Minor transit stations typically include signed bus stop zones, passenger waiting shelters, route and schedule information signing, lighting, bicycle parking and locking facilities, and accessibility for the physically limited.

Major transit stations typically include all of the facilities of a minor station, plus restrooms and pay phones. Other improvements vary by site, but many include park and ride lots and bus turnarounds to accommodate converging routes.

Three of the major stations will include park-and-ride lots. All of the stations will increase the options available for routing and scheduling by providing layover points and passenger amenities. The stations will constitute nodes in a node-link network, serving as points of interconnection among local, express, and crosstown routes.

Initial discussion of Rynerson's paper centered on the soon-to-be-adopted standard of covering 25 percent of the operating cost from the fare-box. The question was raised whether this standard is too low. Currently, Lane Transit is covering slightly less than 20 percent of operating cost from the fare-box. It was, however, pointed out that, for systems up to this size in the Pacific Northwest, coverage is generally about 20 percent. There was also concern expressed that this objective of cost coverage from the fare-box is biased in that a system that carries a large number of discount passengers (such as elderly and handicapped persons) would be unduly penalized. A better objective measure of efficiency versus productivity might be cost per passenger trip.

The discussion then moved to the topic of how to use the scheduling-run-cutting process to save operating cost. A common problem in smaller transit systems is that the policy-making board typically does not realize the interrelationships between scheduling and the budget process. There is a need to inform these boards that scheduling can be used as an analytical tool that evaluates various service options and associated costs. A question was raised as to whether there is a rule-of-thumb on the relationship between reducing vehicle hours of operation and attendant operating-cost savings. The consensus was that, rather than rules of thumb, what is required are guidelines on the process of scheduling and run-cutting for small to medium-sized transit systems. Transit boards should also understand that schedule cutting is not a quick process and should understand what is and what is not possible in making service changes or cutting new schedules.

The discussion next addressed the problem of providing service to new developments. It is the responsibility of the transit service planner to communicate with local land-use planners and general-purpose governments and to sensitize them as to how new housing developments may be planned so as to be served by transit. Many new subdivisions are purposely designed to limit through traffic but, in turn, this limits transit vehicle accessibility. Therefore, it is incumbent on transit planners to insert themselves into the development planning process.

Forecasting Transit Ridership in Smaller Communities

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As the attention being given to transit planning for smaller communities increases, more accurate ridership forecasts are being required. In smaller areas, basic data for these forecasts remain scarce, but a number of successful techniques have been designed to overcome this lack of original data. Among the techniques developed for use by small cities and rural areas in Florida is a first-cut, sketch-planning estimate that roughly forecasts the annual numbers of riders, vehicles, and equipment kilometers. This technique can also be used to estimate capital costs and yearly operating costs. If, on the basis of the initial forecasts, a community decides to pursue a transit plan, additional ridership forecasts will be necessary. Particularly for fixed-route systems, the latent-demand and direct-demand forecasting techniques can be very useful. These two techniques and the results of the initial survey can provide a cost-effective basis that local officials can use in deciding on the most appropriate transit plan for their area.

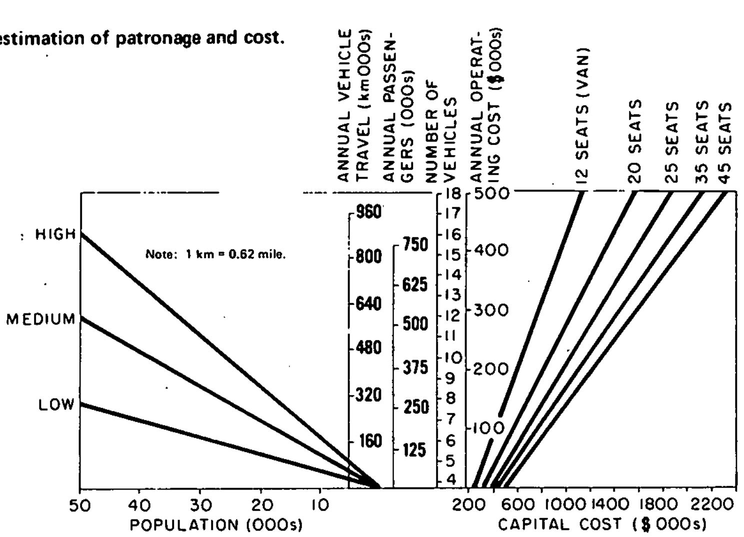
Forecasting transit ridership in smaller urban areas and rural communities has become more analytical in recent years because of the increased attention (social, political, and financial) being placed on the need to provide transit services to the people in these areas. As recently as five years ago, a systemwide forecast was the most to be expected of a transit planning effort for a smaller community. Now, more fine-grained projections are being required; however, the basic data with which to forecast remain as scarce as the financial resources available for the development of small-area transit plans. This situation has fostered the development and use of ridership forecasting tools based on little original data, yet still capable of providing satisfactory results and some reliability.

Experience with these forecasting techniques has led to the recognition that there is more than one level of patronage forecasting for smaller areas. Therefore, in a recent effort to assist the Florida Department of Transportation, a two-step process for ridership forecasting for small urban and rural communities was developed. This process can be used for four types of transit systems—demand-responsive, planned-demand, point-deviation, and fixed-route, fixed-schedule options; however, this discussion will center on the techniques applicable to the latter two, which are more commonly deployed in smaller communities. The entire analytical process for all four types of systems is described in the Florida Transit Planning Manual (1).

FIRST-CUT ESTIMATES OF SYSTEMWIDE RIDERSHIP AND COSTS

Many smaller communities, particularly rural ones and those having fewer than 50 000 people, do not have the capability to develop or operate a transit system. Often, they have neither the demand, the community backing, nor the financial resources to support transit. Therefore, it is unwise to authorize a transit planning effort to proceed to a relatively detailed level of forecasting of either transit ridership or cost if a first-cut, sketch-planning estimate can produce enough reliable information so that an early decision can be made as to whether to pursue transit seriously. To provide data at this early phase, the Florida Transit Planning Manual offers a first-cut analysis tool to forecast approximately, but realistically, the annual number of riders, the number of vehicles that will be needed, and the number of kilometers that will be traveled by the equipment annually. It also provides estimates of capital costs to launch a program over a five-year implementation period and

Figure 1. Nomograph for estimation of patronage and cost.



yearly operating costs. The input to the sketch-planning technique is limited to

1. The population of the study area,
2. The desired level of service (high, medium, or low), and
3. The type of vehicle (such as van, 20-seat, or 45-seat).

The population of the study area should be available from census data, a housing study, or other reputable, easily accessible source.

The level of service provided will determine what facilities a transit system requires and its associated ridership. For this first-cut estimate, high, average, and low levels of service can be estimated as shown below.

Service	Level of Service: High	Average	Low
Weekday			
Headways (min)			
Peak	20	30	<60
Off peak	30	<45	>60
Duration (h)	<16	<12	<8
Saturday			
Headways (min)	30	-	-
Duration (h)	<8	<6	<6
Sun			
Headways (min)	30	-	-
Duration (h)	<8	Little or none	None

The proper selection of the size and type of transit vehicles needed for a system is a function of several factors, but especially of the maximum number of passengers expected to be aboard a vehicle at any one time. Another major factor is the type of transit service desired. Demand-responsive, planned-demand, or other systems serving rural or low-density areas require vehicles on the low end of the size scale (e.g., 12- or 14-passenger vans). Systems that have fixed routes or dense demand might use medium-sized vehicles having up to 25 seats. Larger vehicles would likely be used only in areas having special generators or especially heavy trip interchanges.

Generally speaking, small communities have dispersed demand and use small vehicles. In the absence of clear guidelines, it is reasonable to assume that medium-sized (20-seat) vehicles would be used.

These data and Figure 1 are then used to determine the patronage and cost estimates:

1. From the population of the study area on the nomograph (Figure 1), draw a vertical line to its intersection with the chosen level of service. Through this point, draw a horizontal line that extends to the intersection of the appropriate vehicle-size line. From this intersection, draw a vertical line until it intersects with the capital-cost scale.
2. From the intersections of the horizontal line, read the following: (a) the annual vehicle travel at system maturity, (b) the annual number of passengers at system maturity, (c) the number of transit vehicles required to operate the system at maturity (rounded to the nearest whole number), (d) the normal operating cost of the system at maturity, and (e) the capital costs to launch the five-year transit development effort (on the right-most portion of the x-axis).

Use of this technique gives a general assessment of the systemwide demand for transit and estimates of systemwide transit costs. These data can help local decision makers assess whether transit could satisfy a portion of the transportation needs of the community and whether the costs to provide service would be manageable. If the results are encouraging, the transit planning effort can then continue so that transit service, ridership, personnel, equipment, and associated costs can be estimated in more detail. If the results lessen the enthusiasm for transit and local decision makers decide to terminate the study, the continued expenditure of effort and funds to pursue a fruitless conclusion will be avoided.

ALTERNATIVE TECHNIQUES FOR FORECASTING RIDERSHIP FOR FIXED-ROUTE, FIXED-SCHEDULE SYSTEMS

If the preliminary data indicate a reasonable level of transit ridership and costs and the community decides to pursue the planning process further, more detailed ridership forecasts become essential. There are numerous techniques for this, particularly for fixed-route systems. Two meritorious techniques are the latent-demand and the direct-demand approaches.

Latent-Demand

The important input to the latent-demand method for forecasting ridership is a survey that defines the propensity to use transit of a community. To minimize the cost of this undertaking, only the area that has the greatest propensity should be canvassed. The technique of successive overlays is effective for identifying a market area within a study area. Experience in other studies has given ranges of values of zonal data that indicate the propensity to use transit of a population (see below; 1 km^2 = 247 acres).

Item	Propensity to Use Transit: Low	Medium	High
No. of dwelling units per square kilometer	0-246	247-740	>741
No. of females aged 45-61 per square kilometer	0-73	74-123	>124
No. of persons more than 62 years old per square kilometer	0-246	247-493	>494
No. of blacks per square kilometer	0-73	74-246	>247
No. of persons per square kilometer	0-987	988-2716	>2717
No. of available automobiles per dwelling unit	>1.50	1.00-1.49	0-0.99
Median family income ($)	>9000	6000-8999	0-5999

To apply the technique, these data should be determined on the basis of (at least) enumeration districts, and the propensity to use transit of each analysis unit (or zone) is then classified by each of the seven indicators. Next, the zonal system is drawn on transparent sheets, and each sheet is labeled with one of the indicators of transit use. The zones should be shaded on each transparency as follows: low propensity—no shading; medium propensity—light gray shading; high propensity—dark gray shading. Each overlay can then be placed over the working map; the darker areas of the composite overlay will define the areas that have the highest propensity to use transit. Judgment should then be used in examining the overlays so that the survey area can be defined from within the study area. Typically, the survey area will be a continuous amoeba-shaped figure. Exceptions might be two highly developed areas separated by a physical barrier, such as a river or a bay, or an area containing more than one urban center. Islands of low propensity within a high-propensity area should be included in the survey area.

Although there are many techniques available for conducting surveys (e.g., home and telephone interviews), the mail-back method is reasonably successful and involves relatively little expense. Numerous questions can be asked on a card and space limitations are not often an issue. The questions should obtain information on several issues, including the level of support for transit in the community and attitudes toward subsidization of transit by using public funds. The head of the household should be requested to complete the postage-free mail-back form. Manipulation and analysis of the data conclude the process. The measure of the attitude of the community toward transit is only one of the results obtained; others include information on potential patronage and socioeconomic data. The results can then be coded on an analysis zone basis and input to the latent-demand forecasting approach.

From the latent-demand survey, a total trip market can be defined. This is the optimum forecast of ridership, that which might occur if transit were available at all times and under all conditions and with the greatest possible convenience. This total must be reduced to reflect the characteristics of the proposed transit system. The following steps can be used to develop a realistic definition of the ridership for each alternative fixed-route system being examined; see Table 1 for examples of four alternatives based on a latent-demand ridership of 28 942.

1. Remove from the expanded survey all trips that have one end outside the survey area and could not be made by transit and all those so short they could be made by walking.
2. Determine the coverage offered by each alternative by using the following procedures:
   a. On the base map showing each route and analysis zone, draw a 0.4-km (0.25-mile) band on each side of each route to represent the availability of service as defined by the accepted standard of walking distance.
   b. Reexamine the trip table and eliminate trips that would not be served by transit.
   c. Estimate the percentage of each analysis zone that is covered by this band by an eyeball technique (for example, see below):

Item	Analysis Zone: 40	41
Coverage (%)	100	40
Coverage by route (%)		
10	0	0
11	75	0
12	25	100
13	0	0
14	0	0

   d. Calculate the number of potential zonal trips covered by multiplying the number of potential trips determined by the survey by the percentage of coverage (for example, see below):

Item	Analysis Zone: 40	41
No. of potential trips	140	217
Coverage (%)	100	40
No. of trips covered	140	87
No. of trips covered by route		
10	0	0
11	105	0
12	35	87

Table 1. Trip reduction process for four alternative services.

Step	Ridership for Alternative: 1	2	3	4
1: Reduction due to trips having one end outside survey area and those short enough to be made by walking	26 877	26 877	26 877	26 877
2: Reduction due to walking-distance coverage	10 860	13 790	16 070	6 000
3: Reduction due to tolerance of walking distance (16%)	9 110	11 570	13 480	5 030
4: Reduction due physical impediments, inclement weather, and service characteristics of alternative	6 850	8 700	10 140	3 770

Item	Analysis Zone	
	40	41
13	0	0
14	0	0

e. Add these data to define ridership by zone and by route.

3. Correct the total number of trips to reflect more accurately the tolerance of local residents for walking to the bus. The results of on-board transit surveys for two Florida systems (Clearwater and Lee County) indicate that the 0.4-km walking distance is too long for some potential riders; a further reduction of about 16 percent of the trips from the latent-demand survey is necessary to account for this constraint.
4. Finally, reduce the number of potential trips to account for the service characteristics (such as days and hours of service and headways) and idiosyncracies of the potential systems. For example, weather (particularly rainy days) often affects transit ridership. Physical impediments such as canals, railroads, expressways, and major arterials also affect transit ridership. Obviously, the number of days and the hours of service affect ridership. Past experience indicates that, for a service operating in a typical small community in Florida, the following reduction factors are appropriate.

Days of Service	Duration of Service (h/day)	Reduction Factor
Weekdays only	12-14	33
Weekdays	12-14	25
Plus Saturdays	8-10	
Weekdays	12-14	
Plus Saturdays	8-10	
Plus Sundays (exclusive of holidays)	4-6	21
Weekdays	12-14	
Plus Saturdays	8-10	
Plus Sundays and holidays	4-6	19

5. Sum the ridership for all routes to determine the systemwide totals.

Direct-Demand

When the direct-demand method for forecasting ridership is used, information is required on the number of persons in each analysis zone, the number of those who are more than 65 years old, and the expected characteristics of daily and weekend transit service. From these data and a base map showing each route and analysis zone, the following steps can be used to estimate potential ridership.

1. Draw a 0.4-km band on each side of each route to represent the availability of service as defined by the accepted standard of walking distance.
2. Estimate the percentage of each analysis zone that is covered by this band by an eyeball technique as described above.
3. By assuming that the population of the analysis zone is distributed homogeneously, calculate the population served for each zone, each route, and the entire system (see below).

Item	Analysis Zone	
	40	41
Total population	1256	723
Coverage (%)	100	40
Service population	1256	289
Service population by route		
10	0	0
11	942	0
12	314	289
13	0	0
14	0	0

4. Repeat step 3 for persons more than 65 years old (if this information is not available by analysis zone, estimate it for each route by using the best available data and judgment).
5. From the total population to be served (step 3) and the population of persons more than 65 years old to be served (step 4), use Figure 2 (adapted from the original; 2, p. V.36) to determine the base annual ridership (again, estimate the number of persons more than 65 years old if data are not available).
6. Estimate the one-way loop (i.e., any portion of a route where service in one direction is not on the same streets as service in the opposite direction) factor for each route. Empirical evidence has shown that one-way loops on bus routes are deterrents to transit ridership. Persons who reside on the portion of a route from which access to transit is more circuitous in one direction than in the other have a lower propensity to use transit. These factors can be calculated in the following manner.
   a. Record the total population of the service area by analysis zone (these data should be available from step 3).
   b. For each route, estimate the total number of persons to be served who live on a one-way loop. For portions of the route where service in one direction is two blocks or less from service in the opposite direction, count only the portion of the population on the outside of the loop and within 0.4 km of it.
   c. Compute the number of persons served by a one-way loop as a percentage of the total service population (do this only for the entire route, not for each zone).
   d. Use the percentage calculated above and Figure 3 (2, p. V.39) to determine the one-way loop factor.
7. Use the peak and base (off-peak) headways and Figure 4 (2, p. V.40) to determine the headway factors for both periods.
8. Estimate the transfer-coordination factor for each route:
   a. If the schedule for each route permits easy transfer to all other routes at a central transfer point (e.g., pulse scheduling in which all buses meet at the central point at the same time), the transfer-coordination factor is 1.0.
   b. If the central area is the dominant trip generator in the community and a very low number of transfers might be expected even if the routes were completely coordinated, the transfer-coordination factor is 1.0.
   c. If no coordination of routes is proposed, the transfer-coordination factor is 0.85.
   d. For any other case, use a transfer-coordination factor of 0.80-1.0 (0.90) if transfer conditions are good, but not coordinated between all lines.
9. Estimate a service factor for each route.

Figure 2. Direct-demand estimation: base annual ridership for fixed-route, fixed-schedule transit service.

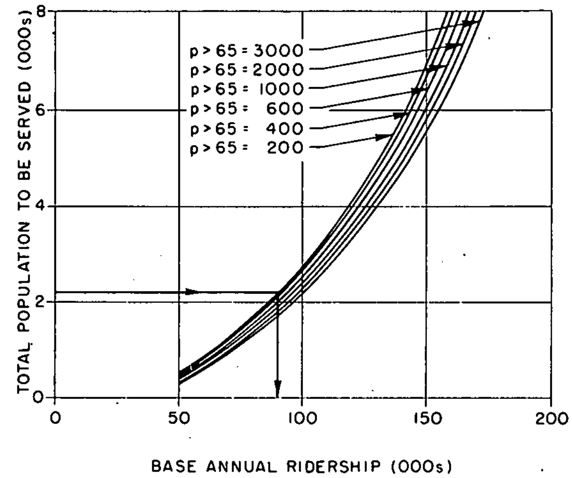


Figure 3. One-way loop factor: fixed-route, fixed-schedule transit service.

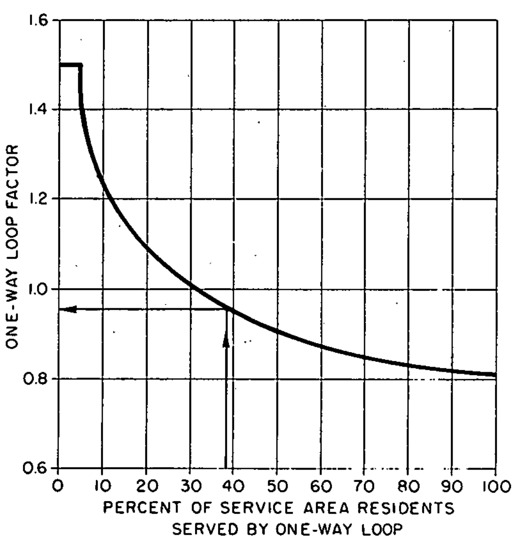
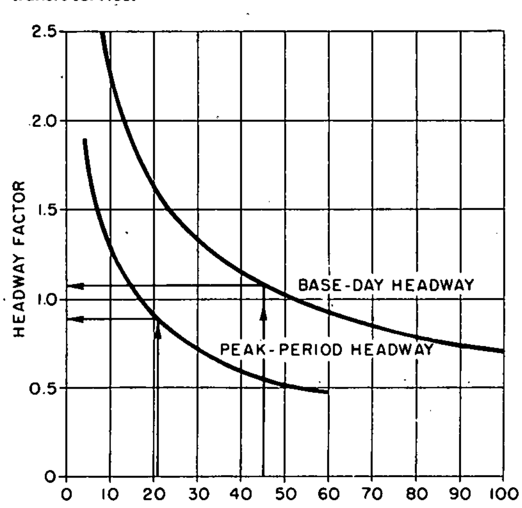


Figure 4. Headway factor: fixed-route, fixed-schedule transit service.



a. For service on Mondays through Fridays (no holidays), use a factor service of 0.67.
b. For service on Mondays through Saturdays (no holidays), use a service factor of 0.75.
c. For service on Mondays through Sundays (no holidays), use a service factor of 0.79.
d. For year-round service, use a factor of 0.81.

10. As described above, correct the number of trips by 16 percent to reflect the fact that many persons cannot (or will not) walk 0.4 km to the bus route.
11. Estimate the number of annual revenue passengers (excluding transfer passengers) for each route by multiplying the base ridership by the product of all factors; an example is shown in Table 2 for route no. 1, which has a trip distance of 6.4 km (4 miles).
12. Sum the ridership for all routes to determine the systemwide total.

SUMMARY

The two forecasting techniques described in this paper and the accompanying latent-demand survey process have been used successfully in a number of communities and are calibrated for ready use throughout the small urban areas and rural communities in Florida. Obviously, they could be extended to areas outside of Florida, although a recalibration would be necessary to tailor them to other conditions. However, they provide a cost-effective basis for assisting local decision makers in determining the practicality and feasibility of transit in their area.

REFERENCES

1. Schimpeler-Corradino Associates. Florida Transit Planning Manual. Florida Department of Transportation, Tallahassee, 1978.
2. D. H. James; Peat, Marwick, Mitchell, and Company. Analyzing Transit Options for Small Urban Communities: Volume 2—Analysis Methods. Urban Mass Transportation Administration, Rept. UTP-PMM-76.1.1, Jan. 1978. NTIS: PB 291 451/3SL.

Table 2. Direct-demand forecast of ridership.

Item	Value
Operating time (h)	
Morning peak (7-9 a.m.)	2
Afternoon peak (4-6 p.m.)	2
Off peak (9 a.m.-4 p.m. and 6-8 p.m.)	9
Saturday (10 a.m.-4 p.m.)	6
Sunday	0
Headway (min)	
Morning peak	15
Afternoon peak	15
Off peak	30
Saturday	60
Service-area population	10 000
Population of service area more than 65 years old	2 000
Population of service area on one-way loop	650
Base annual ridership[a]	180 000
Adjustment factor	
One-way loop[b]	1.35
Base-day headway[c]	1.30
Peak-period headway[d]	1.00
Transfer coordination	0.90
Service	0.75
Walk reduction	0.84
Total adjustment[e]	0.995 1
Adjusted annual ridership	179 100

[a]From Figure 2: X = 10 000 and p >65 = 2000.
[b]From Figure 3: X = 6.5 percent.
[c]From Figure 4: X = 30.
[d]From Figure 4: X = 15.
[e]Product of adjustment factors.

There are three steps to the planning process described in the Florida Transit Planning Manual. The first step consists of an exchange of information on transit between the state department of transportation and the local community. After this exchange, the local officials—now informed as to the planning programs and projects that are available—can make a request to the department of transportation for a transit study.

The second step consists of the establishment of a study staff and a survey of the available information. Staff, person hours, and cost in time are presented in chart form so that the level of detail desired in the study can be correlated with the requirements for these various commodities. The data needs and results are given to the local community, who are also informed as to the requirements for staff person hours involved, the cost of them, and the amount of time required to pursue such a program. There is usually some discussion of alternatives. Local decision makers are advised as to the different types of transit (including paratransit), the various types of equipment, and the kinds of services provided by each.

If the local officials decide to proceed further, the third step is taken. In this step, system needs are defined, patronage forecasts are made, attitudes are surveyed, and benefits and costs are determined. These are presented to local elected officials and again a decision point is reached.

It is important to note that, after each of these steps, the local elected officials are required to make a decision based on the knowledge that has been presented to them. At each decision point, good two-way communications must exist between the local elected officials and the planners doing the work. After the third step, should the local officials elect to proceed, an actual system analysis that has alternatives must be completed and this information be presented to the local officials for decision. Again, after the presentation of the detailed analysis of the best alternatives, a decision must be made by the local elected officials as to whether to proceed with the program by applying for a federal grant or to terminate the program.

It must always be remembered that information exchange is a problem at the local level. Planners must constantly do all they can to keep smaller communities from making costly and time-consuming mistakes.

Estimating Transit Demand, Fleet Size, and Costs for Small Communities

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Forecasting transit demand and estimating costs for transit systems in smaller communities is very difficult. The Ready Reckoner approach developed in 1974 has been used successfully in smaller urban and suburban areas throughout Canada. This approach can be used to estimate potential demand, system size, and cost parameters. It is a shortcut estimating tool intended primarily as assistance to policymakers in deciding whether or not more detailed analyses and feasibility studies are warranted rather than as a substitute for those necessary calculations.

There are approximately 60 Canadian cities that have populations of 50 000 persons or fewer that have operating transit systems, and some 100 or more are reaching the threshold for service at populations ranging from 10 000 to 25 000 persons. However, policymakers in such cities generally have difficulty in estimating the amount of transit service likely to be required and the costs involved, unless they commission a formal transit study.

This problem was addressed in 1974 by the development of a Ready-Reckoner type of approach for Alberta Transportation that can be used to quickly estimate the potential demand, system size, and cost parameters for transit service in small communities. This Ready-Reckoner approach has already been revised several times as a result of about a dozen studies in a variety of small communities throughout Canada.

The Ready Reckoner approach is intended for use in estimating the potential demand for and the cost of providing typical local bus transportation systems in cities or suburban communities having 5000 to 50 000 persons. It is not intended to be a substitute for a careful analysis and feasibility study for a particular city but rather to be a guide to policymakers in determining whether or not such studies should be undertaken at all.

This paper discusses the Ready-Reckoner procedure and explains its application in other North American cities. The methods used to accommodate variations in city size, shape, and population density and for selection of vehicle sizes, operating policies, fares and climatic conditions are described.

The necessary calculations are presented in a step-by-step sequence that includes tables and charts to assist in the analysis. Provision is made for future cost escalation and service variations.

BASIC DATA REQUIRED FOR INTERNAL TRANSIT-DEMAND CALCULATIONS

The basic data required for the calculation of the potential transit ridership, costs, and revenues include the following:

1. The population of the urban area, community, or city;
2. The size of the populated area [in square kilometers (or square miles)]—including neighborhood parks, playgrounds, schoolyards, and cemeteries, but not including undeveloped residential areas or large industrial parks outside the residential areas;
3. The net population density [in persons per square kilometer (or square mile)], which can be calculated from the data determined in steps 1 and 2;
4. The duration of the average work trip by automobile (in minutes) based on the geography of the area and any travel barriers encountered; and
5. The duration of the average trip by bus, which can be calculated by increasing the duration of the average trip by automobile by one-third.

INTERNAL TRANSIT-DEMAND POTENTIAL

The calculation of the internal transit demand is based on Figure 1, which shows a series of curves that represent historic transit-ridership data for approximately 25 small cities (mainly located in western Canada) at varying populations.

The selection of population density as the prime variable was made to encompass the factors of income level, automobile ownership, and city characteristics. For