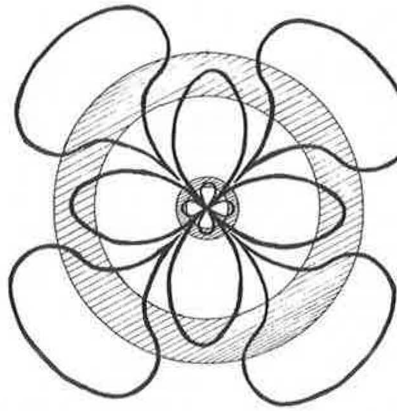

Figure 5. Bus route configuration.

1. Solid waste optimization collection systems (SWOCS)—The routing of garbage trucks is a similar problem but the delivery point is not at the centroid of the pickups.
2. Small urban fixed-route transit planning—This is a similar problem, but the coordinates change for each run on a route.
3. Small urban floating-point transit planning—Requests have been made to investigate routing of vanpools and senior citizen demand-responsive systems.

Other low-density routing problems will be investigated.

In some of the remote or very low-density areas the revival of the country school should be considered. There is a breakpoint at which the cost of operation of these schools approaches the cost of transportation. The psychological factors involved in riding a bus 2 h/day needs to be considered. In 12 years of school, a student could spend as much as 0.5 year on a bus. The four-day school week and study-at-home packages need to be considered. The use of vans to collect distant passengers could reduce riding time. Also, near and far loops need to be investigated.

The major disadvantage of the loop-shaped route is excessive riding time for the first students on the bus, who travel away from their destination half of the time. This route is, therefore, not suitable for long routes but is satisfactory for short- and medium-length routes. Outlying stops should be serviced by more direct routes.

In order to keep travel time under 1 h, the riding distance should be no more than 48-56 km (30-35 miles). By using the design curve (rose petal) with a length of 56 km, the radius of a cell around the central school location can be determined. Loop-shaped routes can be used within a radius of 19 km (12 miles). This is represented in Figure 5. The small circle represents the area in which double-tripping is feasible (a bus unloads after servicing a medium-length route and then immediately services a short route on the outskirts of a town). The radius is approximately 3 km (2 miles). The West Fargo school district uses several short routes of this type. The large circle represents the area in which loop routes of a medium length can be used. Stops in the area beyond the larger circle must be serviced by more direct routes of a general configuration, shown in Figure 5.

CONCLUSION

The development of this model has shown that an expensive network analysis is not needed to route school buses. The coordinates from the computer printout can be easily plotted on an overlay by school district personnel, and decisions on which routes to take are then based on local knowledge in the school district. This leaves the decision on final bus routes and schedules where it should be—at the local level.

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Estimating the Effects of Alternative Levels of Service on Rural Transit Ridership

Wayne R. Ugolik and Robert G. Knighton, Planning and Research Bureau, New York State Department of Transportation, Albany

This paper deals with the need to assess public response to alternative levels of service and travel flexibility on proposed rural transportation systems. A public opinion survey was conducted in rural Otsego County, New York, among 254 households, 30 of which had no telephones. The survey presented three public transportation options (fixed route, dial-a-bus, and mobility club) and asked questions about possible use of such

services at different fare and service levels. The survey questionnaire was designed to minimize noncommitment bias and responses were separated on the basis of automobile availability to minimize the need for adjustment for noncommitment. Adjustment for noncommitment was necessary for the group that had an automobile available. This adjustment was based on the proportion of transit trips made by the automobile-available group on the existing dial-a-bus system (as determined by an on-board survey), which operates in Oneonta, the county's largest city. Estimates of potential ridership were made for each transit option at different fare levels, service levels, and travel-flexibility levels. Although it is not suggested that the demand estimates developed for Otsego County are transferable to other areas, the relative changes in demand resulting from changing fare, service, and travel-flexibility levels should be generally useful.

Providing for the mobility needs of rural residents is a growing national concern. In fact, a 1974 public opinion poll in New York State (1) identified the lack of adequate public transportation as the number one community problem in rural areas.

Estimates of potential usage are essential to planning and implementing any rural transportation system. Previous methods for estimating demand for such service have varied from extremely simple trip rate schemes to fairly sophisticated models (2-7). These methods contribute to the establishment of estimates of demand, but they do not provide a method for assessing public response to innovative approaches to public transportation that might be appropriate in rural areas. In particular, some understanding of how restrictions on service availability might affect ridership is necessary in order to analyze and develop alternative fare levels, service levels, and travel-flexibility policies. This study was intended to provide insight into these matters.

The research involves the design of a questionnaire, its administration in a telephone and personal interview survey, and an analysis of the data obtained. The survey was conducted in Otsego County, a rural county in central New York. The county has a population of 56 000, 16 000 of whom live in the city of Oneonta, where a dial-a-bus service has been in operation since 1974. The remaining 40 000 live in rural areas and small vilages; the largest is Cooperstown, which has a population of 2400 and is famous as the "home of baseball".

The analysis resulted in estimates of potential demand, outside the city of Oneonta, for various proposed transportation services (dial-a-bus, fixed-route bus, and mobility club) at different fare and service levels.

DATA AND METHOD

A sample of 224 households outside the city of Oneonta was selected at random from telephone directories, and one person per household was interviewed. The sample was proportioned among census minor civil divisions in order to ensure representation of all areas of the county. A snowball method was used, whereby persons interviewed were asked if they knew of households that did not have telephones. An additional 30 households were then personally interviewed so that the needs of persons who do not have telephones could be assessed. Thus, the survey resulted in 254 completed questionnaires.

Initial analysis of the sample indicated an overrepresentation of women and older men. Therefore, the sample responses were weighted on the basis of six age and gender categories to align the sample with census statistics (see table below; note that P = the population proportion and p = the sample proportion). The demand estimates were based on the weighted survey results by summing weights rather than units.

Age	Women	Men
16-34	P = 0.165 p = 0.185 n = 47 w = P/p = 0.892	P = 0.150 p = 0.067 n = 17 w = P/p = 2.238
35-54	P = 0.171 p = 0.209 n = 53 w = P/p = 0.820	P = 0.162 p = 0.086 n = 22 w = P/p = 1.88
55+	P = 0.185 p = 0.275 n = 70 w = P/p = 0.673	P = 0.160 p = 0.177 n = 45 w = P/p = 0.904

The survey was conducted during the second week of April 1978. The survey questionnaire (8) was designed to investigate the effects that various service limitations and fare levels would have on the demand for different transportation services. Each respondent was asked questions specific to the last time he or she needed to go somewhere (one round trip). Of particular interest was a question referring to "automobile availability" for that trip. Each of three transportation services (dial-a-bus, fixed-route bus, and mobility club) (9) were described and the respondents were asked whether or not they would have used such transportation service for that trip. The questions were asked sequentially and required simple yes or no answers. After an indication of "yes I would have used that option", answers to questions such as "would you have used that option if. . ." were solicited for various levels of different types of service constraints in increasing order of their limitation to service (such as increasing fares, increasing wait time, and requiring advance reservation time). The weighted positive responses were doubled (assuming a round trip), averaged to reflect trips per day, cross-tabulated by type of service restriction, and expanded to the entire population (16 years of age and over) within the county, but outside the city of Oneonta, to yield an estimated number of one-way trips per day at various service levels. These estimates were then adjusted for noncommitment bias.

Estimates obtained directly from data of this kind are distorted by noncommitment. A 1974 study (4) showed that noncommitment responses sometimes need to be reduced more than 90 percent in order to obtain reasonable estimates of demand. That is, many persons indicate in surveys that they would use a transportation service when in reality, if the service were made available, they would not. This is particularly true for respondents who have an automobile available for their use. Persons who have an automobile who think that they might use public transportation are still more apt to use their automobiles rather than public transportation. This is especially true because obstacles to using public transportation such as waiting time, required advance reservation time, and immediate out-of-pocket cost make an available automobile a much more attractive option. However, persons who do not have an automobile to use are apt to use public transportation if it is available and if its use appeals to them.

In fact, most riders on existing systems do not have an automobile to use. A recent on-board survey conducted on the Oneonta dial-a-bus system (10) showed that 85 percent of the riders had no other means of transportation. Here a rough concept of need enters the picture: The person without an automobile to use needs public transportation more than the person who has an automobile available. One might expect then that persons who do not have an automobile to use are more committed to the use of public transportation. Moreover, the majority of persons reached in a telephone survey have an automobile for their use. Indeed, 89 percent of those surveyed in this study indicated

Table 1. Initial noncommitment response rates (raw data).

Transportation Service	Would Use: Automobile Available	Would Use: No Automobile Available	Would Use: Total	Would Use: Percent	Would Not Use: Automobile Available	Would Not Use: No Automobile Available	Would Not Use: Total	Would Not Use: Percent
Dial-a-bus	94	14	108	42.5	132	14	146	57.5
Fixed-route bus	86	16	102	40.2	140	12	152	59.8
Mobility club	101	8	109	43.0	125	20	145	57.0

that they had an automobile available to use for the last trip they made. Thus, the bulk of the overestimation of demand, which results from the direct use of noncommitment raw data responses, derives from the automobile-available respondents. Therefore, the no-automobile-available and automobile-available respondents were analyzed separately. The distortion that is introduced by noncommitment is indicated by Table 1. Certainly, an expectation that over 40 percent of the population would use public transportation is unreasonable.

By asking each respondent to answer all questions with regard to one specific trip that he or she actually made, the questionnaire was designed to bring the respondent from some vague idea of general transit use to a more realistic conception of actual travel restrictions that might be encountered in using public transportation. We assumed that such a real-world frame of reference would reduce noncommitment bias, particularly among those who need public transportation. In particular, since persons without automobiles are much more apt to use public transportation, we assumed that noncommitment bias among the no-automobile-available respondents was eliminated by the design of the questionnaire. This assumption was supported by the raw data. Of the entire sample of 254 respondents, 28 did not have automobiles available for their trips. Of these, only 12 indicated that they would have used a dial-a-bus at a $0.50 fare; 8 said they would have paid $0.75; 5 said they would have used it at a $1.00 fare; only 3 indicated that they would have paid $1.50. From an empirical standpoint, these numbers appear realistic.

A certain element of demand was expected to be generated by persons who have an automobile available. However, these respondents should generate only a fraction of the total demand. But, the number of automobile-available respondents who indicated in the survey that they would have used public transportation for their trips was more than five times that of the no-automobile-available group. This apparent paradox is due to the high degree of noncommitment among the automobile-available respondents. In order to obtain more accurate estimates of demand within this group, a noncommitment adjustment procedure was developed. The technique was based on the procedure developed by Hartgen and Keck (4). But, rather than using a presupposed trip rate to forecast demand, we assumed that, at a prescribed fare and service, availability level, the automobile-available group would generate a specific share of the total demand.

NONCOMMITMENT ADJUSTMENT METHODOLOGY

Data from the recent on-board survey conducted on the Oneonta dial-a-bus system (10) were used to determine that the average fare for the system is about $0.40 and the required advance reservation time is about 0.5 h. At this fare and service-availability level, 85 percent of the ridership had no other means of transportation. Therefore, about 15 percent of the demand is generated by persons who have an automobile available for their use. We therefore assumed that, at this same fare and advance reservation level, 15 percent of the total demand for a dial-a-bus outside the city of Oneonta would come from individuals who have an automobile available for their use.

The dial-a-bus noncommitment responses of the automobile-available group (weighted by age and gender category) were then expanded to the entire population over age 16 who live outside the city of Oneonta and were cross-tabulated by fare level and call-in-advance level. We determined that at a $0.40 fare and a 0.5-h call in advance, 2722 daily one-way trips would be generated by the automobile-available noncommitment responses. Similarly, we determined that at this same fare and service level, 440 daily one-way trips would be generated by the no-automobile-available responses.

The assumptions that the 440 trips generated by the no-automobile group are committed trips, and that this number is 85 percent of the total number of daily one-way trips, led to the estimate that about 518 daily one-way trips would be made on a dial-a-bus that operates outside the city of Oneonta at a $0.40 fare level and 0.5-h advance reservation. This meant that the noncommitment response for the automobile-available group was 34.897 times what it should be [$34.897 = 2722/(518-440)$]. Therefore, the noncommitment adjustment factor for the automobile-available group is 0.0287 ($0.0287 \approx 1/34.897$). We assumed that the same degree of noncommitment applied at each fare and service level. This assumption is based on the premise that a respondent's answers to questions about increasing fare levels and service restrictions merely help to quantify preference for or against the service, but commitment to use the service remains constant through the levels of fares and service that he or she finds acceptable.

Therefore, in order to estimate the demand for dial-a-bus service under a particular set of service restrictions, the total number of trips generated by the expanded and weighted responses of the no-automobile-available group were summed with 2.87 percent of the total number of trips generated by the expanded, weighted, noncommitment responses of the automobile-available group.

Moreover, because both a mobility club and a fixed-route bus serve the same function as a dial-a-bus (they differ mainly in the level of service), and since each of the persons surveyed was questioned about each transportation option, we also assumed that the same degree of noncommitment applied to the fixed-route and mobility-club options. Thus, the estimate of demand for an option at a particular fare and service level was determined in exactly the same way as that for a dial-a-bus; 0.0287 was used as the adjustment factor for the automobile-available response group.

RESULTS

Dial-a-Bus

The specific factors that limit dial-a-bus service that

Table 2. Dial-a-bus demand estimates.

Fare ($)	Automobile Availability	No Flexibility	0.5-h Flexibility	1-h Flexibility	2-h Flexibility
<0.50	No	436	406	236	178
	Yes	53	50	31	15
	Total	489	456	267	193
0.50	No	436	406	236	178
	Yes	52	49	30	14
	Total	488	455	266	192
0.75	No	298	268	148	148
	Yes	42	39	24	10
	Total	340	307	172	158
1.00	No	202	172	148	148
	Yes	34	32	21	9
	Total	236	204	169	157
1.50	No	124	124	124	124
	Yes	21	18	12	7
	Total	145	142	136	131

Table 3. Mobility-club demand estimates.

Fare ($)	Automobile Availability	No Flexibility	0.5-h Flexibility	1-h Flexibility	2-h Flexibility
<0.50	No	250	232	134	102
	Yes	57	54	33	16
	Total	307	286	167	118
0.50	No	250	232	134	102
	Yes	56	52	32	15
	Total	306	284	166	117
0.75	No	170	152	84	84
	Yes	45	42	26	11
	Total	215	194	110	95
1.00	No	116	98	84	84
	Yes	37	34	22	10
	Total	153	132	106	94
1.50	No	70	70	70	70
	Yes	22	19	13	8
	Total	92	89	83	78

were considered are (a) fare level, (b) required call in advance for reservation, and (c) flex-time. The flex-time factor is an innovative concept that requires the potential user to be flexible in his or her desired pick-up time to the extent that he or she would still use the dial-a-bus service if notified in advance by a dispatcher (presumably soon after making a reservation and specifying a pickup time) that the dial-a-bus might make a pickup as much as 0.5-2 earlier than planned. This added flexibility on the part of the user would make scheduling pickups easier and could aid in increasing vehicle occupancy, thereby requiring fewer vehicles to meet the demand. This would help in the practical implementation of such service. Naturally, as the respondents were asked to be more flexible (increase flex-time from 0.5-2 h) the demand was seen to decrease, yet many respondents appeared to feel comfortable with a 0.5-h flex-time requirement. Demand decreased noticeably from the 0.5-h flex-time requirement to the 1-h flex-time requirement, particularly at the low fare levels. Table 2 gives the demand estimates for the dial-a-bus option for various fare and flex-time levels under the specific limitation of a one-day call in advance for a trip reservation. We thought that this advance reservation time was reasonable from the standpoint of the practical implementation of a demand-responsive service, and in fact it was reasonably well received by the survey respondents. Such tables exist for other call-in-advance levels but will not be presented here.

Mobility Club

The mobility club is a grass-roots approach to rural transportation that has many of the same service characteristics as a dial-a-bus (e.g., door-to-door service) except that the mode of travel is usually a privately owned passenger automobile (9). Thus, potential users would be expected to call to make a reservation, specify a pickup time, and pay for the service. We, therefore, assumed that the relative changes in demand that result from decreases in levels of service for a mobility club would be the same as that for a dial-a-bus service. Survey respondents were, therefore, not asked questions about their perceived use of a mobility club under various fare, flex-time, and advance reservation requirements. Rather, the estimates of demand for dial-a-bus service were adjusted to reflect the different composition (on the basis of automobile availability) of respondents who initially indicated that they would have used a mobility club. Table 1 indicates that the mobility club option was 1.07 times as popular as the dial-a-bus option among the automobile-available respondents ($1.07 \approx 101/94$) but only 0.57 times as popular among the no-automobile-available respondents ($0.57 \approx 8/14$); therefore, each dial-a-bus estimate for the automobile-available group was multiplied by 1.07 to obtain the corresponding estimate of mobility-club demand, and each dial-a-bus estimate for the no-automobile-available group was multiplied by 0.57 to obtain the corresponding estimate of mobility-club demand. Table 3 gives the resulting demand estimates for a mobility club at various fare and flex-time levels under the specific limitation on potential users of a one-day call in advance for a trip reservation. Tables 2 and 3 indicate that the dial-a-bus option would reach more persons who need transportation—i.e., those who do not have an automobile to use.

Table 4. Fixed-route bus demand estimates.

Fare ($)	Automobile Availability	Walk 1 Block to Bus Stop	Walk 0.40 km to Bus Stop	Walk 0.80 km to Bus Stop
<0.50	No	124	68	68
	Yes	28	25	17
	Total	152	93	85
0.50	No	124	68	68
	Yes	28	25	17
	Total	152	93	85
0.75	No	124	68	68
	Yes	27	24	16
	Total	151	92	84
1.00	No	94	68	68
	Yes	23	21	13
	Total	117	89	81
1.50	No	92	68	68
	Yes	15	13	9
	Total	107	81	77

Note: 1 km = 0.62 mile.

Fixed-Route Bus

From the standpoint of practical implementation, the fixed-route bus option is the least likely to provide adequate service at a reasonable cost to residents of a sparsely populated area. This option was considered primarily so that later analysis might be done to see if such service could be made available along specific routes. The specific factors that limit fixed-route service that were considered are (a) fare level (b) distance to bus stop, and (c) bus headway. After reasonable service limitations were proposed, the fixed-route bus option proved to be the least popular option. Table 4 indicates the estimates of demand under the specific constraint of 4-h bus headways.

NO-PHONE RESPONSES

The implementation of some form of demand-responsive system appears to be the most realistic approach for a rural transportation service to reach the most people. This paper has considered two: dial-a-bus and mobility club; however, these systems require that the user telephone a request for service. Thus, an investigation of the needs of persons who do not have telephones is of interest. The fundamental question is, Do these perople need public transportation more than persons who have telephones? That is, are they more apt to be unable to use automobiles? If so, such demand-responsive systems will not be readily available to the people in greatest need of them.

Three important observations were made from the analysis of the responses of the 30 persons who were interviewed in person. Only five indicated no household automobile, but three of these did have an automobile available for their own use; only three persons that had a household automobile did not have an automobile available to use. In total, 83 percent of the no-phone respondents did have an automobile to use (this compares with 89 percent for the entire sample). Moreover, only two of the no-automobile-available persons who did not have a telephone indicated that they would use dial-a-bus; neither would pay more than a $0.50 fare and only one responded to the 0.5-h flex-time requirement. Thus, the need among people without a telephone does not appear to be appreciably greater than that of persons who have a household telephone.

SUMMARY AND CONCLUSIONS

This paper presents a procedure for assessing the simultaneous effects of fare and service levels on potential demand for proposed rural transportation systems—dial-a-bus, fixed-route bus, and mobility club. The method is based on a survey that uses a questionnaire designed to reduce noncommitment bias. This is done by asking respondents to answer all questions in a yes or no format with reference to an actual trip previously made.

Respondents to our survey were classified on the basis of automobile availability. It was empirically determined that noncommitment bias among the no-automobile-available respondents was eliminated by the questionnaire design. However, adjustment for noncommitment bias was necessary for the automobile-available group. The noncommitment adjustment methodology was based on an assumed share of the total ridership that should realistically be expected to be generated at a specific real fare and service level by persons who have an automobile. The results showed that the highest demand would be for a dial-a-bus service, regardless of the fare or service level.

The survey also included a subsample of 30 households that do not have telephones, which were selected by a snowball method. It was found that, based on automobile availability, this group of households did not have a greater need for public transportation than those households that have telephones. However, the method of selecting these housholds may have introduced bias in the subsample. Therefore, further research into the relation between automobile availability and telephone availability is needed in order to more fully understand the transportation needs of persons in rural areas who do not have telephones.

Estimates of demand based on surveys are often high estimates due to noncommitment bias. In the research reported here a reasonably easy adjustment for this bias was made. But, the resulting estimates were based on the assumption that the levels and types of services described can actually be implemented. Actual use of a public transportation service may fall short of these estimates if the promised level of service is not provided.

The concept of flex-time was introduced in the study as a method to serve the public more realistically and in the hope that its implementation could increase vehicle productivity. The idea was well received by the survey respondents. Research is currently being conducted to determine how well demand-responsive systems might actually perform under the various flex-time and service levels described in the questionnaire. The objective is to determine ways to serve the estimated potential demand with a reasonable number of vehicles at a realistic cost level.

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Abridgment

Analysis of Volunteer Driver Systems in Rural Public Transportation

Robert L. Smith, Jr., Department of Civil and Environmental Engineering, University of Wisconsin, Madison

Rural public transportation systems that rely on volunteer drivers who use their own automobiles have been proposed and analyzed theoretically by transportation planners (1-3). Yukubousky and Fichter developed the concept of a volunteer driver system called the mobility club (1). More recently Weaver and Lundberg proposed a friends-and-neighbors rural transportation system supplemented by a conventional van service in North Dakota (2) as a demonstration project under Section 147 of the Federal-Aid Highway Act of 1973. A volunteer driver system has also been developed for the Chester County, Pennsylvania, Section 147 demonstration project (3). Human service agencies have already gained considerable experience in operating volunteer driver systems. Recent inventories of specialized transportation providers in Wisconsin and Texas showed that a significant proportion of the total service was being provided by volunteer driver systems (4, 5). The purpose of this study is to evaluate the potential for continuing, and even expanding, volunteer driver systems in rural areas. Case studies of volunteer driver systems in two Wisconsin counties are used to test the hypothesis that volunteer driver systems can be a cost-effective, feasible means of providing high-quality, specialized transportation service in rural areas. In addition, the role of volunteer driver systems in relation to paid driver systems that use vans or buses is examined in terms of an optimum mix of service types. Finally, the implications for public policy in the implementation of the rural public transportation operating assistance program (Section 18 of the Surface Transportation Assistance Act of 1978) are examined.

GROWTH OF VOLUNTEER DRIVER SYSTEMS

The growth of social welfare programs designed to meet the needs of low-income and handicapped people in recent years has made human resource personnel more aware that programs to provide medical care, nutrition, and other basic human services require transportation to bring the people to the services. Thus, human resource agencies have taken a leading role in the development of transportation systems in rural areas. Volunteer driver programs in which the volunteers use their own vehicles and usually are reimbursed for the expense of operating their vehicles [generally about 9.3-13.6 cents/km (15-22 cents/mile)] provide a low-cost means for human service agencies to meet the transportation needs of their clients.

A volunteer driver system has many advantages. The capital, maintenance, and operating costs of a van or bus system are avoided. Often the existing staff has had experience with volunteer programs so that additional personnel are not required, at least initially. Part-time, paraprofessional staff can be added incrementally as the number of volunteer drivers increases. Sometimes volunteers can also be recruited to aid in scheduling trips. Funds for reimbursement for the distance driven have been available from a variety of sources, including Titles XIX and XX of the Social Security Act of 1935, as amended; local support; and, in Wisconsin and other states, seed-money grants under Title III of the Older Americans Act of 1965, as amended.