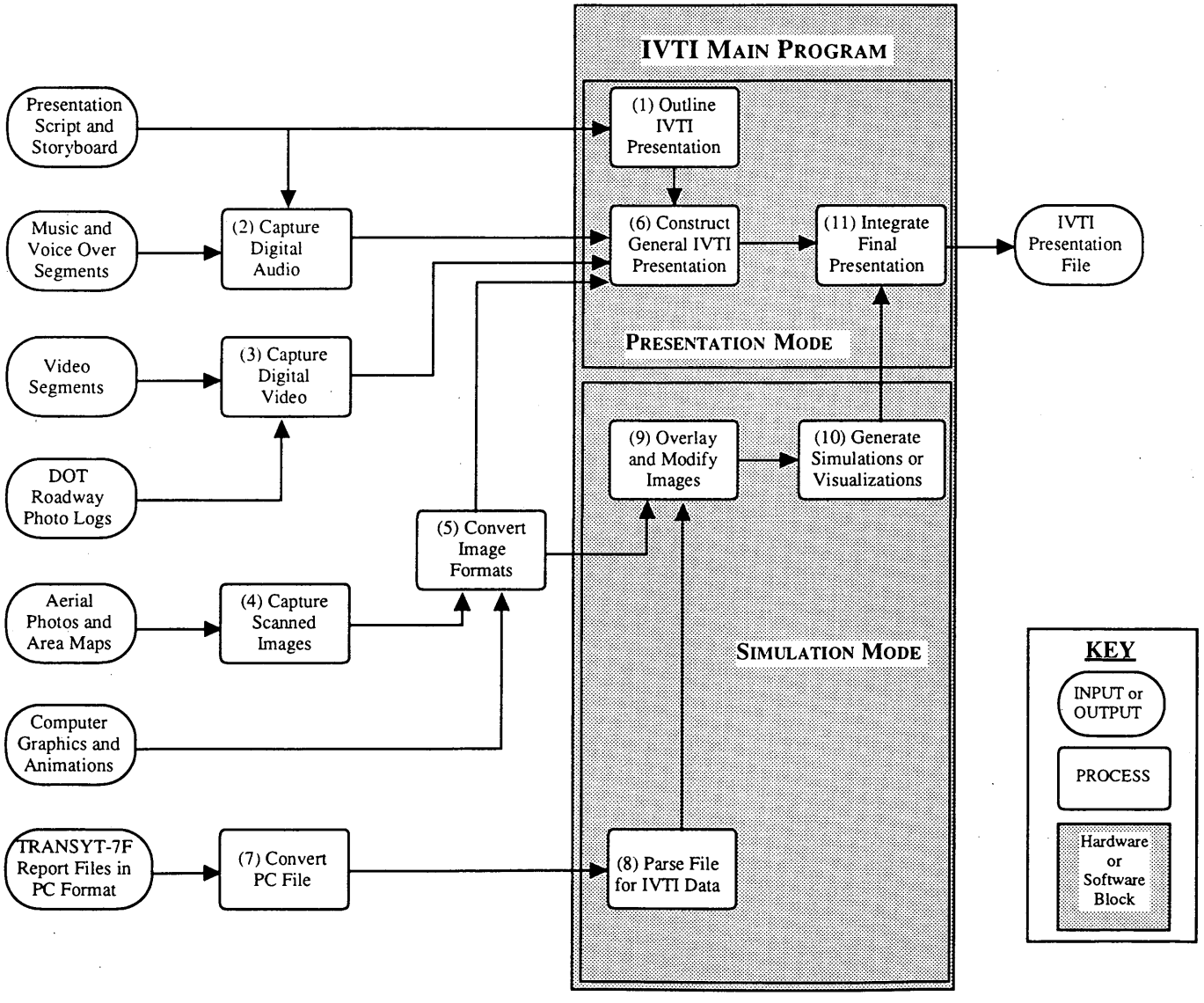

FIGURE 5 Custom software block diagram.

izations then use color-coded graphics to convey traffic flows. The executable MacroMind projector (*5–7*) IVTI presentation file output by the IVTI development system represents the custom software component of the delivery system.

TRAFFIC ANALYSIS WITH TRANSYT-7F

TRANSYT-7F Background

TRANSYT is the acronym for Traffic Network Study Tool. The original version of TRANSYT was developed by Dennis Robertson at England's Transport Road Research Laboratories in 1967. T7F is a macroscopic simulation tool; thus, it processes platoons of vehicles instead of individual vehicles. The analyst can control the size of the simulation steps, which essentially controls the size of the platoons.

Signalized intersections are controlled by either mechanical pretimed or electronic controllers. The latter collect input on vehicular demand from detectors embedded in the pavement or from cameras (i.e., image processing results in real-time counts of approaching vehicles) and set the duration of green accordingly, so that demand is satisfied in a timely and efficient way. Regardless of the technology used, signals operate under a phasing scheme specified by traffic engineers. The phasing is the exact sequence in which the various vehicular and pedestrian movements receive the right of way. The duration of a complete sequence of signal indications is defined as the cycle length. Under a pretimed mode of operation, both phase durations and cycle length are fixed. Traffic-actuated local controllers have the ability to extend or reduce the durations of green (within prespecified limits that ensure safe pedestrian processing, if applicable); therefore, both phase and cycle lengths vary.

It is noteworthy that there is no procedure available that would enable traffic engineers (and local electronic signal controllers) to select the best phasing scheme for each signalized intersection. Thus, a side utility of T7F becomes apparent: assessment of traffic processing under various signal phasing options and choice of phasing scheme best suited to a particular intersection.

There are two main types of estimations with T7F: simulation and optimization. In simulations, T7F estimates measures of effectiveness (MOEs) on the basis of the exact inputs without any alterations. The MOEs from a simulation reflect existing conditions and serve as a base case for comparisons. In optimizations, T7F maintains the exact vehicular traffic data and consults the minimum phase requirements (as set by the modeler on the basis of pedestrian crossing requirements or other constraints); it selects the cycle length (from a prespecified range) that results in the best performance index (PI); and, then, it optimizes phase durations and progression offsets so that negative MOEs such as delays and stops are minimized.

Optimization is achieved through the minimization of an objective function that is called the PI. Because the PI is the sum of "negative" factors (that is, long delays and large number of stops denote poor signal operations), the objective is to minimize it.

T7F input requirements include network geometry, volumes, saturation flows, average speeds, signal phasings, minimum intervals, cycle lengths, and factors describing local driving behavior. The output includes a number of MOEs such as delays, average speeds, queue lengths, and fuel consumption per intersection, specified route, and the entire network. Time-space, progression, and flow profile diagrams are provided on request.

Use of T7F in IVTI: Case Study of Dillingham Boulevard

The first application of IVTI focused on short-term alternatives for alleviation of congestion for the morning commute from west Honolulu to the central business district (CBD). The analysis focused on Dillingham Boulevard, a five-lane arterial that roughly connects the airport area with the CBD. Dillingham Boulevard was selected because it is a key arterial into the CBD for commuters on the H-1 freeway. Given its relatively light traffic in the reverse-commute direction, it is a logical candidate for contra-flow. For the case study, two alternatives were explored: contra-flow and the addition of a high-occupancy-vehicle (HOV) lane, both CBD bound.

The temporary subtraction of a lane from the reverse-commute direction and its addition to the peak direction of traffic is accomplished with closely spaced traffic cones that are set and removed manually by a crew on a light-duty truck. The use of this process (called "coning") is applied along several miles of arterial streets in Honolulu during regular week days. Coning is managed by the Department of Transportation Services of the City and County of Honolulu.

The arterial analysis of Dillingham Boulevard using T7F included ten signalized intersections, all of which are equipped with demand-responsive, electronic signalization systems, the controller of which receives demand input from loop detectors imbedded in the pavement. A number of estimations were run, the results of which are summarized in Table 1.

Platoon progression diagrams generated by T7F indicated a misallocation of resources at the present time. The CBD-bound direction of Dillingham Boulevard is heavily loaded (resulting in a very dark density plot), whereas the reverse-commute direction is clearly underutilized (very light density plot). In contrast, a much more even density was displayed after a lane was taken from the reverse-commute direction and given to the downtown-bound traffic on Dillingham Boulevard.

The results for three highly congested intersections were further verified by using the HCM/CINEMA software (*8*) and by taking advantage of its built-in NETSIM subroutine for microscopic simulation of flow at a single intersection. (NETSIM, from network simulation, is another FHWA/U.S. Department of Transportation-approved traffic simulation software package. It is based on microscopic simulation; thus, individual vehicle trajectories can be tracked and animated on the screen. This improves the analyst's ability to detect weak elements in the intersection's operation.) The results were clearly in favor of the contra-flow lane addition.

A possible threat to the success of the coning for the provision of a contra-flow lane may arise because of the high frequency of buses (and bus stops) along Dillingham Boulevard. Stopping buses generally do not pose a problem because in both directions there is a second lane on which vehicles could divert and avoid stopping behind the buses. However, after coning, only one lane will be available for the reverse-commute direction on Dillingham Boulevard. Thus, buses stopped to process passengers may block the single lane while the signal is green, and oversaturation may occur. This effect was initially assessed with T7F by assuming a lower saturation flow rate (s = 1,500 vehicles per hour of green per lane) for the single through lane. The results indicated a small increase in average delay but no oversaturation. This potential operational problem was also analyzed with NETSIM by estimating that buses stop every 3 min (20 buses per hour), which is close to the average morning headway between buses. The results show that bus blockage does not pose a

TABLE 1 Summary of Traffic Analysis Output

Part 1: Entire Network (Dillingham Boulevard and intersecting streets)

		EXISTING CONDITIONS	OPTIMAL CONTRA-FLOW	FORCED CL CONTRA-FLOW	OPTIMAL w. HOV LANE
	Cycle Length (CL) in seconds	110	80	110	110
	MEASURES OF EFFECTIVENESS				
1	Number of Congested Street Segments (1)	6	6	7	4
2	Average Delay in Seconds per Vehicle	27.2	30.5	36.6	28.1 (31.0)
3	Average speed in mph	10.3	9.5	8.4	9.9
4	Fuel Consumption in gln/hr; all traffic	431	445	480	439 (484)

Part 2: Main Arterial Street (Dillingham Boulevard only)

		EXISTING CONDITIONS	OPTIMAL CONTRA-FLOW	FORCED CL CONTRA-FLOW	OPTIMAL w. HOV LANE
	Cycle Length (CL) in seconds	110	80	110	110
	MEASURES OF EFFECTIVENESS				
1	Number of Congested Street Segments (1)	3	2	5	1
2	Average Delay in Seconds per Vehicle	9.3	7.1	9.9	8.7 (11.1)
3	Average speed in mph	19.9	21.7	19.5	20.4
4	Fuel Consumption in gln/hr	218	204	212	224 (286)
5	Max. Theoretical Throughput	1515 (1947)	2104 (2614)	2411 (2782)	2411 (2504)

Note (1): Lanes approaching but not exceeding 100% capacity utilization.

threat to the operations after coning (i.e., delays increase but no oversaturation occurs).

The second part of the analysis involved the assessment of the potential success of an HOV lane. The HOV lane specification prohibits all left-turning movements along Dillingham Boulevard while the HOV operation is in effect (i.e., 5:30 to 8:30 a.m.). The following two key assumptions were made before modeling Dillingham Boulevard with an HOV lane:

1. One of every three vehicles is eligible to use and will use the HOV lane.
2. The maximum possible banned left-turn vehicles will modify their routes closely around Dillingham Boulevard.

The first assumption simplifies the modeling effort because the through traffic to downtown is evenly spread across the three available lanes; thus, an explicit modeling of the HOV lane is not necessary. This assumption was made because of the limited resources available for this part of the analysis. It is, therefore, assumed that the average occupancy of downtown-bound traffic is 1.33 persons per vehicle, which is reasonable by Honolulu standards. The second assumption is conservative because it forces all left-turning traffic to find a legal way around the prohibition of left turns in the immediate vicinity of Dillingham Boulevard.

Table 1 summarizes the MOEs. For the HOV lane option, a second set of estimates is given in parentheses. These estimates reflect the added travel time of the approximately 1,000 left-turning vehicles, which should perform a set of three right turns around a block to reach the street segment they would have by turning left from Dillingham Boulevard. The HOV lane option is compared with the following:

- Existing conditions,
- Contra-flow with optimal signal timings, and
- Contra-flow with forced signal timings to maintain the existing cycle length.

The maximum theoretical throughput (maximum number of vehicles that can be processed in 1 hr) for the downtown-bound traffic will be much better for all options considered as compared to the existing situation: The facility will be able to serve more than 2,000 vehicles per hour along the peak direction as opposed to about 1,500 at present. At best, the HOV-lane option will provide as much throughput as the contra-flow option. The optimal contra-flow option (Column 2) is a better option, particularly when the critical statistics of congestion (delay) and fuel consumption are considered. However, the appeal of an HOV lane and its potential to reduce single-occupant vehicles should not be underestimated. Thus, a combination of HOV and contra-flow was suggested for fine-tuned analysis because it is an effective and comprehensive option.

Samples of the presentation of this case study with IVTI are shown in Figure 6. The print quality does not do enough justice to the IVTI quality of presentation since IVTI has been designed with exclusive focus on presentation on monitors or projection screens.

SUMMARY

The IVTI system has introduced a new form of model visualization into traffic project presentations. The photo-realistic simulations created by IVTI from T7F output reports enhance understanding of the impacts by showing traffic flow in a real-world context. Demonstrations of the two IVTI presentations completed thus far

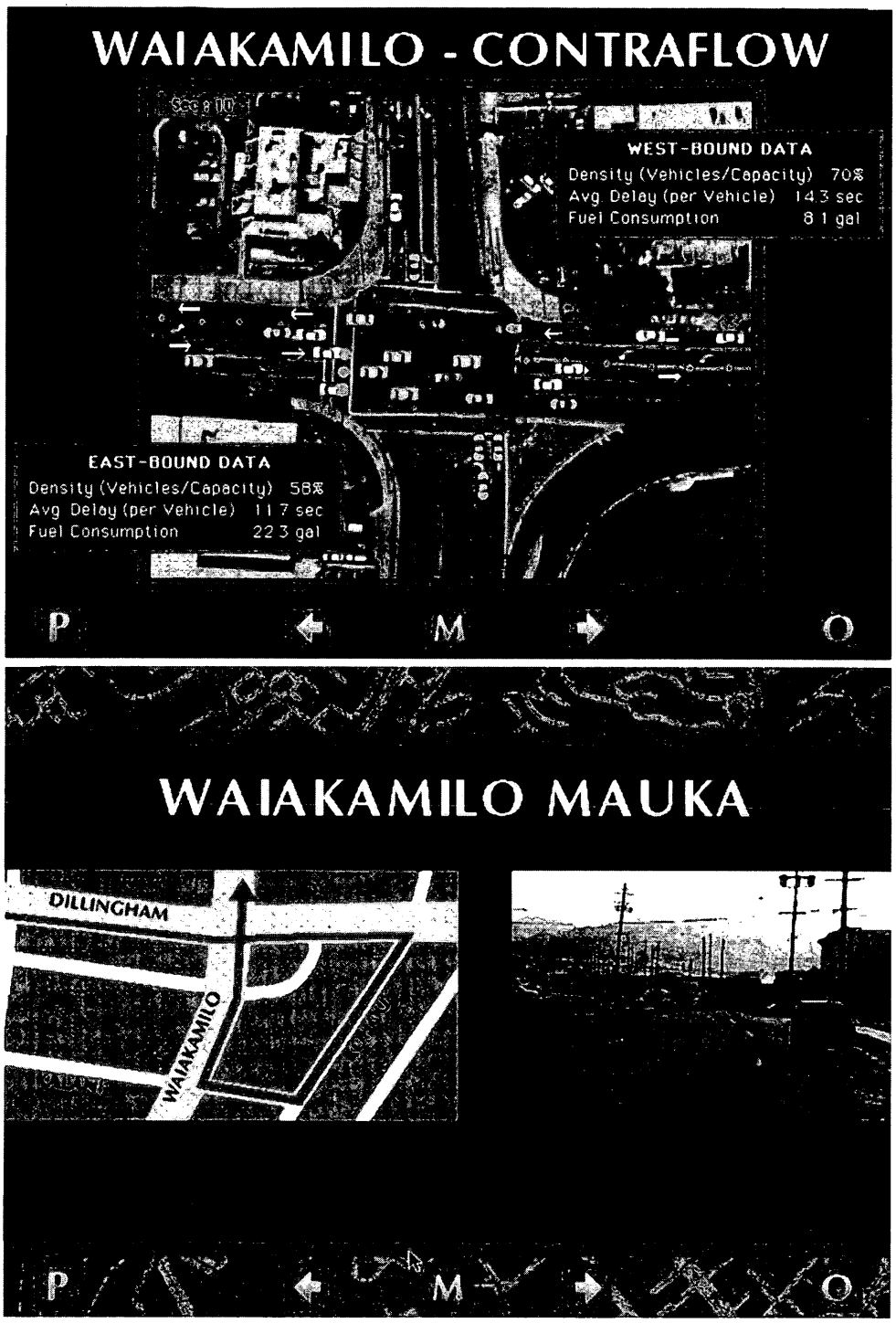

FIGURE 6 Sample output from IVTI.

have yielded favorable feedback. Overall, IVTI has achieved its goal for the effective organization, visualization, and interactive presentation of traffic impacts that are derived from widely accepted traffic and planning analysis computer software. This approach to presenting public works projects will enhance understanding of the goals, benefits, and costs. With a clearer understanding of a proposed project by the general public and by governmental officials, fewer delays in the approval and funding process should result.

IVTI complements other automated design facilities and, from a marketing perspective, will allow HDOT to manage its customers' expectations about the project and throughout all phases of the con-

struction process. HDOT intends to utilize IVTI in its present form to assist in presentations about forthcoming highway projects.

Although this paper has focused on IVTI's utilization of T7F and its ability to present analyses and plans for signalized street networks, future development efforts are expected to include freeway and parking analyses as well as linkages with both harbor and airport projects. The latter are mandated by the Intermodal Surface Transportation Efficiency Act, which focuses on the connections among all modes of transportation, and the distribution of flows of people and goods among them. In addition, several encouraging inquiries from consultants, state DOTs, and municipal governments have boosted the efforts of the developers of IVTI (the Pacific International Center for High Technology Research) to offer it for the PC environment. Future endeavors include input module additions and modifications to enable IVTI to utilize output files from TRAF-NETSIM, other traffic software, as well as trip distribution and assignment output from planning and GIS-T software applications.

The estimated cost of IVTI development has totalled about $250,000. The cost per presentation is expected to vary because a single presentation might consist of any number of graphs, charts, artist renderings, text, animation, aerial photographs, computer graphics, audio voice-overs, and soundtracks. Computer hardware for a kiosk operation would cost about $2,000, not including design of the kiosk itself. System support staff includes individuals with transportation planning and modeling expertise, an Apple Macintosh computer analyst, and persons familiar with the dissemination of the public information.

ACKNOWLEDGMENT

This paper was based on research supported by the Hawaii Department of Transportation and the Hawaii Department of Business, Economic Development and Tourism. The support of the sponsors is gratefully acknowledged.

REFERENCES

1. *TRANSYT-7F User's Manual,* Version 6.4, Transportation Research Center, University of Florida; FHWA, U.S. Department of Transportation, 1991.
2. *EZ-TRANSYT PLUS User Guide,* Version 6.0. Transtek Software, Falls Church, Va., 1989.
3. *Supercard User Manual,* Version 1.5. Silicon Beach Software, San Diego, Calif., 1989.
4. *Supercard Language Guide,* Version 1.5, Silicon Beach Software, San Diego, Calif., 1989.
5. *MacroMind Director Studio Manual,* Version 3.0. MacroMind Inc., San Francisco, Calif., 1991.
6. *MacroMind Director Interactivity Manual,* Version 3.0., MacroMind Inc., San Francisco, Calif., 1991.
7. *ADOBE Photoshop User Guide,* Version 2.0., Adobe Systems Inc., Mountain View, Calif., 1991.
8. *HCM/CINEMA User Guide,* Version 2.0., KLD Associates, Inc. and Polytechnic University, Brooklyn, New York, 1990.

The information in this paper expresses the views of the authors only, who are solely responsible for any errors and omissions.

Publication of this paper sponsored by Committee on Citizen Participation in Transportation.

Redefining Public Involvement

DENNIS J. UNSWORTH

Public involvement requirements have been part of government programs for at least 20 years. But they are often still seen as one of the more onerous aspects of project development as part of the bureaucratic red tape: necessary, but more an obligation than a productive part of the process. The Intermodal Surface Transportation Efficiency Act fostered a new spate of grumbling, as public involvement requirements were expanded from project development to short- and long-term planning. While the scope of the detail and the requirements expand, decision makers and project staff increasingly find that heightened public interest and activism grind projects (and sometimes entire agencies) to a halt. Information meetings, scoping meetings, and hearings are poorly attended, but then controversy swells and citizens turn out in droves to point fingers and raise angry voices. Frustration over an increasing number of controversies arising late in the project development process led the Montana Department of Transportation to develop a new process intended to minimize controversies that stop projects and erode public trust. The goals for that process are described and information contained in a new handbook intended to redirect Montana's public involvement program are highlighted.

A groundswell of concern and frustration inside and outside the department led to formation of a Montana Department of Transportation (MDT) FHWA task force to find a better way to involve the public. The press and a particularly difficult project "blowup" gave the task force ample evidence of the problems. Plans to expand a busy section of US-93 just south of Glacier National Park to five lanes split the local communities; numerous groups took sides and others waged a persistent but unsuccessful fight to redesign the project.

Nevertheless, design features were nearly complete and MDT and the Montana Highway Commission refused to "start over." Local political bodies lined up on both sides of the issue, and the controversy was cast in terms of safety and land use impacts. MDT officials lacked credibility in the eyes of much of the press and local public, making it difficult or impossible to respond to questions and charges.

The project was halted in August 1992 by Montana's senior senator Max Baucus with a "rider" on an appropriation bill prohibiting further work until a study of alternatives was completed. By then right-of-way acquisition was 95 percent complete and utility moves were well under way. The prohibition was announced in local papers and tempers flared again as all sides made allegations. Work was halted within hours of the announcement.

Even though the MDT/FHWA task force was already formed and had outlined a work plan, the problems surrounding the US-93 Somers-Whitefish project related directly to the assignment at hand and underscored the need for change in a dramatic way.

RECOGNITION OF BASIC NEEDS

The charge made to the task force was to develop a new process to supplement or replace the FHWA-approved public involvement/public hearing procedures implementing 23 CFR 771 that would help MDT minimize controversies that stop projects and erode public trust.

New procedures and guidelines grew out of a fairly simple premise: that agency needs and awareness of basic human nature—not statutory requirements—should drive the process.

This is not to say statutory requirements should be overlooked, assuming for the sake of argument they even could be. But meeting the agency's most basic need—to develop facilities and systems in a timely way, accomplishing a clearly stated, well-thought-out purpose—today will require meaningful public involvement. And achieving this level of involvement requires the recognition of basic human needs, such as the individual's need to be recognized and the need to have some control over one's life.

GOALS TO SET DIRECTION, AID DECISION MAKING

Redefining Montana's process benefited from an early effort to identify clearly what was hoped would be accomplished

- Reducing to a minimum the number of projects that "blow up" at the last minute because of public opposition;
- Helping get the project right the first time, thus saving time and money by reducing or eliminating redesign or other delays;
- Improving the department's overall public image in terms of responsiveness, openness, and willingness to change; and
- Improving the public's satisfaction with the final product.

To accomplish this, the focus was to develop goals that were specific enough to help set a direction and aid decision making. The goal-setting effort was difficult; loosely stated or overly broad goals are easier to write but are not very helpful. So the task force struggled to define goals that met a strict test: goals that are specific, achievable, and measurable. The following were adopted:

- To provide useful, timely information to the public throughout the development of projects, from preliminary engineering approval through final acceptance of the completed project by the district engineer;
- To proactively seek public comment and involvement in project development;
- To facilitate open discussion of controversial issues; and
- To respond to comments and suggestions so that useful ideas are incorporated into projects; and to ensure that public comments are heard and considered in technical studies as well as in final decisions.

SIMPLE, HELPFUL HANDBOOK

Implementing the public involvement program involves many employees at all levels, so the statement of purpose, goals, procedures, and advice were all put together by MDT in the form of a simple handbook.

Montana Department of Transportation, P.O. Box 201001, Helena, Mont. 59620–1001.

FIGURE 1 Informal meetings help the agency get the information it needs, anticipate problems, and build relationships that can be productive throughout the process.

FIGURE 2 When people believe that they are not being listened to, they turn to means outside the formal process to make themselves heard.

The effort is to substitute one approach for another: to replace the old set of rules, often handed down from one individual to another—part of the lore of our internal culture with another. So a program of orientation and training is being developed to help employees understand the concepts, to sort out difficulties, and to respond to the complexities and the resistance that are bound to arise. Without training and orientation (or reorientation), some will embrace the new approach whereas many others will resist it.

A handbook was chosen so that this new approach would be defined and illustrated and the intent would be clearly stated. It was carefully written to be easy to read, easy to use as a reference, and helpful and therefore more likely to be used.

MDT's handbook outlines four levels of involvement that relate to the level of complexity and interest in a given project (not just the level of environmental study). The levels range from a very basic program to a much more involved one that includes advisory committees and numerous personal contacts with groups and individuals for more complex projects. The handbook also includes instructions and advice specific to each step in the four levels of public involvement plans. Examples of involvement plans are included, as well, for each level of involvement.

After discussion at the preliminary field review, a public involvement plan is outlined as part of the preliminary field review report. The plan is written by the lead unit—normally an area engineer in the road design or traffic sections. Overall responsibility for the plan and implementation is with the district engineer, assisted by the public affairs bureau.

MORE PERSONAL CONTACT

Recognizing that it is to its benefit to discuss issues and hear about problems and ideas early, the agency places much more emphasis on personal contacts. For example, although asking people to attend evening meetings can often be unproductive, especially when construction is still years away or there is little early controversy, informal meetings with landowners, interest groups, and individuals in their homes or at a neutral location like a local coffee shop can help the agency get the information it needs.

Informal meetings also will help agency staff anticipate problems and build relationships that can be productive throughout the process (Figure 1). The one-to-one exchange that takes place will likely be more productive and also more satisfying. (Barriers to communication have been a common part of past practice: overly formal written communication that did not really say much but reinforced the image of a cold, faceless bureaucracy, for instance; and formal meetings where an "us-and-them" scenario had engineers giving a technical lecture to a group unable to understand much of what was said.)

CLEAR COMMUNICATION

Less-formal meetings make sense and so does less-formal communication. The handbook includes numerous tips, such as writing a letter of intent and news release that are more likely to be read and set a tone that leads to involvement. The following tips are included in the handbook:

- Write the letter in a style that is less formal than that of typical government correspondence. Write your message as if you are speaking to someone in an informal setting; in other words, write it as you would say it.
- Be as brief as possible without eliminating necessary information. Make the correspondence easy to read and understand: write for a general, nontechnical audience, that is, for someone who may know nothing about engineering or project development. Limit your message and limit letters to just one page. If further explanation is necessary, use attachments.
- Do not use abbreviations and acronyms. In addition, stay away from jargon—terms that have special meaning in project development, but do not make any sense to the public. Writing in a "language" people do not understand is not productive and turns people off.
- Use contractions at every opportunity. Say "It's our intent to develop" and "We'd like to hear from you," rather than "It is our . . . " and "We would like. . . ." Contractions are one of the easiest ways to set a less-formal tone in your writing, making your message more conversational and easier to understand.
- Address the question "Why?" Your letter, news release, or other correspondence should include information that clearly explains the reason for the project. For instance, "We propose to improve safety and replace the worn-out pavement by reconstructing and widening the roadway" or "We intend to study numerous alter-

natives and suggest improvements to respond to traffic congestion and safety issues."

TALK, TALK, TALK AND ACT

The handbook encourages communication among the project team and, in more complex projects, among members of the multiagency interdisciplinary team, as well as between team members and the public. Their job is to find the issues, analyze them, and find answers before problems start consuming time and resources. When needs or issues are identified, team members are urged to act. The MDT handbook advises the following

- Do not wait until the next scheduled meeting, which gives difficult issues a chance to become fraught with misinformation and speculation.
- Do not discount ideas or suggestions out of hand. Strive to listen carefully.
- Do not let dealing with issues be a point of frustration. Dealing with issues is the project team's job. Deal with each issue fairly and promptly, even if it is the same issue for the tenth time. This is the challenge and it is what public involvement is all about.
- Actively seek out those individuals, groups, and agencies that may be concerned about or opposed to a project. They must be a part of the process and must be heard. When people believe they are not being listened to, they turn to other means outside the formal process to make themselves heard (Figure 2). Activist organizations and news reporters often help fill this need capably.

KEEPING PEOPLE INFORMED

Interest in project development extends well beyond those who attend the formal meetings. Procedures call for extra effort to arrange news coverage or to follow up with a news account after a public meeting, a decision on the project design or scope of work, or a significant delay.

A news release or public statement in a format and style that are suitable for the medium can help ensure that news is described in terms that help the agency achieve its goals. To do this, the handbook offers the following advice:

- Newspapers cover more detail and can include helpful graphics, such as maps or diagrams. Be guided by the adage "A picture is worth a thousand words."
- Radio news often requires a shorter story, but radio can sometimes incorporate a live interview or tape an interview for airing later—a good opportunity to explain and to provide for interaction. Many radio news reporters will jump at the opportunity to cover transportation stories. Give straight answers and describe what is going on in an interesting way, and these reporters will want to talk to you more often.
- Television (TV) requires graphics. TV reporters will want to shoot video footage. Therefore, be prepared with ideas about where their camera crew can get interesting footage. (Do not expect TV stations to accept footage the agency shoots; that may occasionally happen, but it is rare.) The story is generally brief, so only the bare details can be covered. Be prepared with a clear, concise message. If you are not accustomed to TV interviews, get some training and practice.
- Use of common language and lay terms may be the most important ingredient in getting a message across. It is difficult, but essential, especially when the subject is technical and the speaker (you) is accustomed to talking to other specialists, engineers, and those in the field—not a general audience. Therefore, if you are planning to make a presentation to the public or a reporter, have a small group of your peers or a co-worker listen to your presentation and highlight words or phrases that will not mean much to the general public. Find other terms to describe those things.

RESULTS

Giving attention to a public involvement plan early in the project development schedule, making frequent informal contacts with interested individuals and groups, and concentrating on clear communications are all expected to have a number of benefits.

It is not possible to be all things to all people. Both common sense and experience have shown that public acceptance and confidence in decision making can expedite project development, which will often mean better use of resources and better projects—projects that best meet the overall public interest.

Results from the first effort toward applying the new procedures at MDT are encouraging. Material from the draft handbook was incorporated into the consultant contract for the controversial US-93 Somers-Whitefish highway reconstruction project and the concepts are being applied capably and willingly. As a result, openly hostile relations are improved, with those on either side of the debate working cooperatively to identify issues and suggest solutions. Overall public awareness of the difficulties of the project has been heightened, and the group of active and interested parties has been expanded. The local press, for the most part, is covering the progress instead of the controversy. It is not all good news. But the issues are being covered and information resulting from the numerous studies is presented without skepticism or outright distrust. The project is still months, if not years, away from construction, but the public is undeniably involved in its development.

WHAT'S NEXT?

The MDT/FHWA task force focused on project development. The concepts and practices recommended by the agency were also used on a trial basis to spur involvement in Montana's Statewide Transportation Improvement Program. For example, informal "open house" style meetings were held in the afternoon and early evening at numerous locations. Announcements, including news releases, personal invitations, and newspaper advertisements all set an informal tone and described the process in simple terms and conversational language. Individual meetings were offered, presentations were conducted one on one, and materials were translated and presented in lay terms.

The effort was warmly received. What's more, agency staff enjoyed the process. Attendance at meetings was still poor, but it is recognized that that may not change much. The effort now is to seek public awareness and involvement in other ways and not rely so heavily on the public meeting.

Work is just beginning to integrate planning, programming, and project development into a single, comprehensive public involvement process. Such a process further supports the goal of involving the public in a substantive way and at a time when it is helpful and productive. The specific goals and clear statement of purpose already in hand provide a well-marked path.

Publication of this paper sponsored by Committee on Citizen Participation in Transportation.

Post-Intermodal Surface Transportation Efficiency Act Public Involvement

JULIE HOOVER

The Intermodal Surface Transportation Efficiency Act (ISTEA) and subsequent final rules regarding metropolitan planning, statewide planning, and management and monitoring systems call for increased citizen participation in transportation planning and programming. The progress to date based on a survey of all 50 states and knowledge of over 100 metropolitan planning organizations (MPOs) is reviewed. Although some good examples of participatory planning can be found, many states and MPOs seem to be responding to the ISTEA requirements in a fairly perfunctory manner. Examples of good practice and suggestions for improvement are offered. The purpose of the research was fivefold: (*a*) to summarize the recent history of public involvement; (*b*) to gently prod those states and MPOs that are not embracing citizen participation wholeheartedly into doing so; (*c*) to communicate information about successful participation so practitioners might benefit; (*d*) to document the current state of practice for those who have interest; and (*e*) to identify courses of action for public involvement advocates.

Over the past three decades, the importance attributed to public involvement generally has tended to rise and fall significantly. In the 1960s and early 1970s, the major goal of citizen movements in transportation was to stop highway projects in urban areas, an effort that was highly successful overall. By 1973, proposed highway projects were being blocked by citizens in all but one of the 55 largest standard metropolitan statistical areas.

With the slowdown in urban highway construction, citizen attention turned to alternative means of addressing urban transportation problems and to process. Dramatic shifts in public sentiment led to public acquisition of bus companies in many areas, "new start" heavy—and later—light rail systems, and subsidization of transit service. There was also growing interest in transportation system management, paratransit, and, eventually, high-occupancy-vehicle (HOV) facilities. Transportation planning became more focused on the short term, and there was an increasing emphasis on community and environmental factors and a strengthening of the role of citizens.

The National Environmental Policy Act of 1969 was passed, ground-breaking studies such as the Boston Transportation Planning Review and Miami's highly participatory transit planning process were undertaken, FHWA public involvement training and research projects were initiated, and a Federal Department of Transportation (DOT) Policy on Citizen Participation was proposed. TRB citizen participation committee meetings and panel sessions were overflowing with interested professionals, and their 1978 Williamsburg citizen participation conference exceeded all expectations.

The election of a new administration in 1980 led to declining federal interest in both participatory planning and public concerns about transportation. The citizen participation policy was rescinded and the prevailing implicit message from the top was "just do the minimum required." The majority of states and project sponsors readily complied, although a surprising number were mindful of the benefits of participatory planning from experiences in the 1970s, so they maintained their programs. In addition, project sponsors needing voter approval through referenda for local financing initiatives also often initiated participatory planning, frequently after backroom plans failed to win the necessary votes.

Then, 20 months ago, the Intermodal Surface Transportation Efficiency Act (ISTEA) was approved, calling for "new partnerships" at all levels of government and citizen participation in both metropolitan and state planning.

GENERAL POST-ISTEA CONDITIONS

Before citizen participation under ISTEA is reviewed, it is useful to note some observations about post-ISTEA conditions generally because the broader political and operational context obviously affects the implementation of each of the bill's components.

- First, although ISTEA significantly increased authorized funding levels for both highways and transit, shortfalls in appropriations have jeopardized some coalition-building efforts.
- Second, experience to date with one of the bill's hallmark features, its flexibility provisions, has been mixed. On the one hand, over $400 million in flexible funds has been transferred to transit, and considerably more is anticipated in subsequent years. On the other hand, there is still substantial resistance to the transfer of flexible funds in many places, and some states are pitted against metropolitan planning organizations (MPOs)—the entities charged by ISTEA with making flexible funding decisions). At the national level, there has been extraordinary cooperation at the highest levels of DOT modal agencies, but this spirit has not always filtered down, and FTA is still struggling to be an equal partner with FHWA. Many also advocate more active involvement from the Environmental Protection Administration and its local counterparts.
- Third, some MPOs are experiencing difficulty in achieving consensus and in getting their local jurisdictions to think in terms of the regional good.
- Finally, states and MPOs do not yet have good technical processes and tools in place to deal with the comprehensive ISTEA planning requirements, especially with respect to the coordination of transportation with air quality and land use planning.

POST-ISTEA CITIZEN PARTICIPATION

Within this context, it is not surprising that the status and prospects of citizen participation are also mixed. Although the ISTEA legislation does call repeatedly for citizen participation and a number of examples of good, participatory planning can be found, to date,

Parsons Brinckerhoff Quade & Douglas, Inc., 250 West 34th Street, New York, N.Y. 10119.

many states and MPOs seem to be responding to the new requirements in a disappointingly perfunctory manner.

States

A telephone survey of all 50 states was conducted in the spring of 1993 to ascertain how people were responding to ISTEA's public involvement requirements. The survey focused specifically on state participation with respect to the development of long-range plans, state transportation improvement plans (TIPs), and management and monitoring plans and did not cover project-related activities.

The responses may not be completely accurate because only one person from each state was typically contacted—the public involvement specialist listed in TRB's Directory of State Transportation Agency Environmental Officials—and this individual was not always completely familiar with what was going on or planned. (Where such specialists were not listed, an individual in a closely related category was selected.) In addition, when opinions were solicited, some of the respondents qualified their answers as personal views, not necessarily reflecting the official positions of their agencies. Finally, the information provided was occasionally supplemented on an ad hoc basis with the author's personal knowledge, and subjective judgments were made about what activities were really "meaningful." Nevertheless, the results do give a general indication of post-ISTEA public involvement activities. A summary of the responses is shown in Table 1.

Each state was classified according to one of four overall characterizations: outstanding/very good; doing or planning to do something above minimum requirements; doing the minimum; and possibly not even meeting minimum requirements. One state representing 2 percent of the total was judged to be in the top category (outstanding/very good). Twenty (40 percent) reported doing or planning to do something above minimum standards. Of these, at least six seemed to have potential for approaching meaningful participation that could be outstanding, but their programs were still in early stages. Fifteen, or 30 percent, hovered around the minimum and fourteen (28 percent) fell into the lowest category. Together, the two bottom classifications—doing the minimum or less—totaled 58 percent of the states surveyed.

The following specific survey findings show how these astonishing judgments were made:

- The first question probed what new citizen participation activities had been added, or were contemplated, in response to ISTEA. The majority, twenty-three states (46 percent), reported new activity, but for five states, this activity was limited to programs geared only to either the enhancements program (of the surface transportation program) or Native Americans. Others reported insignificant procedural changes such as providing court reporters at hearings for people who did not want to make a presentation. About half appeared to have made changes that were broadly substantive. Another six (12 percent) were considering or planning to increase their citizen participation activity, but were not yet able to provide specifics. Twenty-one states (42 percent) reported that no changes had been made or were contemplated. Several indicated that they had sufficient programs in place before ISTEA.
- Second, states were asked whether (and how) they were incorporating citizen participation into their long-range plans, management plans, and TIP development. Eighteen states (36 percent) indicated that there was currently no citizen input in any of the three programs; several indicated that there might or would be some in the future. Six (12 percent) justified their lack of programs on the grounds that such public involvement was the sole responsibility of the MPOs. Thirteen (26 percent) replied affirmatively to all three categories, although there is reason for skepticism about at least six of the responses. Another nineteen (38 percent) reported citizen input into one or two of these three activities, usually the long-range plans.
- The third survey question asked whether additional state funding had been allocated to citizen participation as a result of ISTEA. Money is not always an indication of effective programs, but given current levels of state activity, it is hard to see how many could meet the spirit of their ISTEA citizen participation responsibilities without increased expenditures. Disappointingly, 34 states (68 percent) said no additional funding was provided or contemplated. A total of 16 states (32 percent) indicated that funding had increased. Only New Jersey was truly impressive: it has allocated 50 percent of a million-dollar statewide planning study to public involvement.
- Fourth, states were asked whether any aspects of ISTEA had been controversial. A total of 32 states (64 percent) said no, but 18 states (36 percent) said yes. The following areas of controversy in descending order of importance were reported:
  - –The enhancement program (fourteen states),
  - –Comprehending and interpreting ISTEA (eleven states),
  - –Bureaucratic problems (ten states),
  - –Flexibility provisions (seven states),
  - –The need for more public education (five states),
  - –Friction with MPOs (five states),
  - –Suballocation of funds (four states),
  - –The CMAQ Program (three states),
  - –Financial constraints including appropriations shortfalls (three states),
  - –The percent of recyclable rubber tires required to be used as a part of the asphalt program (two states), and
  - –TIP development, FTA relations, vague citizen participation requirements, the management systems, matching funds, the project selection process, unrealistic public expectations of ISTEA, the timing of ISTEA, National Highway System design standards, Clean Air Act amendments, highway demonstration earmarks, and helmet regulations (one state each).

It is surprising that long-range planning was not mentioned at all and that issues related to TIP development and the management systems were not generally higher on the list.

- States were then specifically asked whether any aspects of flexible funding had been controversial. In contrast to the seven states that had previously identified flexibility as a problem, nineteen (38 percent) now agreed it was an issue in their states. Thirty (60 percent) reported it was not, and one state declined to respond.
- Next, states were asked to nominate MPOs under their jurisdiction which had made especially good efforts to promote effective citizen participation. Only 29 states (58 percent) offered one or more nominations. This could indicate that many MPOs do not yet have good programs in place; it may also be that some states are not fully aware of what their MPOs are doing. A total of 50 MPOs were identified by states as having good citizen participation programs.
- Finally, states were asked what role they thought citizen participation had in their ISTEA development. Forty two states, or 84 percent, characterized the role of the public as "important" or "major." Only two state respondents thought it was unimportant and

TABLE 1 Summary of Survey Results

QUESTION	# STATES	%
OVERALL CP CHARACTERIZATION		
• Outstanding/very good	1	2
• Doing or planning CP	20	40
• Minimum efforts	15	30
• Below minimum	14	28
CONTEMPLATING NEW CP ACTIVITIES IN RESPONSE TO ISTEA?		
• Yes	23	46
• No	21	42
• No response	6	12
CP IN LONG-RANGE PLANS, MANAGEMENT PLANS, & TIPS?		
• Some in all	13	26
• Some in 1 or 2	19	38
• None in any	18	36
ADDITIONAL CP FUNDING?		
• Yes	16	32
• No	32	68
ISTEA - CONTROVERSIAL?		
• Yes	18	36
• No	32	64
FLEXIBLE FUNDING - CONTROVERSIAL?		
• Yes	19	38
• No	30	60
• No comment	1	2
NOMINATIONS OF GOOD CP PROGRAMS		
• 1 or more	29	58
• None	21	42
ROLE OF CP		
• Important	42	84
• Unimportant	3	6
• Not sure	5	10

one said it was important only in some areas; four were not sure and one did not reply. This strong show of support contrasted with the paucity of effective programs is a curious incongruity.

A number of the survey states did, however, report some interesting approaches being used. Oregon employed an impressive combination of multiple techniques in their long-range plan development: 49 hearings, a citizen commission, five policy advisory committees, newsletters, and surveys. Alaska seems off to a superb start with extensive training for all of their top management and technical people who deal with the public, a citizen participation handbook for public officials, reliance on state convention and tourist bureaus to identify open house participants in connection with a scenic enhancement travel program, and other planned mechanisms. Although not ISTEA related, Maine's 60-group consensus-building process, culminating in a recently adopted Sensible Transportation Act and the creation of regional transportation advisory committees throughout the state, may serve as a useful model for some. Vermont and New Hampshire seem to have good processes to allow citizens to nominate projects for their TIPs. Minnesota sponsored 150 meetings on the nature of the transportation planning process and the role of citizen participation.

A few places have established blue ribbon committees, including Georgia. Connecticut and Pennsylvania have citizen participation manuals. Mississippi very nicely uses newspaper advertisements to obtain citizen input for their TIPs, has developed a brochure, and addresses all public input not included in their statewide plan in an appendix to the report. New Jersey, Washington, and Missouri will be using focus groups along with other techniques. Washington has also created kits for business and civic organizations that include a video, a survey, and brochures. Finally, a number of states are experimenting with more informal approaches to public hearings, meetings, and open houses; many are creating citizen advisory committees, subcommittees, and task forces; and some are sponsoring surveys.

Since last spring when the survey was conducted, a number of states have initiated the preparation of long-range intermodal plans. The consultant's request for proposals for all of these call for public involvement, and several indicate that they are seeking unusually ambitious programs. This suggests that the prospects for increased participatory state planning may be more optimistic than was initially indicated and that, in some places, there has simply been a delayed response to ISTEA.

MPOs

It was not possible to conduct a comprehensive survey of all MPO citizen participation practices so the assessment in this section is much more subjective. It is based on information provided by the states in the survey discussed above, a review of post-ISTEA literature and internal documents in FHWA files (about 60 sources altogether), ongoing FHWA research about citizen participation in metropolitan transportation planning, and the author's personal knowledge.

As indicated earlier, state public involvement specialists nominated 50 MPOs thought to have good participation programs. Telephone interviews with officials in each of FHWA and FTA's regional offices produced another 40 nominations, and literature reviews and personal knowledge produced another dozen or so. Most of these were duplicative, however, and on scrutiny, many were judged to be less effective than was originally anticipated. On the basis of this information, it would appear that between three and five dozen MPOs may currently have effective public involvement programs.

Similar to the state experience, some exceptional programs are being implemented that could serve as role models and sources of inspiration. The leading program in terms of sheer statistics must be the follow-up transportation planning to Seattle's Vision 2020 undertaking, which tied together growth management and transportation. Over 700 public meetings were held over a 2-year period, and a large number of other techniques were employed, including public forums and hearings, a citizen's summit attended by 500 people, an extensive mass media campaign, an electronic town meeting, and five different surveys that reached over 15,000 voters.

Another impressive program, on a smaller scale, is Albany's. The MPO there sent over 200 surveys to area groups and individuals soliciting input about the structure of the public participation program. The results favored a mix of strategies, rather than overdependence on one method, and led to the creation of nine task-oriented working groups, brainstorming that identified over 500 stakeholders, planned sponsorship of three public conferences scheduled before major decision points, one-on-one meetings, inclusion of existing organizations, and possible use of community meetings/open houses, surveys, and media stories.

A third noteworthy process is being sponsored by the Atlanta Regional Commission. After a highly participatory vision process, this region is now developing a corresponding comprehensive regional transportation plan using a broad range of public involvement techniques.

Other MPOs report successful experience with specific approaches that may benefit others. Portland, Seattle, and St. Louis held conferences combining presentations with workshops. The New Orleans MPO sponsors conferences and seminars with key transportation people as speakers. Pittsburgh has a blue ribbon committee that secured private funding to hold a retreat; San Francisco also has one and is becoming increasingly interested in the long-range plan update. A number of MPOs, including San Francisco's, are establishing citizen committees to deal with the enhancements program. The MPO in Los Angeles (Southern California Association of Governments) has public involvement guidelines that establish a minimum dollar expenditure (10 percent of the total planning budget), require the individual responsible for citizen participation to be a lead staff person knowledgeable about the entire planning process, and stress staff training. Charleston, West Virginia, uses charrettes. Portland, Maine's, MPO ran a description of its proposed projects in a full newspaper advertisement.

Various cities also have sponsored public involvement efforts that are incorporated into MPO activities. Tucson, Arizona, has institutionalized citizen participation to an unusual degree: there is an administrative directive that calls for citizen participation in any major effort the city undertakes, a citizen participation office, a neighborhood protection ordinance that requires neighborhood approval for new limited access highways, and a citizens transportation advisory council. The MPO respects and works within and with these regulations and institutions. Phoenix sponsored a 2015 Futures Forum that was attended by 3,500 citizens; many of the results are reportedly now being incorporated into the MPO's long-range plan.

CONCLUSIONS AND RECOMMENDATIONS

A former FHWA administrator noted that ISTEA implicitly calls for a major "sea change" in the way one plans for transportation. With a growing roster of notable exceptions, there is not yet, however, widespread enthusiastic support for public involvement at either state or MPO levels—a movement characterized by full commitment to do whatever it takes to achieve effective participatory planning. In many states and MPOs it still appears to be "business as usual."

It is clear that the time has come for new approaches and action. It is appropriate and necessary to redefine what effective citizen participation really is and to think much more creatively and big in developing programs. Planners should not be afraid to experiment on a trial-and-error basis and need not feel constrained by lack of funds. (There are many sources of assistance for such activities, including any or all of the following: current budgets, flexible funding programs, private foundations and businesses, or citizen volunteers.)

Because every community is different and every planning process has its unique variations, a single "best practice" public involvement process cannot be recommended. However, some characteristics are common to the most effective programs, including the following:

- Involvement of citizens from the very beginning,
- Carefully thought-out methodology plans,
- Inclusion of a broad mix of strategies and techniques that build on existing citizen participation mechanisms as much as possible,
- Assignment of meaningful roles for citizens,
- Focusing technical attention on issues of substantial public interest, and
- Attitudes of objectivity, fairness, and responsiveness on the part of process sponsors and decision makers.

Additional recommendations include the need for greater professionalism in state and local efforts to elicit public involvement. Every MPO and state should have at least one citizen participation

specialist on their staffs; larger ones should have more. A body of literature exists in this field. Practitioners should be encouraged to build on the state of the art and the lessons learned from the past. More research, information exchange, and training are also needed. It is hoped that federal officials will monitor public involvement efforts and include effectiveness assessments in their certification criteria.

Finally, all believers in participatory planning must work more vigorously to educate decision makers and other governmental officials about the many benefits of public involvement. When participatory planning is absent from or deficient in an ISTEA planning process, it is the obligation of those in the profession to communicate any objections. As with most of the good things in ISTEA, participation advocates are going to have to work hard to make public involvement a reality, but the mission is not an impossible one.

ACKNOWLEDGMENTS

The author thanks Tracey Nixon and Orris Moore of her firm and Florence Mills of FHWA for their assistance.

The views in this paper are the author's alone.

Publication of this paper sponsored by Committee on Citizen Participation in Transportation.

Involving Individuals with Disabilities in ADA Complementary Paratransit Planning and Implementation

JOHN N. BALOG, ANNE N. SCHWARZ, AND ROSALYN SIMON

The paratransit requirements of the Americans with Disabilities Act (ADA) of 1990 require the creation and implementation of an effective public participation program. The program should be designed so that all members of the community, particularly those with disabilities, can contribute to the development and improvement of the transportation services so important to them. Reviews of the paratransit plans and their updates submitted by fixed-route systems made it clear that many require coaching with respect to how to conduct an effective public participation program. A variety of technique can be used to satisfy the letter of the law and fully satisfy its spirit. Considered are the actual requirements of outreach, consultation, opportunity for public comment, accessible formats, public hearings, summarizing issues from the public comment period, and ongoing participation. Suggestions for satisfying the requirements are discussed. Other public participation elements considered to be important are also discussed, including use of the media, surveys of riders and other social service providers, performance monitoring, and planning the public participation process schedule. The most appropriate steps for each technique are offered, and checklists of suggested activities to be used by practitioners are included to ensure that the program is well designed and implemented.

The paratransit requirements of the Americans with Disabilities Act (ADA) of 1990 recognize the importance of public participation to the implementation of program goals. A successful public participation process guarantees that all members of the community, particularly those with disabilities, have the opportunity to contribute to the development and implementation of the paratransit services that are so important to them (*1*).

Considerable benefits can be achieved from a successful process. Community members can offer their ideas and suggestions for improving the service. They can also work with the transit system to help implement new policies and procedures through active participation in the decision-making process. This means that system representatives must have the opportunity to explain why some proposed alternatives are not possible because of available resources.

People with disabilities rely on public participation to express their mobility needs. Each transit system must reflect the importance of transportation as the link to their activities. If people with disabilities believe that this link is in jeopardy, they may exhibit considerable concern about potential changes. Conversely, other community members will usually support a transit system in the necessary decisions if they are assured through communication and involvement that they can benefit from the changes.

J. N. Balog and A. N. Schwarz, KETRON Division, Bionetics Corporation, 350 Technology Drive, Malvern, Pa. 19355. R. Simon, Project ACTION, National Easter Seal Society, 1350 New York Avenue, N.W., Suite 711, Washington, D.C. 20005.

ELEMENTS OF ADA PUBLIC PARTICIPATION PROCESS

ADA requires that specific public participation activities be completed for each paratransit plan. These activities need to be dynamic and continuing well beyond the submission of ADA plan updates. Specific requirements for ongoing public participation include outreach, consultation with individuals with disabilities, opportunity for public comment, accessible formats, public hearings, and summary of issues raised during the public comment period. These requirements are part of Transportation for Individuals with Disabilities. Final Rule (*2*). To effectively satisfy the requirements, a number of techniques are identified and discussed.

Other activities also can contribute to the satisfaction of public participation requirements, including effective use of the media, surveys of riders and social service providers, performance monitoring, and planning the public participation process schedule.

BENEFITS OF PUBLIC INVOLVEMENT FOR TRANSIT SYSTEMS

Many benefits for paratransit systems can be achieved by involving the public in design, implementation, and evaluation. They include avoiding errors, satisfying demand, encouraging the use of other services, easing the fears of riders, and communicating the system point of view.

Gathering input from current and potential riders can avoid costly errors in the long run. In many cases, input from people with disabilities can be educational, providing good ideas for services to satisfy user needs.

By learning about public needs, system efficiency can be improved. Communication with the public is a step toward satisfying demand. It is equally important to communicate the needs of the system to riders so that they can understand the reasons for decisions. Balancing ridership needs while satisfying demand can be achieved by

- Encouraging riders to schedule discretionary trips in off-peak hours, thereby lessening peaks and valleys in demand;
- Encouraging ridership from underserved parts of the service area;
- Determining what types of vehicles are necessary to offer the right mix of features, such as lifts, and to reach and negotiate all parts of the service area; and
- Determining when vehicles are satisfying the needs of individuals.

An important goal of ADA is to move people with disabilities more into the mainstream of activities. Many people with disabilities can use fixed-route service for a number, if not all, of their trips. Communication with the public will encourage the use of all services, including those with fixed routes. Simply making people aware of bus features such as lifts or stop announcement systems and travel training programs can encourage them to ride.

Riders often become concerned about changes to their system. They fear that they will not be able to use it or that it will be more difficult to use. Apprehensive riders can be critical of the system and difficult to work with to bring about changes. Effective communication with the public will address their concerns and allay fears, allow critics to express ideas for alternatives, be more open to changes and the needs of the system, and make attitude changes more easily.

Although not all current riders may fit the ADA definition of eligibility, such as seniors who are not disabled, it is important to include these citizens in the process to learn more about the transportation needs of these riders and alternatives for satisfying them.

Each transit system usually has good technical and economic reasons for the decisions made, but those reasons are not always fully understood by the community. Maintaining communication with the public at all times ensures open communication; that is, there is more likely to be support for the system when its needs are explained to the community.

A successful public participation process can make popular decisions and services even more attractive and can also foster acceptance of less popular decisions. As decisions and plans for fixed-route and paratransit services are being made, it is necessary that community leaders be included in the decision-making process so that they will support these decision as much as possible. Inclusion of community leaders will demonstrate to them and the community at large that the system is trying to satisfy their needs within available resources.

OUTREACH AND THE TRANSIT SYSTEM

Outreach includes steps to offer everyone with disabilities the opportunity to participate in developing paratransit plans, implementing ADA services, and evaluating their quality, including both those currently involved and those who have not previously been involved.

Appropriate steps for successful outreach include the following:

- Selecting goals and targets,
- Developing strategies and materials,
- Assigning personnel to tasks,
- Testing and conducting campaigns,
- Incorporating results into planning and service, and
- Including campaign and planning descriptions in the update.

To identify additional rider groups, "street outreach" programs have been implemented. These are presentations, demonstrations, and other public events at a variety of locations including rehabilitation centers, organizations for people with disabilities, medical facilities, churches, and apartment complexes. In addition, demonstrations of fixed-route bus services have been held at conferences, fairs, and shopping malls. This technique is most effective if demonstrations occur at a diversity of locations and if they can reach a variety of rider groups.

Outreach includes wide-reaching and targeted strategies. Wide-reaching strategies include advertising, media coverage, surveys of groups and individuals, mass mailings, and public appearances.

Wide-Reaching Strategies

The media can be an effective conveyor of information through the following avenues:

- Articles in local and regional newspapers,
- Public service announcements for radio and television,
- Staff interviews on radio and television programs, and
- Television coverage of outreach activities.

All are low cost compared with purchased advertising. Articles, stories, and interviews should highlight the system objectives of obtaining input, forming advisory committees, or conducting public meetings. Coverage should be throughout the service area.

Surveys are an effective method for collecting opinions. Structured questions can be asked about important service issues. Surveys can also inform people about new service features or possible changes and offer them the opportunity to comment.

Advertisements of events and service changes can generate interest and reach out to those not previously included. Because television or newspaper advertising can be costly, other forms of advertising might be more practical and more closely controlled. For example, outreach efforts can be advertised by using space in bus shelters, vehicle exteriors and interiors, transit stops and transfer facilities, and station interiors and exteriors. Advertisements can announce meetings and events, request input on service needs, and invite people to join advisory or ad hoc committees and make suggestions.

Individuals can be reached through public appearances of system representatives at community events and other gatherings such as fairs, festivals, and health exhibitions. Brochures, information handouts, requests for participation, and advertisements of system features can be provided at such events.

Mass mailings can be used to identify previously uninvolved people. Social service agency client lists, riders of other transportation services, residents of congregate housing areas, and members of advocacy groups are good sources. Mailings should convey information and request input.

Through eligibility certification, full lists of riders are available. These lists could be used to request members for an advisory committee. Alternatively, mailings could be more narrowly focused on those who, for example, have ridden more than twice a week. Lists are an effective means of making sure that each committee is appropriately stratified with respect to age, gender, disability, and frequency of system use.

Rider surveys can be completed more quickly and easily than surveys of larger groups in the service area. Riders are easily identified and the surveys can be more specific. Various types of surveys can be used, including phone, mail-back, or on-board surveys. The opinions of current system riders should be sought to support conclusions and decisions.

Surveys of social service providers can alert the system about service quality and rider perceptions. Because many organizations, advocacy groups, and social service providers are involved in paratransit through their clients, ongoing relationships with representatives of these groups exist. Outreach to members and leaders of

these groups can be conducted through meetings to discuss specific service features and service problems, resolve controversies, identify and communicate with nonriding members, and establish service relationships.

Targeted Strategies

In contrast to wide-reaching strategies, the system may also need to employ outreach strategies targeted for specific groups of riders or organizations. Public appearances with a presentation, question and answer session, and information handouts work well, informing members and leaders about the system, educating them about the nature and limitations of the service, collecting input about the service, identifying needs, and explaining little-known features of the system.

Another useful targeted strategy is to contact riders directly. Those who contact the system to complain about service can be well informed about its drawbacks. When a complaint is received, it is important to treat it with professionalism and efficiency. After resolution of the complaint, it can be useful to follow up by contacting the individual to learn more about his or her experiences. This contact can serve two purposes: for the transit system it offers another source of input; for the rider it provides an opportunity to offer constructive input. For the benefit of both, it provides assurance to the rider that the system is interested in the opinions of the community and making improvements.

CONSULTATION WITH PEOPLE WITH DISABILITIES

Consultation is a natural follow-on of outreach efforts. Consultation with people with disabilities involves meetings to

- Discuss service alternatives,
- Evaluate service information,
- Develop service plans,
- Gather input, and
- Draft ADA plan updates.

Steps for successful consultation activities include

- Selecting strategies and a timetable,
- Developing agendas and materials,
- Scheduling activities,
- Conducting the actual consultation,
- Including input in the planning process, and
- Including consultation efforts in all plan updates.

Consultation strategies can include a variety of techniques, such as conducting small group meetings to discuss issues and prepare plans. These groups can be formed through direct contact with riders. Interested individuals who contact the system can be invited to joint consultation groups. Fliers and mailings to riders can also invite membership. Groups can be either short or long term and effectively used to work on individual or multiple issues. The system will need to be prepared to educate participants in some of the aspects of its operations. For example, in discussions of the budget some of the amounts may seem large to people who are accustomed to household budgets; an explanation of the costs may be needed. Similarly, those with a business perspective may need some explanation of government rules for financing programs.

Group meetings with members of organizations that represent riders can be effective. A simple checklist includes mailing invitations to a few groups for a preset date, time, and agenda; visiting organization offices by appointment; setting up meetings with each organization; requesting opinions from organizations; and sending information to groups with a request that they arrange a meeting. Participants should be prepared to understand the point of view of the rider groups and should understand that organizations may have conflicting views. In addition, the system should be prepared to compromise, if necessary. During heated discussions, participants should be asked to suggest specific solutions. To reach a consensus, it is best to address issues one at a time. System representatives should always be prepared with all necessary information.

Because paratransit transports large numbers of people to locations that serve their needs, meetings involving riders, caregivers, and site workers at these locations can be effective. Common destinations may include rehabilitation hospitals, schools, job locations, senior centers, nutrition sites, or dialysis clinics.

National and regional organizations and local commissions representing the interests of people with disabilities often have offices in the community. These groups and their representatives are excellent sources of information and consultation for the paratransit service. They are also a good source with respect to such issues as accessible formats, training, pilot tests, material reviews, and participation in outreach activities.

Consultating with the public can involve participants in a variety of roles, including identifying the popularity of particular issues, gaining advice on the content of proposed ideas for procedures, coordinating numerous groups, and ultimately building consensus.

OPPORTUNITY FOR PUBLIC COMMENT

ADA regulations require that a draft plan be made available for public comment before finalization. This is the opportunity for those who worked on the plan, who have been interested in the process, or who will be affected by the plan and any other interested citizens to review the system draft. People should have at least 1 month before the public hearing to review copies of the documents. They should also have approximately 1 month after the hearing to submit any comments, review any other materials from the hearing, and react to events at the hearing.

System success relies on a broad public review of plans. It is important to devise a process for accepting and recording these comments into permanent records. Comments received may be provided in writing or in alternative formats such as telephone or audiocassette, as well as at the public meetings. For individuals who have other communication capabilities, one must arrange to receive and respond to this input in usable formats.

Several steps need to be accomplished:

- Determining an adequate public comment period,
- Developing methods to collect comments,
- Scheduling the period,
- Publicizing the period, and
- Collecting and responding to comments.

It is important to emphasize to the community that public input is encouraged and accepted throughout the year—not just during a

designated public comment period. A variety of activities should be conducted before the comment period so the public has adequate opportunities to provide input whenever an issue arises. These activities can be simple, including the use of a brochure for paratransit riders and others that includes the system's telephone number for receiving suggestions.

The length of the public comment period is variable. It should be extended for any or all of the following reasons: limited resources, early completion of the draft, serious remaining issues, multiple hearings, or restricted availability of the draft outside the system offices because of limited resources.

Methods of collecting comments will partially depend on the system's history of public participation. In areas with historically good participation, the methods will be known and tested. In others, the methods will need to include a well-planned and advertised public hearing along with other outreach efforts to notify individuals of the comment period.

It is useful to develop a form for the uniform collection of comments. A simple form can be distributed at public hearings that states, "We want your comments!", provides a two- or three-paragraph explanation and a blank area for individuals to write their comments, and is followed by a thank you. Inclusion of the name, address, and telephone number of the system on the form can also be useful. Similar forms should be used to record input from those who telephone their comments as well as for comments in alternative formats such as on cassette or from a teletypewriter (TTY). Staff members should be available in public to receive comments directly from individuals with disabilities and to enter these comments on the form as well.

Because input received during the comment period is for the public record, the system must track the comments received, sort them by subject, and respond to each one. In some cases, a simple thank-you letter or phone call may be sufficient. Others may require some information or clarification. For issues significant to ADA paratransit service, the system must provide a more extensive response.

ACCESSIBLE FORMATS

One of the most important requirements for public participation is the availability of relevant information in accessible formats. Some individuals with disabilities may not be able to read important information if it is available only in printed pamphlets. In fact, many potential users of ADA service may be discouraged from using the system if they cannot use eligibility forms or learn about important service information.

Accessible formats include but are not limited to the following:

- Large print,
- Braille,
- Audiocassette,
- Computer diskette, and
- TTY.

Steps for providing accessible formats include deciding which formats are necessary and possible, determining available resources, arranging for formats, making formats available to the public, advertising format availability, and including descriptions of format availability in the update.

Deciding which formats are necessary and possible is the first step. Information does not need to be provided in every possible format. The appendix to the regulations points out that there is no sense in giving a computer disk to someone who does not have a computer, or a Braille document to someone who does not read Braille. In other words, accessible formats must be usable by the individual who requests them.

A good outreach process will identify rider characteristics through contact with the riders and the various social service providers in the area. These agencies and riders can suggest which formats will be most helpful and most requested. Systems should select one accessible format and keep copies of required or highly requested documents on hand in that format. To avoid the unnecessary cost of translating documents into Braille when they will never be used, audiocassettes should be readily available and Braille should be provided only in special circumstances.

Once a decision has been made on accessible formats, it will be necessary to determine the support resources required to provide them. This step should be simple, provided that a strong outreach process has been established. A number of organizations—local social service providers; independent living centers; vocational rehabilitation offices; state, local, and national organizations for people with disabilities; commissions and services for individuals with visual or hearing impairments; and state, local, and regional commissions on disabilities—can provide assistance in translating information into accessible formats, or readers may be loaned to the system to orally translate a plan. If they are not able to help directly, these groups will be able to direct the system to an organization in the area that will.

In making arrangements for accessible formats, the system needs to determine whether the materials will be produced in house or by a local organization. The most important factors are cost and the time between the request for a format and the time it is delivered to the individual. Lowest cost and shortest turnaround time are the most beneficial.

The volume of materials produced will drive the costs of accessible format production. Estimates for time and cost of production should be made for one copy of each document as well as for documents in bulk. Frequently requested information, such as rider handbooks, should be kept in ample supply in accessible formats. An additional consideration is the format in which information is received by the system. For example, if an application was requested in Braille by an individual, that individual may complete the application in Braille. Or, perhaps an audiocassette copy of the application was returned with an individual's responses recorded on it. In these situations, the information should be transcribed by the organization that produced the original document.

Eligibility information and rider handbooks should be readily available at churches and synagogues, the transit system, local social service providers, independent living centers, medical facilities, and so forth. Annual system updates are expensive to reproduce in alternative formats. A copy in large print or audiocassette, or both, should be available in the local library and at the system's offices along with regular copies of the plan and update. Executive summaries may be inexpensively translated into accessible formats. These summaries may be sent to local social service providers, riders, advisory committee members, and others.

The availability of materials in accessible formats must be adequately advertised or those who require these materials will not know of their existence. Advertising should be done in accessible formats, such as closed-captioned television, large-print flyers posted on vehicles and in facilities, and radio spots. The availability of materials in accessible formats must be fully described in the

plan and subsequent updates. Information in the update should include the formats in which the update was made available, the formats in which applications and rider handbooks were made available, where these formats were made available, the formats that the system had the ability to make available but were not requested, and a description of how, when, and where the availability of information was advertised to the public, including individuals with disabilities.

PUBLIC HEARINGS

The most basic form of participation is the public hearing. ADA regulations require at least one public hearing before the submission of an update, but more than one may be necessary. The purpose is public review of progress toward ADA compliance over the previous year and the review of the ADA plan update. The process should start with outreach, consultation, surveys, and other public involvement well before the public hearing. Months before, the plan should be in the process of being developed with the help of individuals with disabilities. Only after strong outreach and consultation processes should a hearing be held to review the draft plan.

A number of steps are necessary to conduct a successful public hearing, including preparing planning and update materials, determining the date, selecting a site, selecting advertising methods and placing advertisements, holding the hearing, collecting comments at the hearing and in writing, and including documentation in the plan.

Regular public meetings are a good ongoing mechanism for community input, but goals that may be satisfied at a public hearing include final consultation with the public, including individuals with disabilities; discussion of the paratransit service and plan update; and receipt of additional comments and suggestions.

All planning and update materials must be made available to the public at least 30 days beforehand in accessible formats. Scheduling should allow enough time for the completion of the comment period and the incorporation of all comments into a finalized update to be submitted to FTA. For smaller systems with only one population center and a small ADA-eligible population, one hearing may satisfy community needs. However, for systems with a larger population that is distributed over a number of areas, more than one hearing will need to be held.

Hearings should be scheduled to encourage maximum participation; that is, they should be scheduled during the paratransit system's hours of operation to accommodate the transportation needs of the interested individuals. Hearings held during the middle of the day are likely to exclude individuals who are at work or medical appointments. The appropriate time should be determined through the outreach and consultation activities.

Hearing sites need to be convenient for attendees and should include necessary features, such as accessibility for people with disabilities. Good places to start when deciding on a site are facilities that have been used in the past for meetings attended by individuals with disabilities.

The following are additional guidelines for selecting hearing locations:

- Choose a central location in the area of greatest population concentration within the service area,
- Make sure that the site is accessible by public transportation,
- Identify different neighborhoods for multiple hearings in large cities or those involving joint plans, and
- Select sites that satisfy ADA standards for accessibility, including sufficient space for individuals in wheelchairs, control of the temperature in the room, and all necessary equipment.

Extra parking for individuals with disabilities must be provided. In addition, it might be necessary to provide for greater amplification of the sound system or for placement of additional signs for accessible entrances and restrooms.

An attendance sheet should be placed at the entrance to create a record of all attendees and to serve as a basis for expansion of the system's mailing list.

An agenda for the hearing outlining the order of the proceedings should be prepared and distributed to attendees. A typical agenda might start with a brief introduction followed by a presentation of the update or other significant new information. A logical sequence might be discussion of each required section in succession. After the presentation, the hearing should provide an open forum for testimony. Even if all issues had not been resolved in earlier public participation, they should be understood at the time of the hearing and system representatives should be prepared to respond. Issues will not be resolved at the hearing; written responses to the comments should be provided to the individuals testifying.

To maintain order and ensure that all participants have a chance to speak, those wishing to testify should sign up in advance, and there should be a separate sign-up sheet for those who did not sign up in advance. The chairperson of the meeting should call the name of each testifier in turn. A total of 5 min for each speaker is enough for a point of view to be expressed. The time limit ensures that everyone will have a turn. Some flexibility should be maintained, however, for those who have difficulty communicating.

It is important that an interpreter be present to translate oral communication to sign language for those who cannot hear. Interpreters can be found by contacting local and state agencies.

Finally, a record of the hearing should be transcribed.

ISSUES RAISED BY THE PUBLIC

All comments received from the public should be addressed. For many comments the response need only be an acknowledgment of its receipt. For significant issues more action is necessary, such as a prompt, direct response and a clear discussion of how the issue was resolved. Because public comments can come from individuals with all kinds of communication abilities, the system should be prepared to respond in all kinds of formats. If, after a thorough public participation process, no significant issues have been raised by the public, this outcome should be stated in the plan.

ONGOING MECHANISMS

Public participation does not stop with the publication of a plan. To achieve the highest level of success, a comprehensive ongoing process should be developed that satisfies the letter of the legislative requirements in addition to achieving the spirit. The process should continue whatever formal and informal components were initially used. The process also can be substantially changed and improved as needed.

Advisory committees and the hearing can serve as the foundation for a continuing program involving the public. Advisory committees should be constructed to represent the various segments of the local community: representatives should be drawn from social service providers, the transit system, contract service providers,

riders and nonriders, and agencies and organizations involved in transportation-related activities for individuals with disabilities.

Rider and nonrider members should clearly represent the various types of disabilities in addition to age, gender, economic status, and race. Although this would suggest a large membership that can be difficult to manage for issues requiring expendiency, a large membership can be effective in self-regulating the members' actions. A committee with a large, representative population can bring all the issues to the table and use consensus-building techniques to make decisions that are in the best interest of riders and advocacy organizations.

The following steps should be part of the ongoing process:

- Provision of a mechanism for riders and others to voice complaints to and commendations for the system,
- Response to every complaint or commendation and fair resolution along with full formal documentation,
- Analysis of all collected data to establish any trends, and
- Implementation of changes and continued monitoring of complaints or commendations to determine the level of success.

Other formal examples of ongoing mechanisms include telephone surveys, focus groups, driver interviews, call-intake staff interviews, customer service staff interviews, newsletters with suggestion forms, and on-board suggestion boxes.

In conducting telephone surveys, staff should be used during the least busy times of the day to randomly select manifests from the previous week and to call a representative number of riders to determine whether their pickups were on time, they were in time for their appointments, the vehicle was clean, the driver was courteous, and other information. This information makes it possible to assess the quality of service being provided and is greatly appreciated by the riders.

The use of focus groups is a formal technique for soliciting information from riders and nonriders. The concept is to put a number of individuals, (approximately 10) together who clearly are believed to represent the attitudes of system users or nonusers. A facilitator knowledgeable in leading focus groups and in paratransit and fixed-route services explores the views of the participants during an interactive session lasting approximately 2 hr.

Rider focus groups can solicit input on current system service quality levels. Companions to rider focus groups are groups involving nonriders. Although many systems are financially unable to satisfy total demand, it should still be a goal to determine why individuals with disabilities are not using the services that are offered. In 1997 all systems will have to satisfy demand in an unconstrained manner. It is better to find out now why people are not riding and to make the appropriate adjustments to service design than to wait until 1997 and find that nonriders have realized that they can demand the opportunity to use the service, which would put the system in a more difficult position.

Vehicle drivers are the only face-to-face personal contact between riders and the system. Their behavior and attitudes convey a message to each rider; in addition they can also be a good source of information. Because they operate wheelchair lifts every day and have firsthand knowledge of their effectiveness and the quality of service they provide, interviews with drivers can identify problems that ultimately can lead to higher quality of service.

Although drivers provide the only face-to-face personal contact with passengers, call-intake staff are the first individuals contacted when a trip is booked. These staff members are ambassadors for the service and are the basic salespersons. They should be regularly interviewed by management to identify any difficulties for prospective system users. Call-intake staff should be sensitive to individual problems and should suggest changes to their supervisors that would improve the quality of service.

Customer service staff are responsible for problem calls from current and potential riders. They have direct contact with riders and receive information about, for example, whether vehicles are on time, clean, and efficiently scheduled and whether the drivers are doing their job effectively. Interviewing such individuals will identify problems and perhaps provide suggestions to effectively resolve them.

It is important to provide information to everyone on a regular basis. A good mechanism is a simple one-page, two-sided newsletter that includes key telephone numbers, changes to the program, success highlights, schedules of upcoming events, and a mail-back coupon designed to identify suggestions for improving service. These newsletters can be sent to everyone within the data base, handed out on vehicles, or made available via human services agencies, banks, social security offices, and other locations riders might frequent. When individuals offer comments, they are making decision makers aware of positive and negative characteristics. Moreover, future newsletters can be used to summarize suggestions that have been made and the actions that have resulted.

Another way to get feedback is to provide a suggestion box on each vehicle along with forms and pencils. Riders should be encouraged to fill out the forms and to insert them into the locked box. It is important to maintain a high level of confidentiality so that riders will not fear retaliation, and there should be a general policy that a supervisor empties the suggestion boxes each day. The data should be tabulated and responded to regularly to guarantee feedback on submitted ideas.

In addition to the formal ongoing mechanisms discussed here, there are a number of informal public involvement techniques that are useful, including "talk-to-the-boss" days, radio/TV/closed-circuit TV (CCTV) talk shows, booths at fairs, vehicle demonstrations, and rider promotions.

An informal technique that clearly demonstrates the commitment of the chief executive officer is talk-to-the-boss days. In fixed-route systems, the general manager and key departmental heads are available at stations or intermodal facilities so that individuals can approach them and express their ideas. This technique has been used effectively by scheduling visits every Thursday, for example, at varying periods during the day. Some systems have also extended the practice to weekends. Fixed guideway and fixed-route transportation accommodates this technique more easily than paratransit. For paratransit services, the manager would need to identify congregate housing sites, typical work or training locations, medical facilities, or shopping centers known to be frequented by riders with disabilities. Knowing these schedules, decision makers can be where the riders are during any day they would like to meet with them. Decision makers may also ride on paratransit tours at various times and on different days to talk with riders.

Radio, TV, and CCTV talk shows are gaining as a means for people to voice their opinions. Talk shows can allow individuals to make anonymous comments, act as a publicity-generating device, be effective in making nonusers aware of the high quality of service being provided, and provide currently satisfied riders the opportunity to independently counteract the charges of complaining riders.

Maintaining a standard booth with a knowledgeable individual and appropriate handout materials at fairs or shopping centers can

provide personal interaction. System personnel can provide information, answer questions, and listen to complaints and commendations. This information can then be tabulated and transmitted to system decision makers. Keychains, coloring books, shopping bags, and other promotional materials can be used to attract individuals to the booth.

Most systems are adjusting their vehicle fleets. Positive characteristics of accessible vehicles can be used to attract individuals to the system and to acquire information on their opinions. Vehicle demonstrations can be integrated into fairs or made available at shopping centers, medical facilities, and other sites.

In much the way that grocery stores have promotional sales for their customers, a system can provide rider parties. A transit or paratransit free fare day or a family picnic for riders with free entertainment if riders use the system to get to the picnic site can demonstrate an interest and appreciation for customers. At the same time, such parties can be used to demonstrate new or renovated vehicles and to provide a place for riders to interact with decision makers.

There is no one particular ongoing public participation model that is most appropriate. Each system should use a combination of formal and informal techniques to solicit the information that is necessary to planning and operational decisions. The integrated process does not have to be cumbersome and should indeed be fun for the system, riders, and nonriders. It is important to develop a sense of community and, whenever possible a sense of family among riders and system employees, keeping in mind that family members will share information with each other that they would never share with a stranger.

USE OF MEDIA IN PUBLIC RELATIONS

Steps associated with successful use of the media include (*a*) determining the audience to be reached, (*b*) researching the types of media available, (*c*) choosing the combination of media to use, (*d*) writing advertisements and public service announcements, and (*e*) advertising the public participation process.

In deciding how to publicize participation activities, system staff must be aware of the various types of advertising available (and the type of audience reached) in the service area and the positive and negative aspects of each. The system should strive to receive as much exposure as possible.

The use of a media checklist should include at least the following questions:

- Have the types of media available in the service area for advertising the public participation process been investigated?
- Have the appropriate newspaper/TV/CCTV/radio staff members been encouraged to write or broadcast an article or report about the ADA complementary paratransit service?
- Have public service announcements been written?

SURVEYS OF RIDERS AND OTHER SERVICE PROVIDERS

Rider surveys typically collect opinions on service currently provided and proposed service changes. They can also be used to understand the transportation needs of the community, to collect such ridership information as who rides, where they go, and how often they travel; and, as importantly, information on those who do not use the system.

Surveys of other service providers are also useful. It is important to maintain a good working relationship with these agencies to coordinate service, if necessary.

The following steps are associated with the conduct of a successful survey:

- Defining goals and target respondents,
- Determining survey type and target number of respondents,
- Developing questionnaires,
- Pretesting and revising questionnaires,
- Distributing questionnaires,
- Ensuring adequate responses, and
- Tabulating, analyzing, and distributing results.

The goals of a rider survey should be to evaluate the quality of current services, conduct regular quality checks, pilot test materials and documents, evaluate possible service changes, and assess unmet demand and potential ridership. In contrast, the goals of a provider survey should be to assist with coordination efforts, identify other providers, define the nature of paratransit in the area, and estimate demand.

PERFORMANCE MONITORING

In monitoring performance, public participation plays a role in measuring how well the system is operating and the quality as perceived by the community. Each system needs this information. At the same time, independent measures of system performance and how well the system complies with ADA regulations are needed.

Performance can be monitored through information shared in outreach activities, information received during the consultation process, issues raised in the public hearing and public comment opportunity, interaction with the ongoing mechanism for public participation, and surveys of riders and service providers.

PLANNING PUBLIC PARTICIPATION PROCESS SCHEDULE

It is necessary to conduct outreach activities early so that people are made aware of the planning process and have a sufficient opportunity to participate. Consultation efforts can occur after outreach but also must take place during the early stages and throughout the planning process. The public hearing and public comment periods need to occur later in the process, after the draft plans are complete and after general consensus has been reached on issues related to the service. The ongoing mechanism must be active at all times with regular meetings or other activities.

The overall schedule should include outreach activities, consultation, advertisement and availability of the public comment period, development and advertisement of accessible formats, advertisement and conduct of the public hearing, development of the summary of significant issues, ongoing public participation mechanism, development of media relations, formal and informal surveys, and monitoring of performance.

Committing the overall scheduled activities to paper and a chart will allow everyone to know exactly what needs to be done and can be used as a tracking mechanism to guarantee that proposed activities actually occur.

CONCLUSIONS

It is important to recognize that the activities required by the ADA regulations can be fully performed. The important requirements of the regulations and the activities needed have been summarized.

Public participation should be encouraged and anticipated by transit staff professionals, those who currently ride the system, and those agencies involved in the transport of individuals with disabilities. Looking at the requirements not as necessary evils but rather as potential mechanisms for improving transit services should be the prevailing attitude.

ACKNOWLEDGMENTS

The KETRON Division of The Bionetics Corporation would like to thank Project ACTION, National Easter Seal Society, and FTA for the opportunity to develop the *ADA Public Participation Handbook,* which served as the basis for this paper.

Because of space limitations, example techniques for public participation were not included in this paper. Individuals interested in example techniques may acquire a copy of the *ADA Public Participation Handbook* from Project ACTION, 1350 New York Avenue, N.W., Suite 711, Washington, D.C. 20005, or from FTA, which funded the development of the handbook.

Robert Stout, Gary DeLorme, and Irv Chor of FTA were extremely helpful in the completion of the original handbook. Stout demonstrated keen insight by recognizing the need for the handbook and for interaction with Project ACTION and KETRON in its development. DeLorme provided expert advice and concern about the systems he oversees in FTA Regions 1, 2, 8, 9, and 10 along with the federal perspective on the challenges related to public participation. Chor complemented Delorme's role by providing expert advice and counsel on the systems he oversees in FTA Regions 3, 4, 5, 6, and 7. All three also provided careful reviews of the authored materials.

REFERENCES

1. Balog, J. N., A. N. Schwarz, J. E. Rimmer, and M. M. Hood. *ADA Public Participation Handbook*. Project ACTION, National Institute for Accessible Transportation, Washington, D.C., 1993.
2. U.S. Department of Transportation. *Transportation for Individuals with Disabilities. Final Rule.* 49 CFR, Part 37, *Federal Register,* Vol. 56, No. 173, Sept. 6, 1991.

Publication of this paper sponsored by Committee on Citizen Participation in Transportation.

Appropriate Cost Sharing for Paratransit Service

DAVID KOFFMAN

Public transit operators providing paratransit service to comply with the Americans with Disabilities Act are focusing on paratransit as a form of supplementary public transportation. Much of the demand for paratransit service consists of trips that bring clients of social service agencies to and from programs of those agencies. For various historical and institutional reasons, this demand is considered different from the demand by unaffiliated individuals for nonagency purposes. To reduce their financial burden of compliance, the operators often desire to recover all or part of the cost of "social service agency trips" from the agencies. Two case histories are used to illustrate three issues connected with recovering the cost of agency trips:(*a*) How to determine or define which trips are agency trips and which are individual trips; (*b*) Reaching agreement on what is the appropriate fare or share of costs to be paid by the agencies; and (*c*) Determining the actual cost of the agency trips. A cost allocation model for paratransit service, which was used to determine the fixed and variable components of cost for eight different types of service offered by a single provider, shows how such a model is useful for policy decisions.

As paratransit services have developed they have been viewed in two different ways:

1. As a form of public transportation, similar to conventional transit systems, for people who cannot use conventional transit; and
2. As an adjunct to social services for a variety of special groups, including people with disabilities, people with low incomes, and seniors.

The two views are reflected in distinct but connected histories of legislative efforts and programs.

PARATRANSIT AS PUBLIC TRANSPORTATION

The public transportation view is connected to the debate that used to take place over a perceived choice between fixed-route accessibility and separate door-to-door service. This view is embodied in the federal Department of Transportation (DOT) rules implementing Section 504 of the Rehabilitation Act of 1973 (*1*), which required "interim accessible transportation" as a temporary substitute for fixed-route accessibility. [This "final rule" was later reissued in May 1986 after a legal challenge and congressional action and eventually was subsumed into the regulations of the Americans with Disabilities Act (ADA).]

The paratransit provisions of ADA represent the culmination of this view. In requiring that transit operators provide paratransit comparable to the operators' fixed-route services, ADA makes the unspoken assumption that the demand for such services will be comparable, that is, similar to the demand for fixed-route transit in the diversity of trip purposes and destinations served, and the independent nature of most trip makers. This public transportation orientation can be seen in many provisions of the ADA regulations, such as the prohibition on trip purpose rules for nonsubscription trips (also in the earlier 504 regulations), the limitation of subscription trips to 50 percent of demand at any time of day, and the provision that fares for social service agency trips are expected from the twice-fixed route limits that apply to other paratransit trips.

PARATRANSIT AS SOCIAL SERVICE

Most paratransit service in the United States, including both public and nonprofit providers, is of the second type. For example the 1990 San Francisco Bay Area Paratransit Plan (*2*) divided existing paratransit trips into two types:

- General trips were defined as trips by individuals to destinations of their choice, not associated with any agency programs.
- Program trips were defined as trips provided by or sponsored by human service agencies for the purpose of carrying clients to and from programs of those agencies.

The plan found that existing paratransit services in the nine-county San Francisco Bay Area provided about 1.5 million general trips and 4.1 million program trips.

For at least 20 years policy makers and practitioners have been complaining about the uncoordinated nature of social service transportation and attempting to coordinate it. For example, one of the goals of Section 147 of the 1973 Federal Highway Act was to "enhance coordination, i.e., increasing productivity, reducing duplication of services, and arriving at economies of scale among agency transportation providers."

The notion that coordination would lead to reduced cost is also contained in the 1979 504 regulations (*1*) that state the following:

> The recipient, working through the MPO, shall use its best efforts to coordinate and use effectively all available special services and programs in the community in order to ensure the provision of service that meets the standards of paragraph (b)(2)(ii) of this section. Such services and programs may reduce the recipient's expenditure obligation under paragraph (b)(2)(i) of this section. . . .

COST SHARING AS BARRIER TO COORDINATION

One of the (many) barriers to coordination has been the fear that one agency or another will not shoulder its fair share of costs. In particular, some general public paratransit programs, such as those run by

Crain & Associates, Inc., Menlo Park, Calif. 94025.

transit operators and cities, have been concerned that coordinated service will lead to "client dumping" on the part of many agencies —in other words, that agencies would simply discontinue their own service and rely on the public service without making any financial contribution beyond the regular fare. In that event the notion contained in the 504 regulations just cited would be misguided. By coordinating, a transit operator would increase rather than decrease its financial obligation. The case histories in this paper illustrate how these concerns have played out in two areas.

CASE HISTORIES IN TWO COUNTIES

San Mateo County, California

San Mateo County is located on the San Francisco peninsula immediately south of the city and county of San Francisco. It has a population of about 650,000, with moderately dense development in the urbanized areas. The San Mateo County Transit District, known as Sam Trans, operates fixed-route service on an annual operating budget of about $50 million, carrying about 18 million passengers per year on 86 routes with 302 buses.

SamTrans also operates a paratransit system called Redi-Wheels for elderly and disabled riders. Redi-Wheels service is provided under a contract with DAVE Transportation using a fleet of 28 SamTrans-owned accessible minibuses. In April 1992, as part of its ADA compliance plan, SamTrans initiated a supplementary taxi and lift-van program to handle trips for which there is insufficient capacity using the Redi-Wheels fleet.

In the more than 10 years that Redi-Wheels has been operating, the service has come to be dominated by service for social service agencies and their clients. The history of this trend, the language used in discussing it, and policy decisions pertaining to it have been a source of intense discussion and discord between SamTrans and other agencies. Until recently there had been a consensus among most participants in the planning process that providing social service agency trips served important community needs and made the most effective use of resources by serving many group trips. The Paratransit Coordinating Council, a community oversight organization with a mandate from the local metropolitan planning organization, had established a trip priority system that reinforced the focus on agency trips. This consensus began to evaporate during the period leading up to passage of ADA, when the vast unmet need for general paratransit trips came to assume more importance.

Through June 1989, a nonprofit agency, Poplar Center, operated parallel to Redi-Wheels providing service exclusively for social service agency programs. Poplar Center charged the agencies under a variety of rates that recovered amounts ranging from 11 to 100 percent of the cost of service. The remainder was covered by a variety of public funding sources. At this time Poplar Center was also the Redi-Wheels contractor. Redi-Wheels service provided rides to clients of many of the same agencies as did Poplar Center's own service, charging them the regular Redi-Wheels fare, which was $.60 at that time.

In July 1990 Poplar Center discontinued most of its transportation operations because the agency was losing money. SamTrans contracted with DAVE Transportation to provide the Redi-Wheels service, and most of the former Poplar Center agency service was folded into the Redi-Wheels service. At about the same time a new "equitable fare structure" was adopted, which was designed to recover approximately 31 percent of costs from all agencies receiving service. The equitable fare structure proved to be extremely unpopular with certain agencies.

In late 1990 work began on the San Mateo County Paratransit Plan. The situation at that time was as follows:

- Approximately 64 percent of Redi-Wheels trips were being used to carry clients of ten agencies.
- The agencies were being charged according to the equitable fare structure, which would actually recover about 24 percent of the cost of service.
- Two agencies serving clients with developmental disabilities, whose clients had received Redi-Wheels service for $.60 per ride, refused to pay according to the equitable fare structure. Redi-Wheels did not collect fares from those clients and continued to bill the agencies.
- Approximately 21 percent of Redi-Wheels trips were being used to provide subscription service to unaffiliated individuals, primarily for dialysis and cancer therapy.
- ADA had already been passed; it would require unconstrained service primarily directed at nonsubscription travel, which then accounted for only 15 percent of Redi-Wheels service.

Eugene, Oregon (Lane County)

Eugene is the county seat of Lane County. The metropolitan area, which includes the adjacent city of Springfield, has a population of just under 200,000. Fixed-route transit service is provided by the Lane Transit District (LTD) which serves about 6 million passengers per year with a fleet of 77 buses and an annual operating budget of about $9 million.

For paratransit service, LTD contracts with the Lane Council of Governments (L-COG), which in turn contracts with Special Mobility Services, Inc. (SMS) for daily operations in the Eugene area. SMS is organized as a nonprofit corporation and has obtained 15 vehicles through the 16(b)(2) program for use in Eugene area paratransit service.

Paratransit service in the Eugene area has been highly coordinated. LTD has seen this as a way to spread overhead costs over a larger base. Nearly all available transportation-related subsidy funds are channeled through the one contractor, SMS. SMS, as a nonprofit agency, has been able to obtain 16(b)(2) vehicles and generally has been the only applicant for 16(b)(2) vehicles in the Eugene area. In delegating the contracting function to L-COG, LTD has encouraged coordination with the variety of senior services provided by L-COG, including the senior component of the Title XIX (Medicaid) program and the federally funded Senior Companions program.

L-COG has encouraged SMS to provide service to a number of social service agencies. When Crain & Associates began work on the Lane County Long Range Paratransit Plan, the situation was as follows:

- One agency, which provides services to developmentally disabled clients, entered into a formal contract with SMS, under which it paid a flat amount of $24,000 per year and received approximately 4,100 vehicle-hr of service.
- An adult day care agency received service at the regular Dial-a-Ride fare.
- Clients of the county developmental disabilities agency received after-hours taxi service at no charge.

• In response to encouragement from L-COG to make a substantial amount of trips available to the Title XIX program, SMS had quoted rates for Title XIX service that were substantially below the state-allowed maximum rates.

L-COG had also used some Older Americans Act (OAA) funds under its administration to fund a Volunteer Escort program and a flexible-route grocery shopping service for seniors, both of which were operated by SMS. However, by 1990 the OAA funding had been reduced to very small amounts, while the services continued.

Excluding volunteer service and the flexible-route grocery shopping service, about 50 percent of paratransit service was being provided to agency-sponsored riders, including Title XIX clients.

As part of the Long Range Paratransit Plan, L-COG and LTD wished to address the issue of coordination and determine whether the existing distribution of service and costs was fair and mutually beneficial.

WHAT IS AN AGENCY TRIP?

In both San Mateo County and Lane County, transportation officials were concerned about the amount of resources going for social service agency trips and wanted to develop policies that would be viewed as fair while preserving funds for ADA compliance.

Inherently Fuzzy Distinction

A key element in any policy has to be the definition of an agency trip. Staff of social service agencies correctly point out that their clients are individuals and have the same right to service as any other individuals. Much travel to social service programs is initiated at the individual's request. They point out that social service programs serve the needs of particular groups in much the same way other institutions and businesses serve other needs.

San Mateo County began grappling with this issue before final ADA regulations were available. The draft regulations issued in March 1990 did not attempt to define agency trips. As part of its work in San Mateo County, Crain & Associates developed a working definition on the basis of the concept of an "agency slot," which it also proposed to FTA in comments on the draft regulations. The final regulations incorporate language very similar to that of the San Mateo proposed policy. (No doubt, similar comments came from many sources.)

ADA Regulations

DOT's final rule implementing the transportation provisions of ADA (*3*) states

> The entity may charge a fare higher than otherwise permitted by this paragraph to a social service agency or other organization for agency trips (i.e. trips guaranteed to the organization). [*3*, § 37.131(c)(4)]

Appendix D to the regulations, which provides the official interpretation of the rules, includes the following guidance:

> This exception . . . applies to 'agency trips,' by which we mean trips which are guaranteed to the agency for its use. That is, if an agency wants 12 slots for a trip to the mall on Saturday for clients with disabilities, the agency makes the reservation for the trips in its name, the agency will be paying for the transportation, and the trips are reserved to the agency, for whichever 12 people the agency designates, the provider may then negotiate any price it can with the agency for the trips. We distinguish this situation from one in which an agency employee, as a service, calls and makes an individual reservation in the name of a client, where the client will be paying for the transportation. (*3*, Appendix D)

The preamble to the regulations explains that part of the intent of this provision is "to deter 'dumping' of social service transportation onto the public paratransit system."

The ADA Paratransit Handbook interprets the distinction this way:

> Informal referrals by human service agency staff should not, however, be treated the same as contract services. For example, a request for service might be made by an agency on behalf of an eligible rider with a cognitive or communication disability. In this case, the complementary paratransit service fare must be used. (*4*, pp. 5–7)

The handbook distinction turns on the word "contract." However, typically the issue is precisely whether certain trips by agency clients should be covered by a contract of some sort, or whether the agency (acting on behalf of its clients) has a right to service, under ADA rules, with no further negotiation. The language in Appendix D of the regulations indicates several useful guidelines:

1. Is a specific quantity of service guaranteed to the agency?
2. Can the agency designate which of its clients will use the service guaranteed to it?
3. Does the agency make the reservation in its name?
4. Does the agency rather than the client pay for the rides?

The first three guidelines are clear, but the fourth is not because some agencies that pay for service maintain that they are simply acting as a collection agent for their clients, who actually bear the cost. Moreover, the question of whether the agencies should pay is not a given; instead, it is often the issue that needs to be decided.

Resolution in San Mateo County

Both San Mateo and Lane Counties have arrived at similar policy solutions on the basis of the ADA regulations. In the case of Lane County, the process was relatively straightforward and cooperative, whereas in San Mateo County the process was drawn out and discordant. The main focus in both cases was on repeated service of a subscription nature.

The essence of the policy is that trips per se cannot be classified as to whether they are agency or individual trips. However service types can be distinguished. It was decided that agencies should be free to choose between two types of service. As described in the San Mateo County Paratransit Plan, the two types of service are as follows.

• *Agency slot*: A trip guaranteed to a particular agency, regardless of the individual who is using it. The agency could change the persons filling their slots at any time.

• *Individual subscription trip*: A recurring trip for which a standing order is placed. Subscription trips would include trips taken by unaffiliated individuals, for example, to dialysis, therapy, or school. A subscription trip would be guaranteed to the individual rider, not

the agency, hospital, or school. Each individual subscription would be for travel to a particular destination. Individuals who no longer needed to go to that destination would give up that subscription and would go on the waiting list for any new subscription to a different destination. If the individual is traveling to a social service program on an individual subscription (i.e., not an agency slot), the agency has no rights to the subscription.

A waiting list would be established for individual subscription trips. Anyone desiring subscription service who is on the waiting list would be able to call and request each trip as a nonsubscription trip. However, if demand is such that some requests were being denied, they would have no guarantee of service. The waiting list could take into account trip purpose priorities.

Agencies that choose agency slot service would be subject to cost sharing or premium fares. Any agency that does not wish to pay the premium fare for a guaranteed slot could ask its clients to take their chances in obtaining an individual subscription or arranging each trip separately.

It appears that two San Mateo County agencies will decide to treat their clients as individual subscribers. These are the same two agencies serving developmentally disabled clients who objected to the original equitable fare structure. Their clients had historically paid only the regular Redi-Wheels fare of $0.60 (since raised to $0.85). Both agencies are contractors to the Golden Gate Regional Center, which is responsible for the full range of services to people with developmental disabilities. The Regional Center, like its sister agencies throughout California, maintains that it cannot legally pay a public transit agency more than the regular fare for service. The regional centers are also prohibited from charging their clients for services. It remains to be seen whether the regional centers will actually be content with the limitations of individual subscription service.

In contrast, agencies providing services to seniors have indicated their satisfaction with the new agency fare policy. These are the same agencies that had contracts with Poplar Center before and that promoted the original equitable fare structure. They see a guaranteed quantity of service as essential to being able to plan their programs, and according to the agency directors, they pass the cost of transportation on to their clients. Medicaid trips have never been provided by Redi-Wheels and so are not an issue with respect to cost sharing.

Resolution in Lane County

Lane County adopted a similar policy, distinguishing between "contract service" and "individual subscriptions." Contract service in Lane County may be justified not just by guaranteed service, but any kind of service that goes beyond normal dial-a-ride parameters, for example, in terms of quantity of service used, directness of routing, hours, eligibility, or the level of passenger assistance provided.

As in San Mateo County, it appears that agencies accustomed to paying only the regular fare will opt for individual subscriptions, whereas agencies accustomed to paying more will opt for contract service. The actual division with respect to the type of agency is opposite the one in San Mateo County. The Pearl Buck Center, which serves clients with developmental disabilities, will probably continue to contract for service. It may be noteworthy that the Pearl Buck contract has always been with SMS, the private provider of dial-a-ride services, and not with the county or the transit district.

The major adult day care provider, in contrast, will probably request individual subscriptions for its clients. The day care center has always requested individual rides for its clients, who pay the regular fare themselves. At times day care clients have endured significant refusal rates, although not recently. Lane County plans to begin formal subscription service, which has never existed in the past, so day care clients will actually experience improved service.

A significant element of the Lane County plan is to charge higher fares for individual subscriptions than for other trips. Currently all dial-a-ride trips cost $0.30, and monthly passes are available. The Lane County Long-Range Paratransit Plan calls for phasing in a new fare structure under which individual demand-responsive trips will cost the same as the regular fixed-route fare (now $0.75), and subscription trips will cost $0.25 more. At $1.00, subscription fares will still be under the twice-fixed route ADA limit. Monthly passes will be phased out.

Lane County serves Medicaid trips through its paratransit program, but has chosen to treat Medicaid service as distinct from that offered by social service agencies. This decision is based on the long-standing practice of the Medicaid program paying for transportation. As described in the concluding section of this paper, Medicaid will be charged more than it has in the past for service by the dial-a-ride provider.

WHAT IS THE APPROPRIATE AGENCY COST SHARE?

Paratransit fares typically recover a small percentage of the full cost of service—often below 10 percent. In theory, agencies should pay at least enough to compensate the providing or funding agency for any additional burden it incurs from whatever special treatment the agency is receiving. This goes back to the principle that agency clients have the same rights as any other individuals. In other words, a higher fare or cost share is appropriate if clients are receiving more-than-equal rights. This higher cost would apply if the clients avoid having to go on a waiting list for limited subscription service, if they are not subject to the usual eligibility rules, if they receive a higher level of assistance, and so on.

In practice, the decision on cost shares was based not on theory but on negotiation and local circumstances. In San Mateo County a precedent had been set under the old equitable fare structure, which was based on a calculation that the agencies served by Poplar Center had been paying 31 percent of the full cost of service. Therefore it was possible to obtain agreement on a minor increase to 33 percent of actual cost. Because the actual cost per trip with Redi-Wheels is higher than was the apparent cost per trip with Poplar Center (which was actually losing money), the agencies will see a substantial increase in fares. There will be one phase-in year with 25 percent cost recovery.

In Lane County, the transit district took the position that funds available for dial-a-ride service should not be used to subsidize special service for the agencies. This position was consistent with the original philosophy under which the provider had been encouraged to provide agency contract service to achieve economies of scale and spread overhead costs. As will be described in the next section, a careful cost analysis showed that the agency contributions were not paying the full cost of service received and not even the variable cost of service. (The concept of variable cost is discussed more in the next section.) To avoid cross subsidies, while minimizing the burden on the agencies, it was decided to charge 100 percent of the

variable cost of service (less vehicle depreciation) for agency contract service.

HOW TO DETERMINE ACTUAL COSTS OF AGENCY TRIPS

Assuming agreement in principle on an appropriate agency share for certain types of service, it remains to determine what the service received by the agencies actually costs. The simplest method would be to determine the average cost per trip for the system and apply it to the agency trips. That would not be fair, however, because agency trips tend to be highly grouped and do not change much from day to day; therefore they take fewer vehicle-hours per trip and also less scheduling and dispatching time per trip. On the other hand, meeting agency requirements for maximum ride time or extra passenger assistance (delivering patients to doctors' offices in multistory buildings, for example), could result in higher-than-average costs in some cases. Therefore some form of cost allocation model is needed.

The cost allocation problem will be approached in two parts:

1. What portion of vehicle-hours (or driver-hours) is attributable to agency service? The bulk of cost is usually attributed to vehicles and drivers, so it is important to determine whether the productivity of the agency service is higher or lower than the productivity of the other service and by how much.
2. What portion of other costs should be charged to agency service? Estimates must be made of the following, all of which are attributable to agency service: amount of administrative and management time; scheduling and dispatching time; maintenance cost; and volunteer time.

Allocation of Vehicle-Hours

In some cases it is easy to identify which part of each vehicle's schedule is for service to a particular agency. In that case, the vehicle-hours for agency service can simply be tallied up from vehicle schedules. This was the case in Lane County for contract service to Pearl Buck Center for bringing its developmentally disabled clients to and from the center. In this case, provider records gave driver-hours instead of vehicle-hours. It was found that 3,026 driver-hr was used to provide 12,444 rides, a productivity of 4.1 rides per hour, well over the average of 2.7 rides per hour for all demand-responsive service. The difference reflects the grouping of trips and the fact that most of the clients are ambulatory.

In other cases agency rides are mixed in with the other rides, so it is impossible to separate the time used for each category of service. This occurs at least some of the time on Redi-Wheels. In Lane County adult day care and Medicaid clients are routinely mixed in with dial-a-ride clients. Crain & Associates developed a statistical model for allocating hours in this situation. For a sample period, the contract providers were asked to record the information indicated in Table 1 for each vehicle run. Then the following regression model was estimated:

$$\text{Vehicle or driver-hours} = a + b_1 \times (\text{trips of Type 1}) + b_2 \times (\text{trips of Type 2}) + \ldots b_n \times (\text{trips of Type } n)$$

The coefficients b_1 through b_n give the number of hours per trip attributable to each of the trip types. The constant a gives the average number of hours per run not directly attributable to one trip type or another.

Results in San Mateo County

For a sample of 119 vehicle runs on Redi-Wheels carrying 1,900 passengers the results of the regression were as follows:

$$\underset{}{\text{Vehicle-hours}} = \underset{}{3.55} + \underset{(0.039)}{0.697} \times \text{individual trips} + \underset{(0.019)}{0.259} \times \text{agency trips}$$

The values in parentheses under the coefficients are the standard errors of the estimated coefficients, which show that the two coefficients are highly significant (different from 0 with better than 99 percent probability) and also different from each other. R-squared was .53.

The model results indicate that 0.697 vehicle-hr can be attributed to each individual trip, and 0.259 vehicle-hr can be attributed to each agency trip. This means that the agency trips are more productive than individual trips, in terms of trips per vehicle-hour, by a factor of $0.697 \div 0.259 = 2.66$.

TABLE 1 Information Recorded for Allocating Hours

San Mateo County	Lane County
Total vehicle hours per run	Total driver hours per run
Total individual trips on each run	Total general dial-a-ride trips on each run for: Ambulatory riders Wheelchair users
Total agency trips on each run	Total trips on each run for: Adult day care Medicaid, ambulatory Medicaid, wheelchair Pearl Buck (developmentally disabled)

TABLE 2 Allocation of Redi-Wheels Vehicle-Hours

Trip Type	Annual Trips	Annual vehicle hours	Trips per vehicle hour
Individual	32,590	24,804	1.31
Agency	58,591	16,764	3.50
Total	91,181	41,568	2.19

TABLE 3 Allocation of Lane County Driver-Hours

Trip Type	Annual Trips	Annual driver hours	Trips per driver hour
Medicaid Wheelchair	2,615	2,252	1.16
Dial-a-ride Adult Day Care Medicaid ambulatory	25,551	9,790	2.61
Total	28,166	12,042	2.34

Using this factor and data on total annual trips of each type, and total vehicle-hours, it is possible to allocate annual Redi-Wheels vehicle-hours to each trip type as indicated in Table 2.

The values for individual and agency vehicle-hours were chosen by dividing the total of 41,568 vehicle-hr so that the resulting productivities had the correct ratio of 1:2.66.

In San Mateo County, the cost allocation process went no further than this. A cost per trip for agency service was calculated entirely on the basis of the vehicle-hour data. This process assumes that all other costs are proportional to vehicle-hours. On the basis of an overall cost per vehicle-hour of $34.85, the cost per agency trip was determined to be $34.85 ÷ 3.5 = $9.96. Redi-Wheels uses a system of three zones. It was estimated that the average agency trip covers 1.25 zones. Because it was agreed that the agencies would pay 25 percent of the cost for the first year of the new policy, the agency fare for 1992–1993 has been proposed as $9.96 ÷ 1.25 × 25 percent ≡ $1.99 or approximately $2.00 per zone.

Results in Lane County

A number of regression models were tried using data supplied by SMS for April and May 1991. It was found that the models worked best if runs carrying Pearl Buck trips were not included. This fits with the fact that very few other trips are mixed in with the Pearl Buck trips. For the remaining trip types it was found (surprisingly) that there was no significant difference in the coefficients for ambulatory dial-a-ride trips, wheelchair dial-a-ride trips, adult day care trips, and ambulatory Medicaid trips. However, wheelchair Medicaid trips were significantly less productive than other trips, probably because of the Medicaid requirement for "door-through-door" service and the extremely frail condition of many of these riders. The following model, based on 203 vehicle runs, was used for the cost allocation:

$$\text{Driver-hours} = 4.66 + \underset{(0.041)}{0.332} \times \text{Medicaid wheelchair trips} + \underset{(0.017)}{0.147} \times \text{other trips}$$

The values in parentheses under the coefficients are the standard errors of the estimated coefficients, which show that the two coefficients are highly significant (different from 0 with better than 99 percent probability) and also different from each other. R-squared was .34.

The model results indicate that 0.332 driver-hr are accounted for by the average Medicaid wheelchair trip, compared with only 0.147 driver-hr for other trips, including all general dial-a-ride trips, adult day care trips, and ambulatory Medicaid trips. In other words, Medicaid wheelchair trips are less productive than others by a factor of 0.332 ÷ 0.147 = 2.25 (an error of 0.01 is created by rounding from the original six-place values).

Using this factor, data on total annual trips of each type, and total driver-hours, it is possible to allocate annual SMS vehicle-hours to each trip type, as indicated in Table 3.

Lane County Cost Allocation Model

In Lane County the allocation of hours was only the beginning of the overall cost allocation process. SMS provides or supervises seven different service components. These have greatly different requirements with respect to dispatching effort, supervision, and maintenance, as indicated in Table 4. Lane County staff members wanted to know exactly what each service component costs, so they could make decisions about funding the various components and how to charge for them. Determining the actual cost of the various components required allocating not only driver-hours, but also the following: administrative staff time, expenses, volunteer time, maintenance time and cost, and dispatch time. The model was

TABLE 4 Lane County Service Components

Service Component	Description	Cost Characteristics
Maxi Taxi	Flexible route grocery shopping service for seniors	Extremely productive. Minimal scheduling effort.
Volunteer Escort	Door-through-door medical rides for frail seniors	No SMS vehicle cost. Requires considerable coordination time. SMS pays mileage.
Dial-a-ride	Door-to-door service for people who can't use transit	Major dispatching effort. Substantial use of subcontracted taxis.
Adult Day Care	Subcategory of dial-a-ride	Similar to dial-a-ride but all clients go to one location and minor weekly variation.
Medicaid (Title XIX)	Door-through-door medical trips booked by Medicaid offices.	Major dispatching effort. No taxicabs. Extra driver time for door-through door.
Pearl Buck	Contract service to Pearl Buck Center	Minimal dispatching or scheduling effort.
Non-SMS Volunteer	Volunteer rides arranged by other offices. SMS only reimburses mileage.	Very minor overhead cost.

developed by Fred Stoffer, General Manager of Special Mobility Services, and Crain & Associates in close cooperation.

Expense Categories

SMS divided the annual cost for FY1991 into seven categories. The consultant added an eighth category—vehicle depreciation. The categories are described in Table 5. In some accounting systems, depreciation is not allowed as an operating expense, but for other needs it is useful to include to calculate fully allocated cost. The costs were further designated as either fixed or variable. Fixed costs are those that would not change for small changes in the amount of service provided. Variable costs are those that would change as a direct result of changes in the amount of service provided.

Cost Drivers

Cost drivers are factors used to allocate the expense categories. Each of the eight cost categories is allocated according to one of six cost drivers, as indicated in Table 6.

Tables 7 and 8 summarize the results of the cost allocation. Table 7 indicates how each expense category was allocated across the program components, and the resulting total cost and cost per ride for each component. Table 8 provides details on the cost drivers that are the basis for the allocations.

Policy Implications

With the division of costs produced by the model, Lane County was able to evaluate each component of service and make the following key policy decisions.

- The Maxi Taxi service is not an ADA-required service, many of its users can use fixed-route buses, and the Older Americans Act funds that supported it in the past are no longer available. However, the cost allocation showed that Maxi Taxi's cost efficiency comes close to that for conventional fixed-route service. Maxi Taxi is being continued, with a fare increase.
- The Volunteer Escort program (which also used to use Older Americans Act funds) turned out to be surprisingly expensive, because of the effort required to coordinate volunteers. However, it

TABLE 5 Cost Categories

Expense Category	Fixed Costs	Variable Costs
Administration	The part of SMS's Portland office expense billed to the Lane County operation. This includes part of the General Manager's time, billing, and general accounting.	None.
Management, Dispatch, and Coordination	Eugene Program Manager time. Eugene office expenses.	Eugene dispatching, scheduling, and support staff time. Does not include time spent by the Volunteer Coordinator on the volunteer program, but does include some time by the Volunteer Coordinator spent on preparing Title XIX invoices.
Drivers and Mechanics	None.	Wages and benefits of the drivers and maintenance staff.
Vehicle Operating Expense	Vehicle insurance.	Non-labor expenses associated with the vehicles including fuel, tires, and purchased maintenance and repairs.
Volunteer Coordinator	None.	Time spent by the Volunteer Coordinator arranging rides.
Volunteer Reimbursement	None.	Mileage paid to volunteer drivers for in-district services only.
Subcontracted Transportation	None.	Amounts paid to taxi companies.
Vehicle Depreciation	None.	The purchase cost of vehicles charged over the expected life of the vehicle.

was decided that the program was effective in extending service to people who otherwise would not be able to receive service because they are too frail to use dial-a-ride on their own.

- The cost per trip for adult day care service was not significantly different from that for general dial-a-ride service. Adult day care clients had been paying the regular dial-a-ride fare of $0.35 (increased to $0.75 in 1993). A policy decision had been made that agencies receiving contract-type service should pay the full variable cost less vehicle depreciation. In the case of the adult day care agency, that would come to $7.74 per trip. Alternatively the agency may elect to have its clients request individual subscriptions, which will cost $1.00 per ride under a proposed new fare structure.
- Medicaid (Title XIX) service turned out to cost considerably more than the rates that SMS was charging for it. For example, SMS had charged $12.25 for wheelchair trips under 10 mi, but the actual cost was $19.59. In fact, even the state-allowed maximums ($16.62 for wheelchair trips under 10 mi) would not quite cover the full cost of the service provided. A local for-profit Medicaid provider had been complaining that SMS was unfairly competing by offering subsidized rates. It was decided to have SMS raise its rates to the state-allowed maximum to reduce the element of unfair competition and to reduce the drain on funds.
- Pearl Buck service turned out to cost $5.37 per trip, whereas the $24,000 per year paid by the agency amounted to $1.93 per trip. Because it requires contract-type service Pearl Buck will be asked to increase its contribution under the variable-cost-excluding-depreciation policy. On the basis of 1990–1991 costs, that would come to $3.73 per ride.

TABLE 6 Method of Allocating Each Cost Category

Expense Category	Allocated According to:
Administration	All of Allocated Expenses: The sum of all the other expense categories allocated to each program component.
Management, Dispatch and Coordination	Estimated Time: Based on estimates by each member of the Eugene office staff of the percentage of their time which they spend on each of the six major service components.
Drivers & Mechanics	Driver Hours: The number of driver hours for Maxi Taxi and Pearl Buck was available from driver logs. The remaining hours were split among Dial-a-Ride, Adult Day Care, and Title XIX based on the statistical analysis of trips provided in April and May 1991.
Vehicle Oper. Expense	Vehicle Miles: The number of vehicle miles for Maxi Taxi and Pearl Buck was available from driver logs. The remaining miles were split among Dial-a-Ride, Adult Day Care, and Title XIX based on a statistical analysis similar to the one done for driver hours.
Volunteer Coordinator	Volunteer Rides: The Volunteer Coordinator's time was allocated according to the number of volunteer rides arranged by SMS for the Medical Escort, Dial-a-Ride, and Title XIX programs. This assumes that it takes about the same amount of time to arrange a ride for any of the programs.
Volunteer Reimbursement	Volunteer Rides: Mileage reimbursement was allocated according to the number of volunteer rides arranged by SMS for the Volunteer Escort, Dial-a-Ride, and Title XIX programs. In the future this expense category can be allocated exactly based on actual expenditures.
Subcontracted Transportation	Taxi Rides: Taxi costs were allocated according to the number of taxi rides purchased for the Dial-a-Ride, Adult Day Care, and Title XIX programs. This assumes that the average trip length is about equal for all three programs.
Vehicle Depreciation	Vehicle Miles: Based on the estimated life, in miles, of each vehicle based on ODOT guidelines, and the purchase price of the vehicles in SMS's current fleet, an average depreciation of $.273 per vehicle mile was calculated.

TABLE 7 Fully Allocated Cost Model: Allocation of Costs to Program Components

			Service Components							
Expense Categories	Fixed Var	Total Cost	Maxi Taxi	Vol. Escort	DAR	ADC	Title 19 Amb.	Title 19 WC	Pearl Buck	Oth. Vol.
Admin. (Portland)	F	55,296	3,797	1,282	28,197	3,309	3,446	5,427	7,809	2,029
		Allocated according to non-administrative cost								
Management (Eugene)	F	27,816	1,252	1,502	16,272	1,502	2,228	2,835	2,225	0
		Allocated according to estimated Eugene staff time spent on each activity								
Office Exp. (Eugene)	F	33,102	1,490	1,788	19,365	1,788	2,651	3,374	2,648	0
		Allocated according to estimated Eugene staff time spent on each activity								
Dispatch & Coord.	V	45,056	2,028	2,433	26,358	2,433	3,608	4,592	3,604	0
		Allocated according to estimated Eugene staff time spent on each activity								
Drivers & Mechanics	V	169,510	18,527	0	78,668	11,543	7,886	22,565	30,321	0
		Allocated according to driver hours								
Vehicle Insurance	F	36,792	2,074	0	18,738	2,971	2,309	2,939	7,761	0
		Allocated according to SMS vehicle miles								
Other Veh. Oper. Exp.	V	59,072	3,330	0	30,085	4,770	3,708	4,719	12,460	0
		Allocated according to SMS vehicle miles								
Volunteer Coordinator	V	8,686	0	2,227	4,438	0	2,021	0	0	0
		Allocated according to metro volunteer rides								
Volunteer Reimburse.	V	22,085	0	1,730	3,448	0	1,570	0	0	15,338
		$2.35342 per SMS-Vol. ride, $1.34424 per non-SMS vol. ride								
Subcontract Transp.	V	15,853	0	8	15,765	8	64	0	8	0
		Allocated according to taxi rides purchased								
TOTAL COST		473,268	32,498	10,970	241,334	28,324	29,491	46,451	66,836	17,367
COST/RIDE		$6.75	$2.51	$11.05	$10.09	$9.42	$10.80	$17.77	$5.37	$1.51
Vehicle Deprec.	V	59,661	3,363	0	30,385	4,817	3,745	4,766	12,584	0
		$.273 per vehicle mile								
TOTAL COST		532,929	35,861	10,970	271,720	33,142	33,236	51,217	79,421	17,367
COST/RIDE		$7.60	$2.77	$11.05	$11.36	$11.02	$12.18	$19.59	$6.38	$1.51
VARIABLE COST		379,923	27,248	6,398	189,147	23,571	22,602	36,642	58,977	15,338
VAR. COST/RIDE		$5.42	$2.11	$6.44	$7.91	$7.84	$8.28	$14.01	$4.74	$1.34

TABLE 8 Fully Allocated Cost Model: Cost Drivers Used to Allocate Expenses

	Service Components								
	All Components	Maxi Taxi	Vol. Escort	DAR	ADC	Title 19 Amb.	Title 19 WC	Pearl Buck	Oth. Vol.
Office Time	(Estimated by SMS staff)								
Percent		4.5%	5.4%	58.5%	.5.4%	8.0%	10.2%	8.0%	0
Driver Hrs.	(Title XIX/DAR/ADC split by ridership, except for Title XIX wheelchairs)								
Amount	16,917	1,849	0	7,851	1,152	787	2,252	3,026	0
Percent	100.0%	10.9%	0.0%	46.4%	6.8%	4.7%	13.3%	17.9%	0.0%
Vehicle Mi.	(Title XIX vs. DAR/ADC split by ridership)								
Amount	218,539	12,318	0	111,302	17,646	13,717	17,459	46,097	0
Percent	100.0%	5.6%	0.0%	50.9%	8.1%	6.3%	8.0%	21.1%	0.0%
SMS Vehicle Rides									
Amount	53,884	12,942	257	20,491	3,006	2,054	2,615	12,443	76
Percent	100.0%	24.0%	0.5%	38.0%	5.6%	3.8%	4.9%	23.1%	0.1%
Volunteer Rides									
Amount	14,277	0	735	1,465	0	667	0	0	11,410
Pct. of Tot.	100.0%	0.0%	5.1%	10.3%	0.0%	4.7%	0.0%	0.0%	79.9%
Metro Pct.		0.0%	25.6%	51.1%	0.0%	23.3%	0.0%	0.0%	
Subcontracted (Taxi) Rides									
Amount	1,978	0	1	1,967	1	8	0	1	0
Percent	100.0%	0.0%	0.1%	99.4%	0.1%	0.4%	0.0%	0.1%	0.0%
Rides on All Modes									
Amount	70,139	12,942	993	23,923	3,007	2,729	2,615	12,444	11,486
Percent	100.0%	18.5%	1.4%	34.1%	4.3%	3.9%	3.7%	17.7%	16.4%
Rides per Driver Hour	3.2	7.0	N.A.	2.6	2.6	2.6	1.2	4.1	N.A.
Vehicle Miles per Ride	4.1	1.0	N.A.	5.4	5.9	6.7	6.7	3.7	N.A.

Percent of Title XIX Rides on SMS Vehicles for Wheelchair Users: 56%

CONCLUSIONS

The following conclusions were drawn:

1. Decisions about cost sharing turned on local politics, the history of relationships among agencies in each area, and previously established practices. These factors were more important than the type of agencies involved and may have been more important than regulatory constraints on the agencies.
2. The ADA rules about charging for social service agency trips are useful but do not provide clear guidance on what is an agency trip. That distinction will have to be defined locally and may need to include an element of choice.
3. Sound policy decisions require meaningful and accurate data on the actual cost of each type of service provided. The cost allocation model presented in this paper demonstrates how such cost data can be estimated.

REFERENCES

1. U.S. Department of Transportation. 49 CFR, Part 27, *Federal Register*, Vol. 44, No. 106, May 31, 1979.
2. Crain & Associates. *The San Francisco Bay Area Paratransit Plan.* Metropolitan Transportation Commission, Oakland, Calif., 1990.
3. U.S. Department of Transportation. 49 CFR, Part 37. *Federal Register* Vol. 56, No. 173, Sept. 6, 1991.
4. EG&G Dynatrend and Katherine McGuiness and Associates. *ADA Paratransit Handbook.* UMTA-MA-06-0206-91-1. U.S. Department of Transportation, Washington. D.C., 1991.

Publication of this paper sponsored by Committee on Specialized Transportation.