Transit Planning in a Small Community: A Case Study

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This paper describes strategies for estimating potential markets for transit or paratransit service, developing a potential set of transit system concepts, estimating demand for each of a selected subset of concepts, developing an evaluation process, and selecting an implementation strategy. The case study has shown that there is considerable value in conducting limited, small-scale surveys of specific market segments as well as in developing a wide variety of system concepts in order to permit an effective choice among possible systems. An extensive educational effort is needed for the community participants in the process as well as broad-based community representation throughout the process.

This paper records the experience of a transit planning team in its attempt to apply recent research developments and operational concepts to an actual situation. The current emphasis on low-capital highly flexible market-oriented systems and the development of paratransit concepts have created a need for new approaches to planning, new techniques to carry them out, and consideration of alternatives to fixed-route systems. The classical approach no longer suffices.

Methods for estimating the potential demand for a proposed transit service have not adequately reflected service factors that differentiate among the alternative modes available. Generation of alternative systems and their evaluation have often failed to include active, structured community participation. The management concepts that are needed to handle these more complex systems while meeting a variety of related community goals are just beginning to gain consideration.

This project had as its primary objective to define for a community of 70 000 people a public transportation system that could provide the level of service required to meet physical, social, and economic goals. The study framework is shown in Figure 1. The tasks were designed and arranged to maximize participation by the community and to assure complete consideration of a wide variety of potential transit services in alternative forms of system integration.

The study was conducted for the villages of Schaumburg and Hoffman Estates, Illinois, two adjacent and intertwined suburban communities located about 40 km (25 miles) northwest of the Chicago central business district (CBD). In 1975 the study area encompassed a population of 69 000 and had an employment level of 26 000 jobs. Projections to 1985 show a population of 135 000 and employment of 71 000. The area is characterized by a scattering of trip attractors. There is no CBD for either village, nor is it intended that one be developed. In addition, two railroad commuter lines (the Chicago and North Western Railway Company to the north and the Milwaukee Road to the south) are used by the residents, primarily to get to and from work in the Chicago CBD. Neither of these lines has stations in the villages. A major junior college is adjacent to the study area.

Present public transportation within the study area is extremely limited. Taxi companies serve several of the suburban communities in the area. A school-bus company also provides limited peak-period service on a fixed-route basis to one of the commuter railroad stations. Demand-responsive transportation is available to handicapped persons through a program administered by the office of the township supervisor.

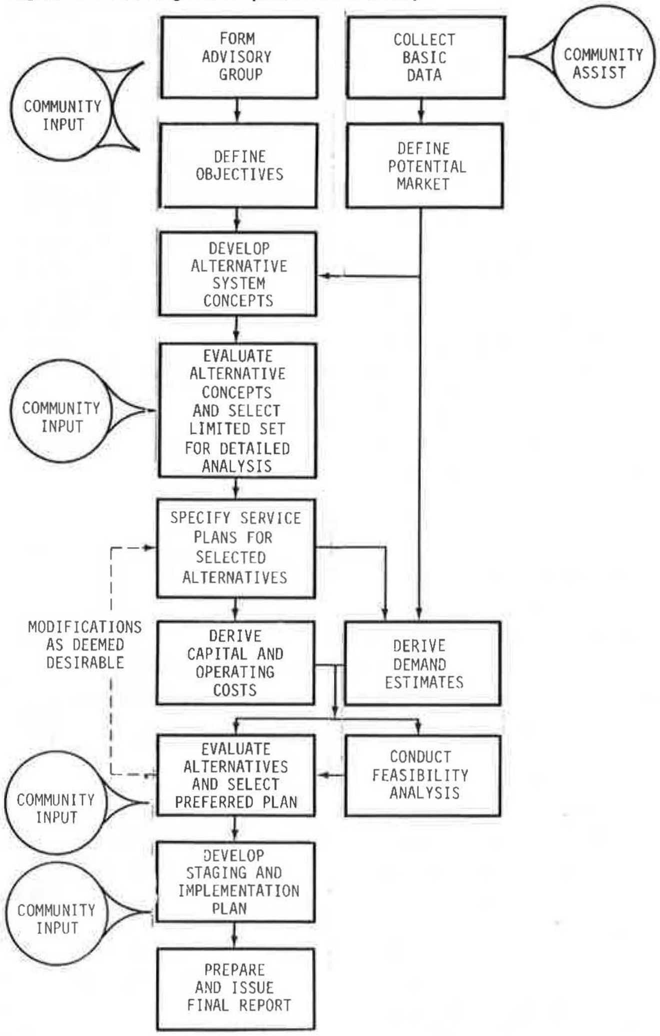
Housing consists primarily of single-family dwelling units. Most growth, however, will be in the form of high-density apartment complexes. According to the 1970 census, there were about 16 600 households in the study area. The average household income at that time was $15 600. More than 25 percent of the population was under age 15, and 2 percent was over age 65. There are a large number of multiple-car families (only 3 percent of the households had no automobile available and half owned two automobiles) and an even larger number of licensed drivers (45 percent of the households had more drivers than automobiles). Consequently, trip patterns are generally dispersed both in space and time over the area of approximately 11.3 by 9.7 km (7 by 6 miles).

MARKET ESTIMATION

Surveys were performed to assist in identifying the sizes and characteristics of the various markets to be served

*Mr. Pfefer was a staff member and Mr. Stopher was a consultant of Jack E. Leisch and Associates, Evanston, Illinois, when this research was performed.

Figure 1. Flow diagram for public transit study.



in the community. The primary market segments surveyed were rail commuters (those who work in the Chicago CBD), internal commuters (those who live and work in the community), and shoppers (residents shopping in the community). A number of other market segments were also identified but were not considered appropriate for the survey work. Hand-out, mail-back questionnaires were designed and distributed for each of the three markets. A sample survey is shown in Figure 2.

The rail commuter survey resulted in 1891 returns, 639 of which were from residents of the study area. The internal commuter survey produced 3355 returns, with 1377 from study-area residents. The shopper survey resulted in 1579 returns, 958 of which were from residents. Table 1 summarizes the general findings of the three surveys.

The surveys showed that the internal commuters and shoppers, neither of whom have any bus service currently available, had a low level of interest in using a bus. In contrast, rail commuters, for whom limited bus service is already provided, showed a higher willingness to use the bus under any conditions. Also, walking distance was found to be more important than in-vehicle time. Most respondents who would use a bus even if it took longer would be willing to take it even if it took almost twice as long as the car (10 to 14 min longer compared with the average travel time of 13 to 17 min).

Table 1. Summary of survey findings.

Item	Rail Commuter	Internal Commuter	Shopper
Mode of travel, percent			
Automobile driver	71	86	83.0
Automobile passenger	18	11	0.6
Shared automobile ride			
One passenger	44	23	31.0
Two or more passengers	13	1	17.0
Bus	10	—	0.2
Peak period, percent of trips			
6:15 to 7:30 a.m.	84		
6:30 to 9:00 a.m.		77	
5:30 to 6:30 p.m.	74		
3:00 to 5:00 p.m.		64	
Average travel time, minutes	15	17	13
Estimated cost of trip by present mode, cents	43	44	37
Maximum bus fare traveler will pay, cents	44	39	38
Trip frequency of five times a week, percent	88	80	—
Licensed drivers, percent	96	96	93
Households with automobiles, percent	98	99	99
Average number of drivers in household	2.20	2.38	2.44
Average number of automobiles in household	1.62	1.82	1.88

In general, the survey identified a fairly typical suburban community with high dependence on the automobile, high automobile competition (i.e., a high ratio of licensed drivers to automobiles in the household), and generally relatively short travel times within the village. It was clear that a transit service will have a relatively difficult time competing with the current levels of service offered by the automobile.

The next step was to develop estimates of the total market for transit service within the communities. The primary sources for estimating the sizes of the various market segments were census data and local data collected by the villages. It should be noted, however, that the villages under study are among the fastest growing in the country, and the market estimation process was being conducted nearly five years after the completion of the last decennial census. Special census data gave up-to-date population values but no updating of characteristics.

In addition to the three groups surveyed, four further market segments were considered to be likely to generate reasonable levels of transit use. The figures derived for all market segments in 1975 are summarized below.

Market Segment	Market Size (trips/avg weekday)	Market Segment	Market Size (trips/avg weekday)
Rail commuter	3 000	Personal business traveler	12 600
Internal commuter	9 300	Social-recreational traveler	8 400
Shopper	21 000	Total	57 200
Elderly	2 600		
Handicapped	300		

It should be recognized that the total market estimated here (approximately 19 000 trips per year) does not cover all segments of the population, nor does it provide for all types of trips that might be undertaken.

TRANSIT SYSTEM CONCEPTS

Once a satisfactory definition of the size and characteristics of the potential markets in the community has been established, the appropriate systems can be considered.

The development of system concepts represents a first pass at a definition of alternatives for the markets that have been identified and characterized. The work at this point was conducted at a conceptual level, both in terms of definition and evaluation. This is the point at which the planner has the greatest freedom of expression and can consider the broadest variety of modal alternatives (1) and the most unorthodox of ideas. It is necessary, however, to conduct such conceptual work within a structure that encourages efficiency. Guidelines were established with community representatives. A broad-based taxonomy of services was developed. Evaluation of the concepts and the selection of some for further analysis were based on the identified goals and guidelines.

Objectives and Guidelines

The study involved a strong emphasis on community participation in the planning process. An advisory group that consisted of representatives of the community at large, elected officials, professional employees of the village, and regional transportation agency representatives was formed. The initial role of this group was to formulate goals and guidelines for this study.

We devised sets of questions to get the advisory group started in their thinking, comments, and recommendations concerning basic objectives, levels of service, and system characteristics. The group resolved questions and conflicts around the table with these sets of questions as a frame of reference. It was understood that the result would be a tentative finding of the group, subject to change as work proceeded and as issues gained clarity.

It is important to note that the initial meeting at which tentative objectives and guidelines were established was preceded by two sessions at which presentations were made to educate the group about the planning process, the potential range of transit service available, and the variety of markets to be considered.

The elements that were most important to the advisory group are summarized below.

Figure 2. Sample questionnaire distributed to railroad commuters.

1. WHEN DID YOU LEAVE HOME FOR THIS STATION TODAY? . . . . [:] am

2. HOW DID YOU TRAVEL TO THIS STATION TODAY?

[ ] Car & parked at station (how many with you in the car? ___)

If so, was parking . . . [ ] Free [ ] Daily or Metered [ ] Monthly ?

[ ] Car & dropped off [ ] Bus [ ] Walk (all the way) [ ] Bike/Motorcycle [redacted]

[ ] Other ______________ (please specify)

3. WHEN DID YOU ARRIVE AT THIS STATION TODAY? . . [:] am

4. WHAT IS THE SCHEDULED TIME OF YOUR TRAIN TODAY? [:] am

5. WHAT IS THE PURPOSE OF YOU TRIP? [ ] To work or work related [ ] Shopping

[ ] Personal business (visit doctor, bank, lawyer, etc.) [ ] Social/Recreational [redacted]

[ ] Going home [ ] Other ______________ (please specify)

6. HOW MANY TIMES PER WEEK DO YOU MAKE THIS TRIP TO THE STATION? [ ] Less than 1 day a week

[ ] 1 to 4 days a week [ ] 5 days a week [ ] More than 5 days a week

7. HOW MUCH DO YOU ESTIMATE THAT IT COSTS YOU, ON THE AVERAGE, FOR TRANSPORTATION TO THIS STATION? *(DO NOT INCLUDE PARKING COSTS - ONE-WAY ONLY)* ___________

8. WHEN DO YOU EXPECT TO ARRIVE AT THIS STATION ON YOUR RETURN TRIP TODAY? . . . . [:] [ ] am [ ] pm

9. WHERE DID YOUR TRIP TO THIS STATION BEGIN?

a.) Nearest Intersection or address: ______________ (example: Acorn & Beech) [redacted]

b.) Municipality: [ ] Schaumburg [ ] Hoffman Estates [ ] Other ______________ (please specify)

10. a.) DO YOU HAVE A DRIVER'S LICENSE? [ ] Yes [ ] No

	None	One	Two	3 or More
b.) HOW MANY OTHER LICENSED DRIVERS ARE THERE IN YOUR HOUSEHOLD?	[ ]	[ ]	[ ]	[ ]
C.) HOW MANY CARS (TOTAL) ARE AVAILABLE TO YOUR HOUSEHOLD?	[ ]	[ ]	[ ]	[ ]

11. WOULD YOU RIDE A BUS TO AND FROM THE TRAIN STATION IF . . . . *(PLEASE CHECK EACH QUESTION)*

	Yes	No		Yes	No
a.) ...you waited inside your home for front door pick-up?	[ ]	[ ]	d.) ...it took less time than your present trip?	[ ]	[ ]
b.) ...you waited at the nearest intersection?	[ ]	[ ]	e.) ...it took the same time as your present trip?	[ ]	[ ]
c.) ...you walked 4 blocks to the bus stop?	[ ]	[ ]	f.) ...it took longer than your present trip? If yes, how many minutes longer? ___	[ ]	[ ]

12. IF YOU WERE PROVIDED WITH THE TYPE OF SERVICE DESCRIBED IN 11 a) AND e) ABOVE, WHAT MAXIMUM ONE-WAY FARE WOULD YOU BE WILLING TO PAY? . . . . ___________

13. ARE THERE OTHER TRIPS FOR WHICH YOU WOULD USE A BUS SERVICE? [ ] Yes [ ] No

IF YES, PLEASE SPECIFY______________ [redacted]

WE WOULD APPRECIATE YOUR IDEAS ON BUS SERVICE IN THIS AREA: ______________ [redacted]

1. General objectives: service for transit captives and those with high levels of automobile competition in the household, coordination with regional systems, flexibility, strong positive image, reasonable subsidy levels, and ability to attract people away from automobiles.

2. Service objectives: on-time arrival at destination, elimination of need to change vehicles, consistency in travel times, assurance of getting a seat, fare discounts for the elderly, handicapped, and children, credit-card or ticket option for paying fares, use of small vehicles (12 to 25 seats), ability to take a direct route, requirement of exact fare, and availability of telephones in public places to call for service or information.

3. Specific guidelines: maximum walking distance of three to four blocks (less for shoppers and almost none for handicapped), maximum waiting times from 20 min (for rail commuters and shoppers) to less than 10 min (for internal commuters and special groups), maximum riding times of 30 to 45 min for internal commuters and 30 min or less for others, and maximum fares of 50 cents.

As work progressed toward more detailed system selection and design considerations, some minor shifts in emphasis were voiced by the group.

Concepts

A significant amount of time was spent reviewing with the advisory group the variety of conventional and paratransit services that were available to meet the identified needs of each of the market segments. The characteristics and greatest potential for application of each were discussed. Generally, discussions centered on conventional fixed-route service, dial-a-ride (including shared-taxi service), subscription services, pooling programs, and jitney operations. Potential service integration was also emphasized.

The conclusions were tabulated in a format that facilitated development of integrated service concepts. The early project work had identified the interest in providing a system tailored to the community to be competitive with the automobile. This, combined with the relatively low population density and lack of a CBD, was taken to indicate the desirability of a dial-a-ride operation to serve off-peak demands. Fixed-route, subscription, and pooling options were considered worthy of further consideration as peak-period services. Twenty alternative system concepts were listed. For each alternative concept, special tabular summaries were prepared that described the service provided to each market segment with maps, where appropriate, showing routings or service areas. This, combined with a review of the goals and guidelines established, provided a basis for narrowing the selection. Selected concepts were analyzed in further detail through derivation of several operational factors regarding the user and the operator. This provided more quantification with respect to walking, waiting, and travel times; number of vehicles required, by type; and cost considerations. The final set of evaluations was then made.

The advisory group determined that detailed testing should concentrate on defining an off-peak dial-a-ride service and studying as alternative peak-hour services (a) dial-a-ride only, (b) dial-a-ride and subscription service, and (c) fixed-route only.

Comparing Costs of Alternatives

A key element in the evaluation of alternative systems is the comparison of expected costs. Of interest here is the comparison between the more conventional service and demand-activated systems. Although dial-a-ride service is often considered more expensive than a conventional system, some of the more thoughtful studies (1, 2) have shown us that one must be careful to define the conditions of comparison carefully. Further pursuit of that discussion is included here in order to extend the philosophy that has been developed (1) and to place it in the perspective of the process of transit planning and design.

First, one must ask on what basis the systems are being compared. More theoretical analyses (2) have assumed a level of demand, hypothesized a service sufficient to handle the assumed demands, and proceeded to cost and evaluate them. Another approach is to define a level of service (1), hypothesize alternative modal operations that meet that standard, and compare costs at a given level of demand. This is often difficult to do to everyone's satisfaction since it is difficult to arrive at a satisfactory definition of level of service and to agree on the relative weighting of the elements that produce the level of service (e.g., waiting time versus riding time).

In the case of the transit planner, it is not usually possible to compare systems with equal levels of service. Similarly, it is not likely that the alternative systems being evaluated will have equal attractiveness in a given market setting. It is therefore necessary to develop an effective gauge of potential demand that takes into account market dynamics.

Figure 3 presents a simplified picture of the relationship between market diversion and cost per passenger for two alternatives. The curves are schematic representations and would more accurately appear as step functions. It is assumed that diversion is from a total set of markets spread more or less ubiquitously about the area. Assuming that system A is the more attractive service in this market context, there are two potential conditions under which cost per passenger is less for system A than for system B.

The first is the point at which demand density is so low that system B is apparently inefficient, i.e., demand densities lower than P_1. This has been demonstrated (2) to be the case when comparing demand-activated (system A) with fixed-route (system B) services. It is a result of reaching a base operating condition at which buses are running at extremely low load factors. The same level of ridership (or greater, for the more attractive system) can be serviced with flexible routing and scheduling, using fewer vehicles, and at a lower cost.

More to the point, however, is the second condition in which system A might be near, at, or below the cost per passenger of system B. With a demand density of P_2, system B costs C_3 and system A costs C_2; the difference represents the additional fare or subsidy that would be required to supply demand-activated service. But, considering the market dynamics for system A, its share of the market could easily become P_3, at which point its cost per passenger would be C_3, the same as for system B at P_2. Such a condition might occur, for instance, with door-to-door dial-a-ride service in certain market contexts when the unique service attributes of such a system have a major impact on trip-making and mode-choice decisions. Clearly, it is necessary that the dynamic effects of differences in market attractiveness be considered before making snap evaluations.

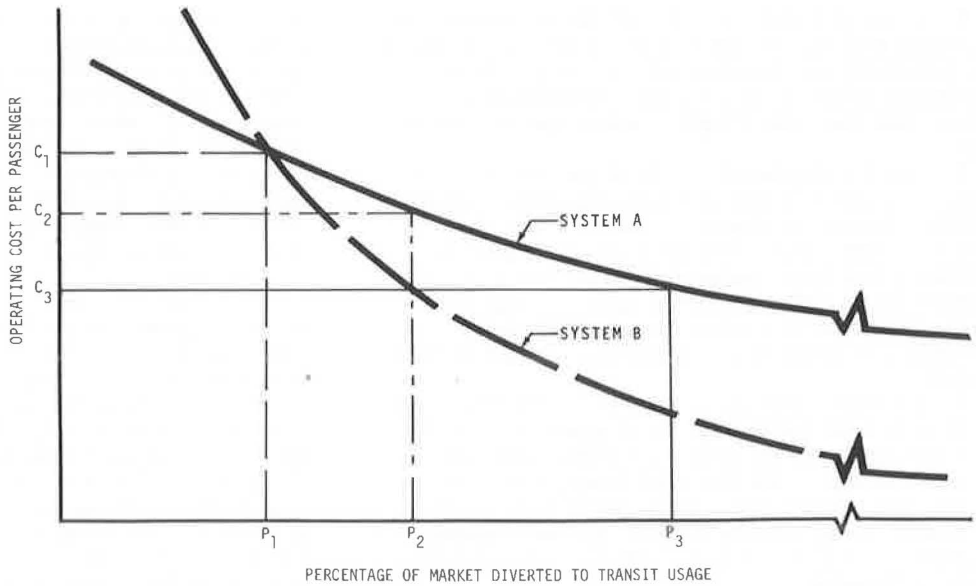


Figure 3. Schematic representation of relationship between market diversion and cost per passenger.

DEMAND ESTIMATION

Model Description

It is necessary to arrive at estimates of ridership for each alternative being considered in order to arrive at estimates of system size and costs that can be used in the overall evaluation process. Many studies on the design of paratransit facilities have used only judgmental estimates of the likely ridership for a proposed system. In contrast, the present study undertook the development of disaggregate behavioral choice-modeling techniques, from which estimates of the potential ridership for a number of alternative systems were generated. The basis of this technique has been described in other documents (3, 4, chap. 16). It offers two important benefits for the type of estimation needed in this study. It can be applied to very small data bases, and the models are simple enough in operation, once calibrated, to handle fairly efficiently a rather large number of alternative systems.

Principally, the technique is structured around a calibration of models to the revealed preferences of individual travelers. The resulting model indicates the probability that an individual will choose a particular course of action, e.g., a specific mode of travel for a specific trip. The probabilities that are produced by most of the models are conditional probabilities, i.e., that a particular mode of travel will be chosen for a particular trip, given the origin, destination, and purpose of the trip and given that a decision has already been made that the trip will be undertaken.

The model was developed to be responsive to a set of attributes that describe the alternatives open to an individual. This is the sense in which the model is termed behavioral. On the basis of both current theory and ease of use, the most common form of model is the multinomial logit model.

$$p_k^i = \exp[G^i(X_k)] \Big/ \sum_M \exp[G^i(X_m)] \qquad (1)$$

where

p_k^i = the probability that individual i chooses alternative k from the set 1, 2, . . . , k, . . . , m, . . . , M;

G^i = an individual-specific (or homogeneous group-specific) function of alternatives of the alternatives; and

X_k = a vector of attributes of alternative k.

In the case under study, the binary logit model was selected since the primary current mode of travel is the automobile and the alternative would be some form of transit or paratransit. While a number of previous research projects have shown that other attributes besides cost and time are important in the decision-making process, the research has also shown that cost and time alone determine a large measure of the choice. We therefore decided to develop a model for the case study in terms of these two parameters alone.

$$p_b^i = \exp[\alpha_0^i + \alpha_1^i(c_a^i - c_b^i) + \alpha_2^i(t_a^i - t_b^i)]/1 + \exp[\alpha_0^i + \alpha_1^i(c_a^i - c_b^i) + \alpha_2^i(t_a^i - t_b^i)] \qquad (2)$$

where

p_b^i = the probability that individual i will choose the bus;

t_a^i, c_a^i = the time and cost, respectively, by automobile for individual i;

t_b^i, c_b^i = the time and cost, respectively, by bus for individual i; and

α_0^i, α_1^i, α_2^i = coefficients to be determined from observed choice behavior.

Calibration of the Model

The calibration of a model in the form of equation 2 required data on the choices made by individuals between at least two alternative modes. Two procedures were possible. First, if transit service existed within the area, the model could be calibrated on data for the choices made in relation to that system. Alternatively, a model could be transferred from some other area that is geographically and socioeconomically similar to the one under study. In this case, it was possible to collect data on present bus use and to develop from this a calibration procedure.

Calibration of the model required a data set that specified the travel times and travel costs for each individual by automobile and by bus. The questionnaire had only ascertained travel times and travel costs for the trip actually undertaken. As a result, it was necessary to construct the data on the alternative mode for each traveler to the station by using bus operation data, simulated vehicle runs, estimates that used routings on maps, and other assumptions based on survey responses. A logit model was then fitted for a choice between bus and automobile.

$$p_b^i = \exp(-1.37 + 0.054\Delta t^i + 0.0021\Delta c^i)/1 + \exp(-1.37 + 0.054\Delta t^i + 0.0021\Delta c^i) \quad (3)$$

where

$$\Delta t^i = t_a^i - t_b^i \text{ and}$$
$$\Delta c^i = c_a^i - c_b^i.$$

This model was found to be statistically significant at better than the 99.9 percent level, and each of the coefficients of travel time and travel cost was significant beyond the 99 percent level and had the right signs. The model also indicated, as would be expected, a bias against bus use, as shown by the minus sign on the constant. The model was therefore accepted as being an appropriate one for estimating ridership for any fixed-route option, which is what the existing bus service provides. It should be noted, however, that the sophistication suggested in equation 2 was not carried through in practice, since a single model was calibrated for the choices of all individuals. The individual-specific element in the model is simply the specific difference in cost and time that each individual experiences.

As noted above, the constant α_0 indicates a bias for or against a mode of travel, based on other characteristics than those specified in the mode, such as the differences between the automobile and bus in comfort and convenience. Since the purpose of the model was to estimate ridership for options other than a conventional bus, it was considered that some adjustment might be needed for the value of the constant term to reflect the differences in other attributes offered by certain paratransit alternatives. After investigating other studies and service implementations, we reduced the constant term by one-quarter of its value for predicting such paratransit options as dial-a-ride or subscription service. The refined model is

$$p_{pt}^i = \exp(-0.913 + 0.054\Delta t^i + 0.0021\Delta c^i)/1 + \exp(-0.913 + 0.054\Delta t^i + 0.0021\Delta c^i) \quad (4)$$

where p_{pt}^i = the probability that individual i will choose a paratransit alternative given a choice between paratransit and automobile. The two models shown in equations 3 and 4 were then applied to current and future peak market segments to provide ridership estimates for the alternative service configurations tested in the study.

Development of Model Predictions

The models developed can be applied only to work trips in the communities. No data existed for calibration of a modal-split model for off-peak trips since no such bus service was offered in the village. We assumed that the relationship between responses to the survey item on the work trips would hold for nonwork trips, thus permitting us to estimate the modal split for nonwork trips on the basis of the responses to those questions.

Ideally, predicting potential ridership would require the estimation of differences in time and cost for each individual who might be traveling to either a railroad station or a workplace within the communities. Since this is clearly not feasible, a procedure is required for estimating the probabilities for some subsample of individuals and aggregating this to represent the total population, a problem typically handled by the use of a disaggregate model (5, 6).

The specific strategy we selected was somewhat different from most of those examined before. The communities were divided into 40 zones established on the basis of census tracts and census block groups. A random sample of 75 for each of the three market segments was then chosen from the completed questionnaires, and the respondents' home addresses and workplaces or rail stations were located on maps of the communities. We recorded the characteristics of the reported trip to the rail station or to work for each of the respondents, computed the service characteristics for each transit service option, and estimated the travel time and travel cost for each system. The models were then applied to produce a set of probabilities for each person in the three random samples. We estimated the number of automobile users and transit users for each zone by summing the probabilities for our respondents within the zone (the number of people in each market segment within each zone had been estimated previously). To obtain the final volumes of travel on each system, the proportion of transit trips estimated from the random sample was multiplied by the total population of the market segment within the appropriate zone. This provided a set of forecast ridership estimates for each of the alternatives considered.

Critique of Process

The procedure was found to be reasonably responsive, but it would have been better to have had a model that was able to separately specify walking and waiting times, particularly since demand-responsive and subscription services are significantly different in these regards from conventional bus systems. Unfortunately, data limitations did not permit a model of this form to be calibrated. It would also have been desirable to include differences in comfort and convenience. Furthermore, analysis is needed on the extent to which the aggregation procedure used introduces error into the estimation process. However, the estimates of ridership obtained appear to be in reasonable conformance with operating experience in the various locations in which demand-responsive or fixed-route, fixed-schedule service has been implemented. There is therefore no reason to reject the results of the application of this model.

In the application of the procedure, estimates were made of the likely growth of patronage, with the assumption that full patronage would only be reached after 3 years. Figure 4 shows the type of growth pattern that was forecast, with high and low estimates for each market segment.

EVALUATION AND REFINEMENT OF THE PLAN

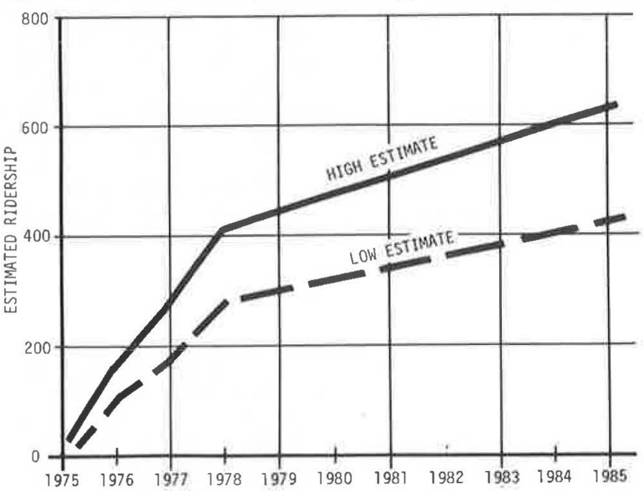
Once estimates of ridership had been derived, it was possible to generate the data required for an adequate evaluation of the alternatives. The evaluation of the detailed plans involved a return to the goals and objectives established early in the planning process. As was expected, new objectives were derived. Two of particular interest were that the system permit a management structure that used local private entrepreneurs to the maximum extent deemed advisable and that compliance with federal and state requirements be ensured to qualify for capital and operating assistance. As a result, the

Table 2. Summary of the analysis of alternatives.

Alternative[a]	Fare ($) Peak	Fare ($) Off-Peak	Fare ($) Both	Annual Ridership	Annual Operating Cost ($)	Annual Revenue ($)	Annual Subsidy ($) Total	Annual Subsidy ($) Per Capita	Ratio of Revenue to Costs	Cost per Ride ($)	Maximum Fleet Size
DAR only	1.00	0.40									
Low estimate				990 000	1 270 000	528 000	742 000	11	0.42	1.28	31
High estimate				1 625 000	1 905 000	846 000	1 059 000	15	0.44	1.17	50
Sub/DAR A	1.00 (DAR)	0.40 (DAR)	0.40 (Sub)								
Low estimate				970 000	1 100 000	385 000	715 000	10	0.35	1.13	24
High estimate				1 595 000	1 610 000	595 000	1 015 000	14	0.37	1.01	36
F-R/DAR	1.00 (DAR)	0.40 (DAR)	0.40 (F-R)								
Low estimate				785 000	1 775 000	275 000	1 500 000	21	0.15	2.26	24
High estimate				1 215 000	2 286 000	475 000	1 811 000	26	0.21	1.88	28
Sub/DAR B			1.00								
Low estimate				585 000	715 000	495 000	220 000	3.40	0.69	1.22	24
High estimate				870 000	955 000	715 000	240 000	3.45	0.75	1.10	36

Note: Total market from which transit trips are diverted = 19 000 000 trips per year.
[a]Abbreviations: DAR = dial-a-ride, Sub = subscription service, F-R = fixed-route buses.

Figure 4. Dial-a-ride ridership estimates for railroad commuters.



final evaluation and selection were based on a synthesis of the quantitative, semiquantitative, and qualitative measures of effectiveness.

Costs and Revenues

In order to arrive at operating costs, an estimate of fleet sizes was necessary. Although simulation programs have been developed for limited sets of transit modes, they do not cover the spectrum. Also, the lack of operating experience with paratransit services in the Chicago area would make it difficult to arrive at accurate inputs for the models that did exist. A manual approach was adopted. The diversion estimates, along with assumed routings, headways, and typical productivity estimates (7, 8, 9, 10), were used to determine the expected loading and number of vehicles required for each period to maintain the service specified in deriving demand estimates. The weekday was divided into four periods for analysis: morning peak, midday, afternoon peak, and evening. The same design volumes were assumed for these periods on Monday through Friday. Saturday was dealt with separately. Analyses for Sunday were not differentiated by period. The number of vehicle-hours by period was estimated. The operating costs for each plan were calculated by using average vehicle-hour costs as derived from local operating experience and supplemented by experience with paratransit services in comparable areas.

Capital costs were determined by using the fleet requirements determined above, including those for stand-by vehicles, and applying up-to-date unit costs quoted by various manufacturers. Related capital equipment (e.g., for communications) and facility costs (e.g., office space) were also estimated. Revenues were estimated, using the assumed fare structure, by applying the established fares to each market segment. The demand estimates previously described were used to determine the number of riders in each market. Revenue estimates were made for each plan or variation being tested. Annual costs and revenues were analyzed, along with the other measures, in selecting a plan for recommendation. An example of the results of this revenue and cost analysis at the point of initiation of service is shown in Table 2.

Selection and Refinement

After considering the detailed analysis of costs, revenues, subsidies, service levels, management alternatives, and so on, the advisory group decided to recommend the implementation of a peak-hour operation consisting of a combination of subscription service for commuters and dial-a-ride for noncommuters, with dial-a-ride service continued for off-peak periods. In addition, recommendations were made for a program to encourage car- and van-pooling plans, primarily through local employers. The subscription service and pooling programs were to be oriented toward two basically different commuter patterns—feeders to regional line-haul systems and service to local employment. Both of these were considered important, and the different characteristics of each had to be recognized in order to provide the proper service.

The plan required refinement in many areas. Ridership estimates were retested and alternative fare levels were considered. System management concepts were made more specific and problems of service coordination were addressed. Projections of system operating levels were made for 5-year and 10-year periods. Staging and implementation programs and concepts were developed, including a step-by-step process toward inauguration of service. Of specific interest here is the analysis of alternative fare levels and system management plans.

For any type of service offered, the fare charged would have an effect on the use of the system and revenues and, thus, an effect on operating costs, as well as profit or subsidy levels. Commuter trips had been found to have little sensitivity to fare levels below 75 cents according to available data in this community. The noncommuter market, however, exhibited greater sensitivity to fare variations. As a result, an analysis of the recommended plan was conducted at four fare levels. An average fare was used to represent a more complex schedule of charges that varied according to the market group. Average fares of 40 cents, 60 cents, 75 cents, and $1 were tested. Estimates of ridership and system size were made by using the analysis procedures described above. A typical mix of vehicles, using 25-passenger buses, 12-passenger vans, and specially equipped passenger automobiles, was derived for each. Costs, fares, and revenues were calculated as described above. The results were tabulated and plotted. Figure 5 presents a typical relationship, showing projected values for the first stage of operation with a mixed fleet ranging from 20 vehicles (at a $1 average fare) to 30 vehicles (at a 40-cent average fare). Resulting costs per ride were about $1.10. The annual subsidies required for each level were:

Average Fare ($)	Annual Subsidy ($)	Subsidy per Capita ($)
0.40	840 000	11.20
0.60	420 000	5.60
0.75	335 000	4.45
1.00	110 000	1.50

The decrease in subsidy levels from the average fare of 40 cents to the average fare of $1 is about $730 000 but there is an associated decrease in ridership of about 485 000 rides per year. The decision on which fare policy to follow clearly involves a trade-off between maximizing attractiveness to the community (and resulting use of the system) and minimizing the amount of public support required to operate the system.

These estimates of revenues are based solely on expected fares. Additional sources of revenue or support may be found to further reduce the operating subsidies required.

Management Concepts

The recommended combination of subscription, pooling, and dial-a-ride service will require a management system that can appropriately coordinate the financial and physical resources to meet transportation needs as they are identified. In addition, if federal funding is to be made available, it requires that existing jobs not be eliminated and operating businesses not be harmed because of this service.

The villages have a range of alternatives available for managing a transit system. At one extreme, all functions can be carried out by a local (village) or regional governmental unit. This would include marketing, dispatching, vehicle maintenance, vehicle operation, and storage, as well as the hiring and managing of all required personnel. At the other extreme, the villages can license a private operator to perform all these functions. A given community has a set of conditions that will allow a tailored system to be developed somewhere within this range of possibilities, at a level that will provide the best overall results for the community.

In considering the various possible arrangements, a management and operation concept has been developed for the Schaumburg/Hoffman Estates transit system, shown diagrammatically in Figure 6. It was proposed that a central public transportation agency be formed to manage and operate the system. This could be the responsibility of the two villages, a regional agency, or Chicago's Regional Transportation Authority. The management functions would include the initial steps of implementing the service as well as the ongoing tasks of marketing and monitoring. A basic feature of the concept proposed here is that the agency does not operate, maintain, or store its vehicles (except, possibly, a limited fleet as explained below) but contracts for these services through local entrepreneurs. The agency's responsibility, therefore, is to establish service standards and contract requirements for bidding and to negotiate the final service agreements.

The agency's operational responsibilities would be primarily those of a broker or coordinator of public transport service. This would include the acquisition of vehicles and related capital equipment (thus allowing for federal and state subsidy support). In order to maintain central control over the vehicles in operation and to assure the proper level of service, the agency would also develop the dispatching system, as well as take in all revenues and pay out on its contracts. Since other local or regional transit systems either border on or pass through the service area, it would be desirable for the agency to coordinate with these other systems to create a unified transit-service area. Finally, it is possible that the agency could operate and maintain its own small fleet of vehicles in order to gain first-hand experience and knowledge that would enable it to better monitor its outside contracts. This would also give the agency flexibility to take a larger share in actively operating the system, should it become necessary or desirable.

Since the transportation agency would act primarily as a broker in the system, the role of the other parties should be explained briefly. It was assumed that a local bus company would be contracted to operate, maintain, and store the required medium-sized and, possibly, small-sized buses. It was also assumed that a local taxi company would be contracted with to operate, maintain, and store the required passenger-car units and, possibly, small-sized buses. The vehicles could be provided through the agency or through the local company. If the latter, the vehicles would have to meet the agency's standards, which would include the use of the agency's vehicle colors and logo. Drivers provided for the vehicle by the local company would have to be tested and certified by the agency. Should the vehicle be owned by the local company and used for its own purposes when not plugged into the system, it would be necessary, to protect the system's image, to require that only drivers certified by the agency be allowed to operate the vehicle.

In addition to working with the local transportation companies, the agency might make direct arrangements with individuals or firms. Thus a pooling arrangement could be made in which one of the commuters also becomes the pool driver, which would significantly lower operating costs. The person selected to drive might be given free fare as well as other incentives. If a van-pool vehicle is needed for off-peak service, arrangements could be made for a professional driver to pick up the vehicle at the van-pool driver's place of employment and return it before his or her scheduled departure at the end of the day. The agency could work through an employer, who might also be willing to subsidize the program. In addition, car-pool matching services could be provided.

In summary, the proposed concept has the advantages of minimum capital investment in facilities, minimum agency personnel requirements, maximum use of local entrepreneurs, and flexibility to meet varying needs.

CONCLUSIONS

It has become clear that there are a number of sensitive issues in providing plans for transit and paratransit in any community, particularly small communities. In particular, it is very important to be able to produce accurate but inexpensive demand estimates for low-cost,

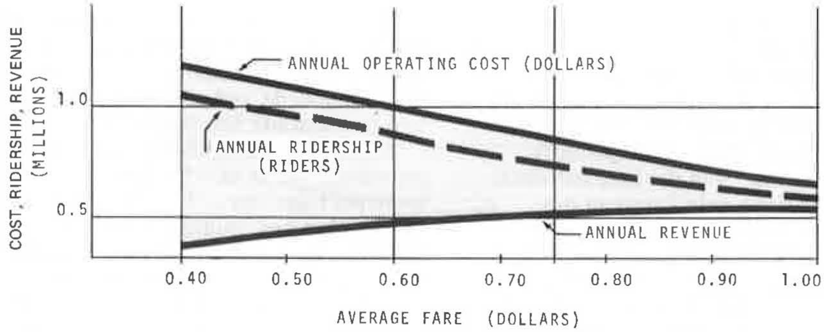


Figure 5. Results of feasibility analysis for the first stage of operation.

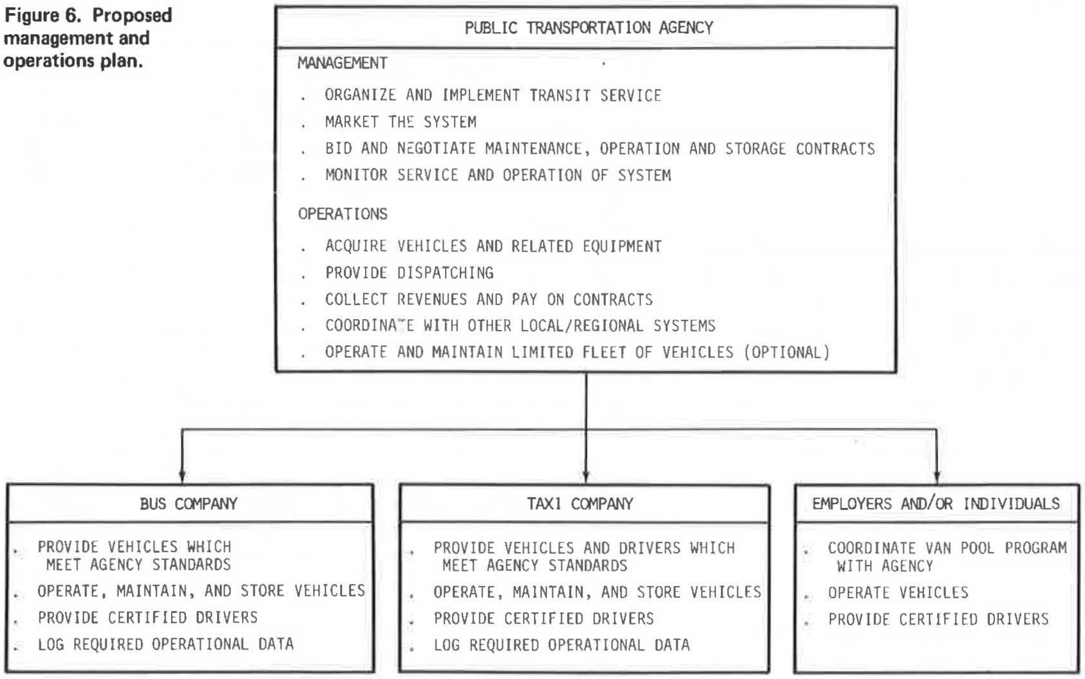


Figure 6. Proposed management and operations plan.

highly flexible systems. It is also of considerable importance to develop an operating strategy that will not alienate existing transportation firms (e.g., taxi companies) but that retains sufficient control of any system in the hands of the community.

In this paper, strategies have been described for estimating potential markets for transit or paratransit service, developing a potential set of transit system concepts, estimating demand for each of a selected subset of concepts, developing an evaluation process, and selecting an implementation strategy. In all cases, these strategies represent an initial trial of a particular method, from which a number of lessons can be drawn. The case study has shown that there is considerable value in conducting limited small-scale surveys of specific market segments. While our self-administered questionnaire lacks controlled response and may produce biased results, it can be checked against census data and its biases may be small. In developing estimates of the size of various markets, research is needed into the trip-making rates of a number of segments of the population, particularly those that are not subjected to surveys.

The development of a wide variety of system concepts that facilitate the generation of an optimal system or systems was also important. A qualitative analysis was found to be appropriate and sufficient to lead to an effective choice among candidate systems. Two inputs that should be provided at the system-concept stage are the various system costs and some reporting of operational experience with new transit concepts in other communities. The latter should include demonstrations of various types of vehicles and field visits to operating systems.

The demand-estimating process used a low-cost policy-sensitive method that was capable of responding to most of the needs of this study. Further use of the technique, with better data and before-and-after testing, will provide many of the improvements deemed desirable for greater responsiveness to new system concepts. Specifically, data are needed on the access and egress travel times and on the factors relating to comfort, waiting time, and waiting location that may distinguish levels of patronage among new transit-system concepts. Research is needed to determine the accuracy of the aggregation procedure as a function of sample size.

The emphasis in this study was on deriving a plan for immediate and near-future service. The high degree of flexibility within the systems being proposed and the dynamic development potential in the community make long-range transit planning an unnecessary academic exercise at any but a conceptual level. This approach can be taken with a high level of confidence and least likelihood of service retraction, assuming that the indicated level of service and an effective marketing procedure can be maintained.

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REFERENCES

1. J. D. Ward. Evaluating Demand-Responsive Transportation Systems. TRB, Special Rept. 154, 1974, pp. 146-153.
2. D. E. Ward. Theoretical Comparison of Fixed-Route Bus and Flexible-Route Subscription Bus Feeder Service in Low-Density Areas. Transportation Systems Center, U.S. Department of Transportation, Cambridge, Mass., 1976.
3. W. C. Taylor and T. K. Datta. Technique for Selecting Operating Characteristics of Demand-Actuated Bus Systems. TRB, Special Rept. 147, 1974, pp. 54-69.
4. P. R. Stopher and A. H. Meyburg. Urban Transportation Modeling and Planning. D.C. Heath and Co., Lexington, Mass., 1975.
5. D. McFadden. Conditional Logit Analysis of Qualitative Choice Behavior. In Frontiers in Econometrics (P. Zarembka, ed.), Academic Press, New York, 1973.
6. F. S. Koppelman. Travel Prediction With Models of Individual Choice Behavior. Center for Transportation Studies, MIT, Cambridge, CTS Rept. 75-7, June 1975.
7. S. Lerman and N. H. M. Wilson. Analytic Model for Predicting Dial-a-Ride System Performance. TRB, Special Rept. 147, 1974, pp. 48-53.
8. A. Saltzman. Para-Transit: Taking the Mass out of Mass-Transit. Technology Review, July-Aug. 1973.
9. R. F. Kirby and others. Para-Transit: Neglected Options for Urban Mobility. The Urban Institute, Rept. UI-4800-8-2, June 1974.
10. Demand-Responsive Transportation: State-of-the-Art Overview. U.S. Department of Transportation, Aug. 1974.
11. F. S. Koppelman. Guidelines for Aggregate Travel Prediction Using Disaggregate Choice Models. TRB, Transportation Research Record 610, in preparation.