tation system. For example, the potential for a volunteer driver system to serve as a feeder system for a regular fixed-route system needs to be examined.

ACKNOWLEDGMENT

The information and background material required for this study were provided through the cooperation of a number of people. Special thanks are extended to Christine Beatty of the Dane County RSVP Driver Escort Program; John Pfotenhauer and Charles Hurlbut of Independent Living, Inc.; Colleen Barnett of the Grant County Department of Social Services, and Richard Audetat of the Grant County Commission on Aging. The views expressed in this paper are mine, and I am responsible for the facts and accuracy of the data presented.

REFERENCES

1. R. Yukubousky and D. Fichter. Mobility Club: A Grass-Roots Rural and Small Town Transport Concept. New York State Department of Transportation, Albany, Prelim. Res. Rept. 69, Aug. 1974.
2. V. C. Weaver and B. D. Lundberg. Rural Public Transportation: North Dakota Case Study. TRB, Transportation Research Record 638, 1977, pp. 44-46.
3. D. J. McKelvey and R. S. Watt. Innovative Approaches to Rural Transportation. TRB, Transportation Research Record 661, 1978, pp. 1-6.
4. Transportation for the Elderly and Handicapped in Wisconsin: Report 1—Analysis of Specialized Transportation Services. Division of Planning, Wisconsin Department of Transportation, Madison, July 1976.
5. R. Briggs. Characteristics of Local Passenger Transportation Providers in Texas. Department of Community Affairs, University of Texas, Res. Rept. 45, Austin, Jan. 1977.
6. Memo from the Wisconsin Commissioner of Insurance to All Counties with Volunteer Driver Programs. Madison, March 14, 1978.
7. K. P. Ceglowski, A. M. Lago, and J. E. Burkhardt. Rural Transportation Costs. TRB, Transportation Research Record 661, 1978, pp. 7-14.
8. First Quarter 1978 Evaluation Data. Rural Highway Public Transportation Demonstration Program, Federal Highway Administration, Aug. 1978.
9. R. P. Warren and J. Collura. Second Progress Report on Barnstable County Rural Public Transportation Demonstration Program. Barnstable County Public Transportation Program, Barnstable, MA, Feb. 1978.
10. R. Perez and K. Guenther. Six Month Report on AATA Out-County Dial-A-Ride Service. Ann Arbor Transportation Authority Board, Ann Arbor, MI, Memo, Feb. 25, 1977.

Publication of this paper sponsored by Committee on Rural Public Transportation.

Abridgment

Forecasting Experiments for Rural Transit Policymakers

Yorgos J. Stephanedes, Department of Civil and Mineral Engineering, University of Minnesota, Minneapolis
Thomas J. Adler, Thayer School of Engineering, Dartmouth College, Hanover, New Hampshire

Four major groups are involved in the development of transit service in an area: (a) users, (b) management, (c) planning and funding agencies, and (d) the community. This paper addresses problems faced by transit managers and funding agencies. Such problems have been identified through the interaction of state and federal officials and during a review of rural transit systems in northern New England performed during the first part of 1978 (1). The authorization of more than $24 million for FY 1976 by Section 147 of the Federal-Aid Highway Act of 1973 and $420 million by Section 303e and Section 313a of the Federal Public Transportation Act of 1978 for FYs 1979-1982, will encourage the growth (in size and number) of rural transit systems. With this growth, the number of problems will increase.

Some of the first problems that transit managers face are in the initial application for funding and making plans based on socioeconomic and demographic characteristics of the service area. During the same period, federal subsidies for rural transit projects may be allocated to applicants based on the relative merit of alternative proposals. The benefit/cost standards that a local community applies to the expenditure of federal or state subsidies can be somewhat different from those used for local subsidies; since the former are considered to be marginally free, the accrual of any form of benefit is a net gain to the community. In most cases this means that the effectiveness of the expenditures of federal subsidies depends heavily on an operator's internal evaluation of his or her service or on the external evaluation of the allocating agency.

These problems are further complicated by the urgency with which funding agencies expect to see results in order to decide about funding continuation and budget approval. Because of this urgency, state and federal officials often use single average values to describe system performance in order to make decisions about the long-term feasibility of rural transit operations. Such values are then compared against each other at the national level and decisions made about whether a system's performance is acceptable or not. The danger of such decision making is illustrated by Figure 1. During its 19th month of operation the transit system in Bennington, Vermont, exhibits acceptable behavior. The same system if reviewed at the end of the 7th month would seem unacceptable. The figure shows that about 19 months were needed for the Bennington system to reach equilibrium behavior (i.e., a range of performance values that do not change appreciably with time). The magnitude of this overall system delay depends on four individual delays, each of which is from 4 months to one year long (2). These delays have been identified during our work on case studies of rural transit systems in northern New England:

1. Vehicle acquisition delay,
2. Schedule change delay,
3. Subsidy award delay, and
4. Ridership information delay.

GENERAL RESEARCH APPROACH

This research consisted of three sequential sets of activities. The first was an evaluation of the rural transit systems in northern New England (primarily New Hampshire and Vermont). The evaluation and comparisons served as a base of information from which the more generalized analyses proceeded.

In the second part, the effects of characteristics of (a) the service area, (b) management policies, and (c) funding policies on different measures of productivity and efficiency were tested. One of the findings was that an overall delay of at least one year occurs before the system exhibits steady-state behavior. For example, this delay was about 19 months for the Bennington system, as evidenced by the behavior of its ridership over time. Another finding was the existence of a seasonal variation in system performance, which was particularly evident from the moving average of a performance measure (e.g., the 4-month moving average of the Bennington load factor, which exhibits a seasonal variation during a period of 6 months) (see Figure 2).

The third part of the analysis was a detailed study, by use of a computer simulation, of the effects of different policies or environmental changes (e.g., energy shortages) on rural transit productivity and efficiency (both in the short and long term). Examples of the types of policies that were tested are (a) different federal or local subsidy policies, (b) fuel price increases, and (c) different operating and design strategies (e.g., fleet size, vehicle utilization, and service area). The set of nonlinear differential equations developed to simulate the rural transportation system across time incorporates (a) logit travel demand models (3, 4) previously shown to be transferable to areas of differing characteristics, modified and calibrated in rural Goffstown, New Hampshire, and (b) supply and resource functions developed empirically in rural northern New England. More information on the model structure and a comparison with other existing models can be found in Stephanedes (5) and in other forthcoming papers.

Figure 1. Bus ridership in Bennington, Vermont.

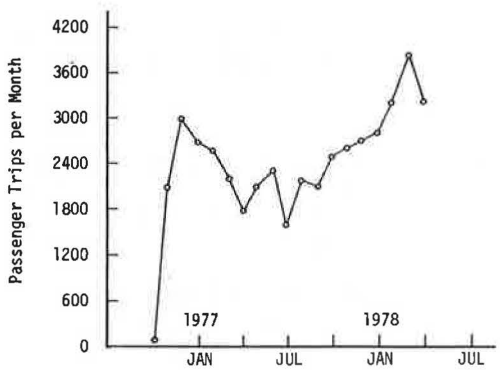
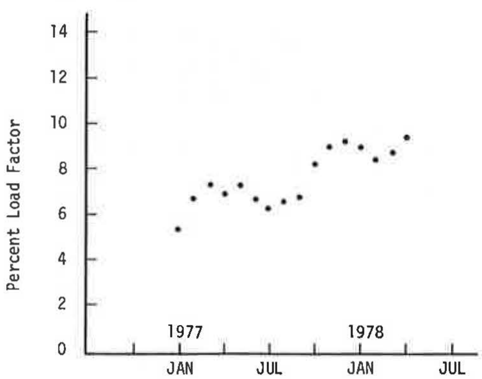


Figure 2. Bennington load factor (four-month moving average).



EXPERIMENTS THAT USE THE RURAL TRANSIT MODEL

The results of simulation experiments reflect the implications of structural assumptions used in formulating the model. [Area and service characteristics that were input to the model are detailed in Stephanedes (2).] For example, this particular model assumes that managers and funding agencies behave in a particular manner in response to changes in ridership. In most cases, these representations should be different, depending on the specific transit system being analyzed. The same basic structure, as represented by the existence of certain delays (e.g., in vehicle acquisition) and of interrelationships (e.g., between ridership changes and service levels), should, however, apply to all rural transit systems. Thus, the results of experiments described here should be interpreted as having numerical values that apply to the specific prototype system, whose managers and funding agencies behave as assumed, but the direction of changes applies more generally to other rural transit systems.

Should High-Quality Service Be Offered Early in System Life?

An example was used of headways that were assigned a lower upper limit (30 min; base value = 1 h), and lower initial headways (24 min; base value = 30 min). These decisions were combined with an aggressive managerial policy that had a low desirable load factor (0.3; base value = 0.5). Even though load factors remained slightly below full capacity, headways became half of the base value, passenger trips tripled, and noncapital net cost per kilometer decreased by 30 percent [from about \$0.54 (\$0.75/mile)] within a five-year period. The choice of service quality to be offered remains to be made by the transit manager, who could be aided in this task by the use of a simulation approach.

Should Capital or Operating Subsidies Be Reduced?

When capital subsidies are reduced to 50 percent of what is applied for and initial capital equipment are doubled, service quality declines slowly, as does ridership (by 60 percent) and noncapital net cost (by 35 percent). The prototypical system in our example went into the zone of unacceptable service (headways above 1 h) after seven years of operation. Given that service quality and ridership start to decline only toward the end of the fourth year, this policy may be tried in combination with incentives to increase the local share of transportation costs while the transit system still enjoys a good reputation with the community.

Reduction of operating subsidies causes service quality to quickly deteriorate. Within two years headways fall (from about 25 min) to the lowest acceptable level, ridership decreases by 90 percent (from about 320 passengers/week), and costs more than double. Similar results were obtained by doubling initial capital and by varying subsidy decreases between 20 and 50 percent.

If Operating Subsidies Are Reduced, Should New Systems Be Preferred?

After the transit system had been in operation one to two years, operating subsidies were reduced by 20-50 percent. Results did not differ appreciably from the case where operating subsidies started at a reduced level. Unless old systems have picked up the necessary local funding support, they are as likely to suffer at reduced subsidy levels as are new systems.

How Much Should Be Spent for Advertising and How Much for Streamlining the Transit Funding and Schedule Change Process?

Rider information delays are particularly high for rural systems. Because of low demand, capital acquisition delays are also appreciably higher than should be expected. Because the rural transportation programs are new, a large amount of paperwork is necessary during the funding application process. The same holds for procedures to approve schedule changes, especially when they are in conflict with interests of established interstate carriers. The question that arises is, What will be gained if these delays are reduced?

When information delay alone was reduced by 50 percent, the behavior of the system did not change appreciably, except for the total net cost at the end of five years, which was reduced by 5 percent. When all other delays were reduced by 50 percent, noncapital net cost increased by 100 percent and buses ran 20 percent less full than in the base run—probably a result of excess capacity, because ridership was still slow in responding. Reduced delays by 50 percent across the board, however, increased the noncapital net cost by 50 percent but caused a 60 percent increase in ridership; thus the noncapital net cost per vehicle kilometer was reduced by 15 percent.

What Is the Effect of Fare Increases and Promotional Policies on the System Behavior?

Fare increases have negative effects on ridership, and such effects are smallest when changes are instituted late in the life of a system (i.e., at least after the first six months of operation). Data from the two Section 147 systems in Vermont confirm this observation.

Promotional policies (e.g., free rides) have negligible effects on ridership, unless they last for a long period (i.e., six months). Data from the Stagecoach system in Bethel, Vermont, confirm this observation.

CONCLUSIONS

A simulation technique is used in the analysis of the effects of different policies on the development of a rural transit system. Results from policy experiments agree with the observed behavior of rural transit systems in northern New England. The technique is useful primarily as a quick-turnaround policy-analysis tool. A complete simulation run consumes less than 10 s of central processing unit time on a Honeywell 66/40.

The technique has potential applications for policy analysis at two levels: (a) at the managerial level to provide help in project planning and operation and (b) at the fund allocation level to help in decisions about funding approval, funding allocations, and funding renewal. The inclusion of a large set of policy-relevant variables as endogenous in the rural structure allows for the testing of policies that vary with time, and requires relatively limited initial data input. No intermediate data are necessary.

Four major delays in rural transit are identified. Specific ways of reducing the effects of delays are proposed and applied to experimental cases. The effects such improvements have on transit behavior are not obvious and may vary, depending on the particular way such improvements are instituted.

Further research will identify, through implementation case studies, ways in which transit managers and others can use the model to increase the effectiveness of rural transit programs. Inclusion of more variables as endogenous to the transit structure will make it possible to ask policy questions of a much broader spectrum.

ACKNOWLEDGMENT

This work is partially supported by the U.S. Department of Transportation, Program of University Research.

REFERENCES

1. C. Connell, T. J. Adler, Y. J. Stephanedes, and S. R. Sterns. A Review of Rural Transit Systems in Northern New England. Thayer School of Engineering, Dartmouth College, Hanover, NH, DOT/OS/80006, 1978.
2. Y. Stephanedes. Performance Indicators and Policy Evaluation in Rural Transit. Thayer School of Engineering, Dartmouth College, Hanover, NH, Ph.D. thesis, Nov. 1978.
3. M. Ben-Akiva and T. Atherton. Transferability and Updating of Disaggregate Travel Demand Model. Center for Transportation Studies, Massachusetts Institute of Technology, Cambridge, MA, Rept. 76-2, 1976.
4. T. J. Adler and M. Ben-Akiva. Joint-Choice Model for Frequency, Destination, and Travel Mode for Shopping Trips. TRB, Transportation Research Record 569, 1976, pp. 136-150.
5. Y. Stephanedes. A Feedback Dynamic Model for Transportation Systems. Proc., 2nd International Symposium on Large Engineering Systems (Univ. of Waterloo) Sandford Education Press, 1978.

Publication of this paper sponsored by Committee on Rural Public Transportation.