computers and sophisticated support software may be desirable and cost effective for processing great quantities of data. At most other agencies, less-expensive microcomputer hardware may be suitable. In all cases, automated data entry methods will permit the movement toward more-efficient, paperless information systems. Used in conjunction with distributed processing technology, these systems offer endless possibilities for contributing to overall transit productivity.

Finally, the appropriate phasing of system implementation will vary among agencies depending on management objectives and resource availability. Usually, development of a transit MIS begins with the financial and accounting modules, since these interface with nearly all other system modules. In addition, these modules provide the means for meeting Section 15 reporting requirements. As modules are added to the MIS and experience grows, information flow becomes more comprehensive, which encourages the expansion of or interfacing with other analytical capabilities. The planning and scheduling support system is an example.

SPECIFIC RESEARCH IN SERVICE PLANNING METHODS

Because of their complex nature and high development costs, service planning methods are receiving particular attention in the Urban Mass Transportation Administration's Office of Planning Methods and Support. Projects are under way to develop what would in effect be modules of the previously proposed planning and scheduling subsystem. Many are ad hoc projects; they test the feasibility of certain analytical approaches and simplifying assumptions. Others emphasize data-collection technology.

For instance, pilot development of a stand-alone microcomputer system is being sponsored in cooperation with a particular transit agency that will provide a vehicle and driver schedule data base that will accept data typically collected from on-board surveys and counts. It will provide route-point analysis, ride checks, and on-time reliability statistics and will produce headway sheets, paddles (trip schedules), and timetables--all of which are essential to any transit operation.

Complementary to this effort, research in the near future will permit interfacing of this microcomputer system with a simply modified transit network planning capability that has comprehensive costing techniques. Vehicle and crew scheduling may be accomplished with a variety of operating objectives such as minimizing the extraboard (operator with no assigned run) or the overall vehicle-crew operating cost. With such a planning capability, another objective may be to minimize vehicle use, perhaps at the expense of driver hours. With simple analytical tools, many alternatives can be explored.

Design efforts will emphasize the concerns of the user and require minimal need for specialized ADP or computer systems knowledge. Modular considerations will permit packaging according to local requirements and allow computerized system growth as needs change and local experience and confidence evolve.

In summary, transit operating agencies must respond to local concerns and priorities and, to qualify for federal funding, must relate them to national goals as well. This implies flexibility in measuring, forecasting, directing, and reporting transit performance and productivity. Information management through automated data processing appears to offer this opportunity.

REFERENCE

1. Introduction to the Urban Transportation Planning System. Urban Mass Transportation Administration, U.S. Department of Transportation, UPM-20, March 1979.

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

Abridgment

Evaluation of Alternative Transit Routing Configurations in a Hypothetical Low-Density Area

KEITH M. THELEN, ARUN CHATTERJEE, AND FREDERICK J. WEGMANN

The provision of fixed-route transit services in low-density suburban areas poses significant problems for urban communities. Traditionally, fixed-route bus service has been provided to these areas as an extension of the radial system in the core city. However, little information exists that would guide the selection of a certain pattern under a given set of conditions. As energy continues to be in short supply, the question of extensions of fixed-route service to low-density areas may become more pressing. This paper discusses the intrinsic service characteristics of six alternative routing patterns in a hypothetical low-density area. Costs (determined from vehicle miles traveled), coverage area, passenger travel time, and competitiveness with the walk mode are the performance measures used to evaluate each routing pattern. The results indicate that different types of routing configurations do have different implications with respect to these performance measures. No single pattern was found to satisfy all service objectives equally well. Therefore, it is necessary for decision makers to assign priorities to different service characteristics and then to make the necessary trade-offs between those characteristics to arrive at a decision that meets community objectives.

Documentation is lacking of evaluations of different transit routing configurations in low-density areas. Lundberg and Brown (1), Vuchic (2), Sullivan (3), Sharma (4), and Ross and Wilson (5) discuss issues related to different routing configurations, but none examines the specific service characteristics of alternative routing configurations. This paper discusses such specific service characteristics and the trade-offs that must be made in the route-selection process.

STRATEGY FOR ANALYSIS

Network Characteristics and Routing Patterns

Six routing patterns were simulated in a 16-mile^2 hypothetical area. The area was assumed to have uniform densities and trip-generation rates so that the routing patterns did not have to accommodate locations that had a concentrated demand. It was also assumed to lie at the outer (suburban) end of a core-city route, and travel times are measured from each of 116 zones to the transfer point with the core route. No travel-demand pattern was superimposed on the transit routes. Components of the network on which the routing patterns were simulated are listed below:

Component	Description
Link length	0.2 mile
Zone size	0.4 $mile^2$
Vehicle speed	12 mph
Vehicle travel time per link	1 min
Walk speed	3 mph
Walk time per link	4 min
Wait time at transit stop	0 min
Service frequency	20 min
Total number of zones	116

Six different routing patterns were simulated in the study--one circular loop, two circular loops, four lines, two narrow loops, three narrow loops, and a meandering loop. Figure 1 (two circular loops) and Figure 2 (three narrow loops) illustrate two of the routing patterns and also the general characteristics of the hypothetical area.

Evaluation Tools and Measures

The package of computer programs known as the Urban Transportation Planning System (UTPS) was used as an analysis tool in this study. Three network-analysis programs--UNET, UPATH, and UPSUM--were used to generate performance measures.

Four types of service parameters were used for the analysis--costs (determined by vehicle miles traveled), passenger travel time, coverage area (area within 0.2 mile of transit service), and competitiveness with the walk mode (whether it is faster to get to the transfer point with the line-haul route by transit or by walking).

A service frequency of 20 min was assumed for all routes. The routes were not designed to minimize driver and vehicle requirements, which is a function of systemwide routing and scheduling. Thus, driver layover times have not been minimized. In addition, wait time was assigned a value of zero to eliminate inappropriate wait-time distortions that were introduced on some routes with the use of the UTPS package.

PERFORMANCE OF ROUTING PATTERNS

Table 1 presents the results of simulating different service patterns in the hypothetical area. The single-circular-loop pattern has the fewest number of vehicle miles traveled per hour and is therefore the least expensive to operate. It also provides the worst coverage area, is the second worst in terms of total passenger travel time, and is also noncompetitive with the walk mode for a large number of zones. It is apparent that costs can be minimized with the single-circular-loop routing pattern but only at the expense of other service elements.

The best service configuration in terms of total passenger travel time is the one that uses the four-line route. However, this would be the most expensive to operate since it has the largest number of vehicle miles traveled.

The best service pattern in terms of coverage area is the three-narrow-loop route. However, it is expensive to provide this service. The best service pattern in terms of competitiveness with the walk mode (to the transfer point) is again the three-narrow-loop configuration.

USE OF PERFORMANCE RESULTS IN DECISION-MAKING SITUATIONS

The results presented in the previous section show that the different routing configurations have varying implications with regard to cost, level of service, and coverage. The following example shows how the choice of a routing configuration would involve trade-offs between two service parameters--cost and coverage area. Similar trade-off decisions would have to be made when passenger travel time is weighed against costs. If decision makers are presented with accurate data on the trade-offs among routing patterns, they can select the configuration that most nearly achieves their objectives for a particular area.

Incremental-Cost-Effectiveness Approach: Cost Versus Coverage Area

A situation may exist where decision makers wish to achieve the greatest coverage area for the least cost when a particular area is served. If we assume that this situation is being applied to the routes in the area previously discussed, the information in Table 2 would be used to arrive at a decision on the appropriate route. To bring the first 51 zones within 0.2 mile of a route costs about \$224 000/year, or \$4404/zone/year, to serve. Bringing the next 38 zones within 0.2 mile of a route would cost an additional \$180 960/year, or \$4702/zone/year. The third level of expenditure would bring an additional 13 zones within 0.2 mile of the service at an additional annual cost of \$37 440, or \$2880/zone/year. The burden on decision makers would be to determine (a) the expenditure limit for the service, (b) the number of zones of service, and (c) the amount to spend for each zone brought closer to the service. An explicit consideration of objectives and trade-offs should be brought into the decision-making process. For each alternative, the information in Table 2 indicates what is to be gained with increased expenditures. Decision makers must decide in terms of local priorities whether improvements in coverage area are worth the additional cost.

Implications

From the previous discussion, it is apparent that a point of diminishing returns can be reached with increased expenditures. Although a detailed examination of alternative routing patterns may not always be a part of the decision-making process, the previous discussion points out the need for such assessments before a new service is begun.

The discussion on incremental cost-effectiveness also points out the need to educate and assist policymakers in making trade-offs in the decision-making process. In a climate where objective decision making is desired, specific objectives could be achieved with the proper guidance from staff persons.

Refinements Needed

One factor that significantly influences cost is frequency of service. Subsequent analyses could vary this parameter, and the incremental cost-ef-

Figure 1. Two-circular-loop routing pattern.

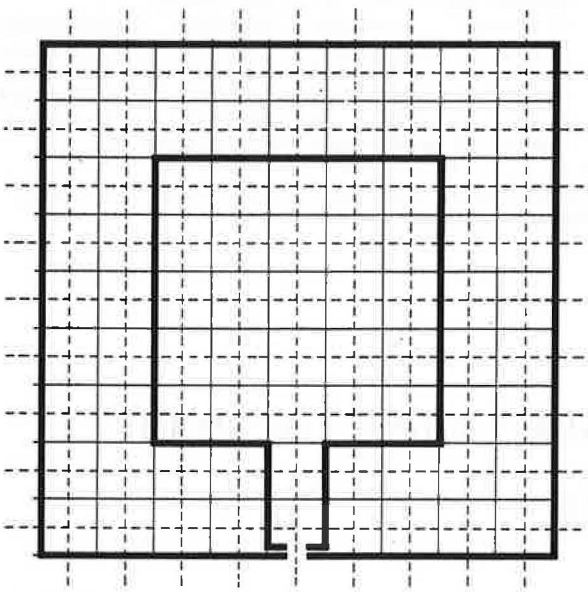

Figure 2. Three-narrow-loop routing pattern.

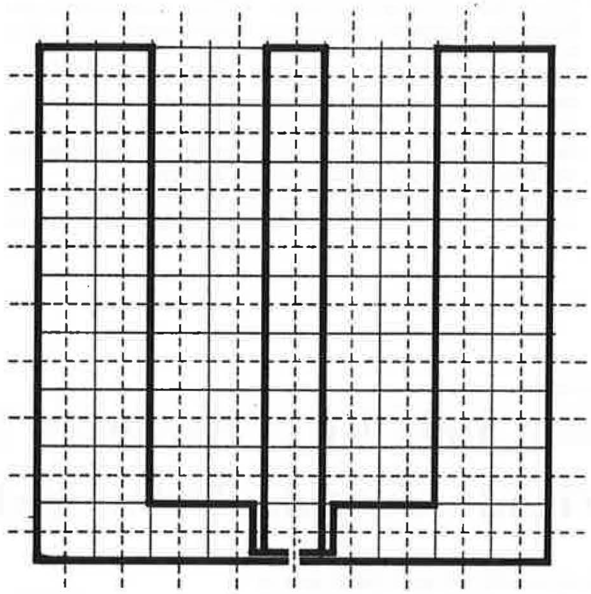

Table 1. Service attributes of alternative route configurations.

Service Pattern	Speed (vehicle miles/h)	Average Total Passenger Travel Time[a] (min)	Not Competitive with Walk Mode (no. of zones)	Coverage Area (no. of zones)
Two circular loops	71	29.379	10	102
One circular loop	36	33.328	25	51
Four lines	116	20.431	2	81
Two narrow loops	65	25.017	2	89
Three narrow loops	88	22.397	1	112
Meandering loop	71	37.638	5	86

[a] Consists of in-vehicle time plus walk time.

Table 2. Incremental cost-effectiveness: cost versus coverage area.

Routing Pattern	Annual Costs[a] ($)	Incremental Annual Costs[a] ($)	Incremental Coverage Area (no. of zones)
One circular loop	224 640	224 640	51
Two narrow loops	405 600	180 960	38
Two circular loops	443 040	37 440	13
Meandering loop	443 040	0	−16
Three narrow loops	549 120	106 080	26
Four lines	723 840	174 720	−31

[a] Cost figures assume $2.00/vehicle-mile operating costs 12 h/day, 5 days/week, 52 weeks/year of operation; and 20-min headways.

fectiveness approach could be expanded to include different service frequencies.

A precise cost-assessment analysis would have to be area specific if the suburban service were tied directly to the core route. Driver layover times could be minimized by specific adjustments to the routing patterns within the localities in which they are implemented.

Adjustments to the precise shape of the routing patterns would also be necessary in specific areas to accommodate nongrid or curvilinear street patterns. Adjustments to the precise shape of a route may also be necessary to accommodate specific activity centers.

SUMMARY

It is possible to reach general conclusions about the trade-offs between different routing patterns from the data presented in this study. Planners and operators can see the trade-offs among costs, coverage area, and passenger travel time among the various types of routing configurations presented in this paper and use the data to form general opinions on the advantages and disadvantages of each type. This work should be expanded and refined in real-life situations, however, if more definitive conclusions are desired.

The discussion of incremental cost-effectiveness illustrates two points. First, the discussion demonstrated how the data generated in the study can be structured and applied to decision-making situations. Second, it demonstrated the magnitude of trade-offs between routing patterns and that a point of diminishing returns could be reached with increased expenditures.

REFERENCES

1. B.D. Lundberg and R.L. Brown. Transit Route

and Schedule Planning. Proc., Lecture Series on Urban Transportation, Urban Transportation Program, Marquette Univ., Milwaukee, WI, June 1973, pp. 67-103.
2. V.R. Vuchic, ed. Transit Operating Manual. Department of Civil and Urban Engineering, Univ. of Pennsylvania, Philadelphia; Bureau of Mass Transit Systems, Pennsylvania Department of Transportation, Harrisburg, 1978.
3. B.E. Sullivan. Route Layout Philosophy and Service Coordination Particularly for Light Rail Transit. In Light Rail Transit, TRB Special Rept. 161, 1975, pp. 26-36.
4. S. Sharma. Intraurban Transport Optimization Through Operations Research Techniques. Traffic Quarterly, July 1976, pp. 371-390.
5. T.J. Ross and E.M. Wilson. Activity-Based Transit Routing. Transportation Engineering Journal of ASCE, Sept. 1977, pp. 565-573.

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

Abridgment

Time Stability of Attitudes Toward Transit Use in the Orlando, Florida, Urbanized Area

CECIL O. WILLIS, JR., AND JAMES W. LEE

Early attempts at modeling transit use in the Orlando, Florida, Urban Area Transportation Study (OUATS) assumed that the rather low use of the area's inadequate transit system would continue into the future. Direct generation of modal split and the forecast of automobile person trips locked the area into forecasts of low transit use both in the original study in 1965 and in the first update of OUATS in 1970. In 1973, this shortcoming in the travel-forecasting procedures used in the area was corrected. A mode-share model was developed from expressions found in the Minneapolis area and calibrated to conditions in the Orlando area determined through a transit-attitude survey conducted in 1973. The questionnaire used in this survey was designed to provide input into a mode-share model so that future patronage of alternative transit systems could be determined. In 1978, another survey was accomplished as a part of an update to OUATS. This survey was designed to duplicate the earlier survey to the maximum extent possible. This duplication included attempting to question the exact respondent reached in 1973. The intent of the duplication was to allow for a validation of the modal-split relationships developed from the original survey. Although this validation is important, particularly to the Orlando area, there are other questions to which these results can be applied. A basic assumption of the urban transportation planning process is the stability of trip characteristics over time. Other studies have shown mixed results, and generally these studies are limited to trip-generation expressions. The results in the Orlando area indicate that those relationships that might be used in modeling mode use do remain stable over time, at least for the purposes of short-range planning (three to five years). This is particularly significant when the time frame of the two studies in Orlando is considered. The results of the two surveys also imply that there is stability over time in mode-choice attitudes, even over a period when significant changes occurred in socioeconomic factors generally related to mode choice. These results would therefore also tend to support similar stability in other areas over longer periods of time. This could be particularly important to other areas that might be considering updating existing mode-choice surveys.

Early attempts at modeling transit use in the Orlando, Florida, Urban Area Transportation Study (OUATS) assumed that the rather low use of the area's inadequate transit system would continue into the future. Direct generation of modal split and the forecast of automobile person trips locked the area into forecasts of low transit use both in the original study effort in 1965 and in the first update of OUATS in 1970.

In 1973, this shortcoming in the travel-forecasting procedures used in the area was corrected and a mode-share model was developed based on mode-share relationships found in the Minneapolis area. This model was calibrated to conditions in the Orlando area determined through a transit-attitude survey conducted in the area in 1973. The questionnaire used in this survey was designed to provide input into a mode-share model so that future patronage of alternative transit systems could be determined.

1978 TRANSIT-ATTITUDE SURVEY

In 1976, a major plan reevaluation was begun as part of OUATS (1). This major update of the transportation planning effort in the Orlando area necessitated validation of the model chain then in use. This validation effort was accomplished in the traditional manner by attempting to match existing highway ground counts with results from applications of the model chain based on existing conditions.

It was realized that the existing low use of the area's transit system would be extremely hard to duplicate through an application of the mode-share model developed in 1973 and therefore that the normal validation process could not be used. For this reason, it was decided that a second survey would be conducted in an attempt to determine whether transit-use attitudes had changed in the area. This survey would be used to validate the expressions developed from the 1973 attitude survey that were input to the mode-share model.

The purpose of the 1978 attitude survey was to determine whether opinions toward transit had changed since the original survey in 1973. An attempt was made to survey as many of the 1973 respondents or households as possible. In addition, the same questionnaire was used, with only minor revisions permitted.

The 1973 survey form was reviewed in an attempt to try to improve questions that might be misunderstood by those being interviewed. Additional questions were inserted to provide a check on the responses to certain questions. These revisions were minor in order to satisfy the Florida Department of Transportation's desire that the questionnaire not be changed from the basic format and terminology used in 1973.

COMPARISONS OF THE TWO SURVEYS

In 1973, a sampling procedure was developed to ensure that socioeconomic groups (determined by responses to the question regarding income) would be proportionately represented in the survey. The first step taken was to determine the proportion of