erage travel and delay times and speeds by the routes and segments selected.

Primarily, the routes selected for study are those anticipated to experience at least some delay time. In the report, those segments having what is considered to be excessive delay time are flagged. Because almost all delay appears to be caused by traffic signals, delay times are reported by direction of travel.

Analyses of the data varied from area to area. Prime consideration was given to the specific information the local planners and engineers wanted. For example, the Longview study analysis consisted of expanding the 9-h counts to 24-h traffic and furnishing a 24-h nondirectional turning-movement diagram for each intersection. In addition, the desired 24-h data included total vehicles and person volumes, occupancy rates, total and percentage of trucks, number of diesel and nondiesel trucks, and total approach volume for each leg of the intersection. These data items were also reported for each leg of the intersection for the nondirectional peak-hour volume and percentage of the 24-h period and the directional distribution. The analyses necessary to provide these data were extensive.

For another study area, McAllen-Pharr-Edinburg, most of the local planners and engineers wanted to use traffic engineering simulation programs to determine signal timings. This required a different product from the study.

The McAllen-Pharr-Edinburg study area has a population of 150 000 and is experiencing rapid growth. Because of this rapid growth, traffic congestion in some areas has become acute.

In this study, no attempt was made to expand the turning-movement counts to 24-h volumes. Directional turning-movement counts for all vehicles were prepared for the total 9-h count period and the peak hour in each of the three time periods counted (morning, noon, and afternoon). In addition, turning movements for truck traffic were reported.

In none of these studies was transit a major concern to the local people. In some of the areas, a short-range transit study had been done previously by consultants. The only work done in these studies relative to transit was an inventory of existing public transportation facilities. This was done because there are so many government programs funding such a wide spectrum of functions that collectively can be labeled public transportation and it appeared desirable that local people be made aware of such facilities. These inventories were listed in the report.

A formal report was made for each study. These reports, however, were considered of secondary importance. The technicians who used the data had access to the actual field reports as the work was in progress and, therefore, printing costs were held to the minimum and the number of copies printed restricted.

Some of the most commonly asked questions relative to these studies are about their costs. Such questions are difficult to answer, and it is almost impossible to provide comparative data as salaries paid vary considerably.

The costs for the McAllen-Pharr-Edinburg study totaled about $32 000. In this study, 121 major intersections and 33 manual-count stations were monitored, and 176 km (110 miles) of arterials were surveyed for speed and delay. These costs included about $22 000 for the field work and $10 000 for the analysis and reporting.

Two project supervisors were furnished by the Texas Department of Highways and Public Transportation. The actual counts were made by persons hired locally. The two supervisors spent about eight weeks on the job—two in preparation of the study (i.e., scouting the intersections to be counted, scheduling, and training) and six to collect the data.

These costs do not include those for the 24-h counts made, which were considered to be primarily for use in validating the travel-demand models to be used for forecasting. Nor do they include the preliminary work, which consisted of meetings with local people to discuss the details of, Do we do a study? What procedures will be used? and How will it be funded?

Earlier studies using these procedures employed a manual forecasting technique. Forecasts for short- and long-range target years were made by using some rather simple procedures.

A map of the existing and future thoroughfare systems and a traffic-zone map were the primary tools. The differences between the existing and the target year productions and attractions were calculated and posted on the zone map. These differences and the existing traffic volumes and turning movements then formed the basis for estimating future traffic volumes.

Although these procedures are rather unsophisticated, the final product appears to be as satisfactory as a traffic assignment for use in planning and superior to the assignment for highway design purposes. Satisfactory results for this type of forecast, however, require skilled and experienced personnel.

The procedures outlined in this paper were designed explicitly for particular areas. They have successfully provided the data that were needed at the time they were needed. It should be emphasized, however, that they are not necessarily cheaper or simplified. They were designed to produce a specific product.

It is certainly desirable to design methods that will be faster, cheaper, and more accurate. That is fine. It is also necessary to be certain that the data produced are useful and used.

Application of Manual Techniques for Travel-Demand Estimation

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Manual techniques can be valuable in many aspects of transportation planning, especially for small and medium-sized cities. To effectively use these techniques, the planner must be aware of the procedures, assumptions, and, consequently, the utility of the outcome. The use of sensitivity

surfaces often facilitates the planning product. This paper describes the use of manual techniques for travel-demand estimation through two scenarios, a site analysis in Boise, Idaho, and a corridor analysis in Columbus, Ohio. The quick-response advantage of manual techniques is emphasized.

This paper describes two scenario applications of techniques for travel-demand estimation that were developed in a National Cooperative Highway Research Program project described in greater detail elsewhere (1). The first, in Boise, Idaho, concentrated on the analysis of the effects of traffic on the surrounding street system of a site development. The second investigated the effects of traffic along a corridor adjacent to, but outside of, the Columbus, Ohio, transportation study area.

The scenarios illustrate not only the use of the techniques but also the level of effort that their use requires. The techniques were developed without dependence on high-speed computers. They are designed to be applied through the use of analysis forms and a desk calculator.

BOISE, IDAHO, SITE ANALYSIS

The Boise scenario is for a proposed residential development and major shopping center. The Boise metropolitan transportation study area covers approximately 240 km^2 (93 $miles^2$). In 1970, the population was 85 000; this grew to about 108 000 by 1974 and is expected to reach 158 000 by 1990—this is relatively rapid growth. In 1970, the median family income in the Boise urbanized area was $9900; there was an average of 1.50 automobiles/household, and approximately 91.4 percent of work trips were made by automobile.

Because of the anticipated growth, there have been numerous requests to the metropolitan planning organization to analyze and evaluate local and regional effects of proposed new developments. Quite often, the time to evaluate these proposals and their effects is short, and short-cut manual methods are desirable for planning and analysis.

This scenario considers the analysis of the effects on transportation of two proposed developments in the Foothills area north of the Boise central business district and an existing north-end community. The proposed developments include

1. The Highland Square Shopping Mall [which will have 16 600 m^2 (179 000 ft^2) of enclosed commercial area—12 900 m^2 (139 000 ft^2) of shopping and 3700 m^2 (40 000 ft^2) of office space];
2. Thunder Hill Village, a part of the Foothills development [which is proposed to have 1159 dwelling units consisting of single-family, townhouse, and apartment units at a dwelling-unit density of 8.4/hm^2 (3.40/acre) and 4650 m^2 (50 000 ft^2) of convenience shopping and offices];
3. Claremont development, also in the Foothills development [which is proposed to have 1151 dwelling units consisting of single-family, townhouse, and apartment units at a density of 3.16/hm^2 (1.28/$acre^2$) and no commercial development].

Steps Undertaken for Scenario

It was assumed that the proposed developments would be completed by the year 2000. A Boise metropolitan transportation study had recently developed forecasts of trip generation for 149 analysis areas (zones) representing the future study area. The new development was not accounted for in the actual forecasts and is, therefore, treated as new activity not previously considered. The general steps in the scenario were as follows:

1. The entire study area was zoned for ease of manual application and to provide sufficient detail for traffic estimates in the area surrounding the new developments.
2. The zonal trip-generation forecasts were zoned to the new analysis areas.
3. The proposed-development distribution of land use in each analysis area was estimated.
4. Trip-generation characteristics were used to develop person-trip-generation estimates for the proposed developments based on land-use and anticipated socioeconomic characteristics.
5. A gravity-model manual distribution procedure and parameters were used to determine the distribution of trips to and from the new developments.
6. Transit-use and automobile-occupancy estimates were used to obtain automobile vehicle trips to and from the new developments.
7. Manual traffic-assignment procedures were used to assign critical trip movements to appropriate routes (considering only trips to and from the new developments).
8. Traffic allocated to alternative routes was redistributed based on a balancing technique to account for deficiencies in all-or-nothing assignment procedures.
9. Capacity implications of the new developments were analyzed.

Summary of Scenario Results

The results of the travel-estimation techniques were satisfactory. The complete scenario, including a modal-split analysis not discussed in this paper, was conducted in approximately 60 person-h; a breakdown of the time requirements by the major steps is shown below:

Major Step	Time Required (person-h)
Trip generation	12
Trip distribution	33
Trip assignment	9
Modal split	3
Miscellaneous	3
Total	60

Also, if the approach of using only home-based work trips and then expanding to total trips had been used rather than handling the three trip purposes separately, considerable time savings would have been realized. The trip-generation step would have reduced to about 10 h, the trip-distribution step to about 14 h, the assignment step to about 8 h, and the entire scenario to about 38 h.

COLUMBUS, OHIO, CORRIDOR ANALYSIS

The Columbus scenario is for a corridor located just outside the existing Columbus transportation study area. The corridor is an 8-km (5-mile) stretch running along OH-256 between Pickerington and Reynoldsburg. It is on the eastern border of the Columbus study area and is oriented in a north-south direction between two major highways—US-33 and US-40.

Currently, the area adjacent to OH-256 is largely rural with a few small residential subdivisions. The route itself is a 5.45-m (18-ft) wide two-lane rural road having an undulating alignment. It has short vertical sight distances but, because of its rural location, has

an operating speed of 77 km/h (48 mph).

There are proposals to concentrate development in the eastern part of Columbus and in the OH-256 corridor during the next 20 years. The corridor population is expected to increase to 54 545 in the year 2000 and employment for the same year is estimated at 21 599 jobs [compared with expected totals in Franklin County (the existing Columbus transportation study area boundary) of 1 259 816 people and 613 702 jobs].

The assessment of significant growth effects in a corridor area that is external to an existing transportation planning study area can be very time consuming when computerized models and procedures are used. Such an effort requires expansion of the study-area cordon to include the corridor and the development of system networks for the area. The manual techniques, however, require only the quantification of significant land-use variables.

The following information was provided by the Ohio Department of Transportation and the Middle Ohio Regional Planning Council:

1. 1974 land-use data by traffic analysis zone for Franklin County;
2. Year 2000 land-use control totals for Franklin County;
3. Year 2000 land-use data by traffic analysis zone for the OH-256 corridor outside Franklin County;
4. Highway characteristics, including existing networks for Franklin County, and travel characteristics; and
5. The general development plan for the OH-256 corridor area.

Steps Undertaken for Scenario

The general steps in the scenario are as follows:

1. The analysis districts were defined.
2. Year 2000 land-activity data were organized by analysis district as preparation for the use of trip-generation procedures.
3. Trip-generation procedures were used to estimate the year 2000 productions and attractions.
4. Home-based-work and home-based-non-work person trips were used to develop trip tables that were then converted to vehicle trip tables.
5. Vehicle trips were assigned (because of the lack of competing facilities, an all-or-nothing technique was used without further redistribution of trips, by facility, after assignment).
6. Volume-to-capacity ratios were calculated to analyze conditions anticipated to occur with the proposed year 2000 development plan.

Summary of Scenario Results

The scenario pointed out the following issues:

1. The current highway facilities in the OH-256 corridor cannot accommodate the travel desired as dictated by the development plan.
2. The facilities plan should not depend solely on OH-256 to satisfy the travel desires of the area. Travel should be encouraged to distribute among the major arterials provided.
3. The land activity plan, particularly in the area west of OH-256 between Refugee Road and US-33, should be evaluated in more detail with regard to level of development and access to area arterials.

Conducting the scenario required 66 person-h of computation and analysis broken down as shown below:

Step	Time Required (person-h)
Development of analysis districts	4
Organization of land-activity data	13
Development of productions and attractions	6
Development of travel-time matrix	4
Development of home-based work-purpose trip table	16
Development of home-based non-work-purpose trip table	13
Development of total trip table	5
Trip assignments to network	3
Capacity analysis	2
Total	66

Most of the first block of time involved the summarization and expansion of land-activity data to the year 2000. In those cases where satisfactorily organized data are already available, this time can be minimized.

It was found that the trip-distribution-step time requirements decreased as experience with the data work sheets and the various graphs increased (note the 3-h reduction in time between the development of the home-based-work and the home-based-non-work trip tables). It was also found that the entire trip-distribution procedure could be carried out by clerical staff and a minimum of professional supervision. The trip-assignment procedure, however, was carried out by professional staff—primarily because of the path selection that had to be made while the stringing of trips was accomplished.

In general, the manual procedures were found to be easy to carry out. For this particular scenario, which had its major focus outside the existing study area, the total elapsed time when the manual procedures were used was less than that required to process the information by computer in an existing transportation planning procedural framework.

REFERENCE

1. A. B. Sosslau, A. B. Hassam, M. M. Carter, and G. V. Wickstrom. Quick-Response Urban Travel Estimation Techniques and Transferable Parameters: User's Guide. NCHRP, Rept. 187, 1978.

The use of manual techniques should be given serious consideration in conducting transportation planning studies. There are several inherent advantages in performing an analysis manually. First, the planner has a better understanding of the assumptions used in the analysis—in a computer analysis, the planner is too often caught in the black-box syndrome and thus places too much confidence in the results without carefully evaluating their reasonableness. Second, a manual analysis allows the planner to develop a better understanding of the nature of the problem being investigated. Third, the analysis can be performed by a planner at the local level who may not have access to computer facilities. Finally, the manual analysis may result in the ability to provide quick-response answers to decision makers.

In deciding on the applicability of manual procedures, the amount of time required to perform the analysis manually, as opposed to using the computer, should be carefully evaluated. If it is necessary to recycle through the analysis to look at several different alternatives, it may be more cost-effective to do the necessary front-end work for a computer analysis. In any event, however, the use of manual techniques should not be dismissed as technically invalid for analyzing solutions to transportation problems.

The workshop participants agreed that manual procedures are particularly useful for evaluation of the effects of major new developments on an existing street system. Generally, this type of evaluation requires a quick response to provide information before decisions are made.