Hillegass

analyzing transit options for small urban communities

VOL II

analysis methods

Technical Report Documentation Page

1. Report No. UMTA IT-06-9020-78-2	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Analyzing Transit Options for Small Urban Communities Volume Two: Analysis Methods		5. Report Date January, 1978 6. Performing Organization Code
7. Author(s)		8. Performing Organization Report No. UTP.PMM.76.1.1
9. Performing Organization Name and Address Peat, Marwick, Mitchell & Co. 1025 Connecticut Avenue, N.W. Washington, D.C. 20036		10. Work Unit No. (TRAIS) IT-06-9020 11. Contract or Grant No. DOT-UT-50021 13. Type of Report and Period Covered
12. Sponsoring Agency Name and Address U.S. Department of Transportation Urban Mass Transportation Administration 400 Seventh Street, S.W. Washington, D. C. 20590		14. Sponsoring Agency Code

15. Supplementary Notes

Written in association with:
D.H. James, Transportation Consultant

16. Abstract

This manual provides an analytical framework and supporting analytical techniques to assist in the analysis of transit options for small urban communities. It is intended for use principally by planners and decision-makers in communities with less than 200,000 residents, but many portions would be useful in larger urban areas as well. Sufficient information is provided in the manual to permit the small urban community to conduct its own analysis without resorting to outside assistance.

The information and analytical techniques contained in this manual are presented in three volumes. This volume, Volume Two, Analysis Methods, contains the fifth chapter of the manual. In this chapter, an evaluation approach is described and detailed techniques are presented with which one can estimate the patronage, cost, and revenue implications of a transit service operation; these are three key elements in the evaluation of transit service alternatives.

17. Key Words Bus Paratransit Small cities Transit planning tools Travel demand	18. Distribution Statement Available to the Public through the National Technical Information Service, Springfield, Virginia 22161.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	129	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

Report UTP. PMM. 76.1.1

Contract No. DOT-UT-50021

ANALYZING TRANSIT OPTIONS FOR SMALL URBAN COMMUNITIES

Volume Two: Analysis Methods

Prepared by

Peat, Marwick, Mitchell & Co.

1025 Conn. Ave., N.W.
Washington, D.C. 20036

In Association with

D. H. James

Transportation Consultant

January 1978

Prepared for

U. S. Department of Transportation
Urban Mass Transportation Administration
Office of Planning Methods and Support

FORWARD

Today's transportation planner must confront ever-changing issues within a variety of working environments. To assist him, UMTA's Planning Methods and Support program researches, develops, and distributes planning tools, including the documentation of novel planning studies, new design and forecasting techniques, and germane research results. This report is one example. Prepared by recognized experts, its content clearly presents usable planning concepts, and thus constitutes a valuable addition to the growing set of computerized and manual techniques comprising the UMTA/FHWA Urban Transportation Planning System (UTPS).

More important than the production and dissemination of a new tool is the experience and opinion of its user. Local issues change. Better methods evolve. Or, realistically, errors may appear in the final product. We depend on you, the transportation planner, to alert us to any of the above. We need your comments and your ideas. Please let us hear them, so we can continually improve our products.

You may obtain additional copies of this report from the National Technical Information Service (NTIS), Springfield, VA, 22101. On your request, please reference IT-06-9020-78-2.

Robert B. Dial, Director
Office of Planning Methods
and Support (UPM-20)
Department of Transportation
Washington, D. C. 20590

ABSTRACT

This manual provides an analytical framework and supporting analytical techniques to assist in the analysis of transit options for small urban communities. It is intended for use principally by planners and decisionmakers in communities with less than 200,000 residents, but many portions would be useful in larger urban areas as well.

The procedures and techniques presented in the manual are oriented to state and local planners and decisionmakers who are called upon to analyze transit options but who have limited data and time to perform these analyses. Sufficient information is provided in the manual to permit the small urban community to conduct its own analysis without resorting to outside assistance. At the same time, modifications, embellishments, and improvements to the procedures and techniques set forth in this manual are encouraged should local data or past analyses suggest more appropriate methods.

The information and analytical techniques contained in this manual are presented in three volumes. Volume One, Transit Service Objectives and Options, contains the first four chapters:

- Chapter I - Introduction
- Chapter II - A Procedure for Planning Conventional Transit and Paratransit Service in Small Urban Communities
- Chapter III - Identifying Objectives for Local Transit Services
- Chapter IV - Formulating Transit Service Opportunities

In these four chapters the structure, content, and applicability of the manual is set forth, a general approach to analyzing transit options in small urban communities is described, the specification of local transit service objectives is discussed, and information to assist in the formulation of transit service opportunities is presented.

Volume Two, Analysis Methods, contains the fifth chapter of the manual:

- Chapter V - Evaluating Transit Service Alternatives

In this chapter, an evaluation approach is described and detailed techniques are presented with which one can estimate the patronage, cost, and revenue

implications of a transit service operation; these are three key elements in the evaluation of transit service alternatives.

Volume Three, Summary of Management and Operations Experience, contains the last two chapters of the manual:

- Chapter VI - Planning for Transit Management and Operation

- Chapter VII - Transit Experience in Other Urban Communities

These two chapters describe the activities of a transit operation, explore the relations between these activities, identify arguments for and against local control of transit organizations, and provide numerous data and statistics that characterize the financial and operating performance of existing conventional transit and paratransit services in small urban communities.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES (CONT.)

LIST OF TABLES (CONT.)

LIST OF TABLES (CONT.)

LIST OF FIGURES

LIST OF FIGURES (CONT.)

LIST OF FIGURES (CONT.)

LIST OF FIGURES (CONT.)

LIST OF FIGURES (CONT.)

LIST OF FIGURES (CONT.)

Chapter V

EVALUATING TRANSIT SERVICE ALTERNATIVES

A. Introduction

Evaluation is an activity that continues throughout the planning process. It is conducted formally, however, at the end of the feasibility analysis and detailed evaluation phases and periodically during the implementation phase. The structure of the evaluation activity does not change with each phase, but the character of the transit service alternatives to be evaluated does. A large number of less well defined alternatives are evaluated in the feasibility analysis phase; fewer but more detailed alternatives are evaluated in the detailed evaluation phase. Evaluation in the implementation phase consists of analyzing the results of initiating new or different transit services and should be the first step in a regular and periodic monitoring activity.

The evaluation of individual transit service alternatives is based on:

- the degree to which each alternative achieves transit service objectives or standards set by the community (and by the transit manager if an existing system is in operation); and

- the financial implications of each alternative in relation to transit service cost limits or budgets set by the community.

At the conclusion of the feasibility analysis phase, the above information is obtained for a wide range of transit alternatives in sufficient detail: (1) to provide guidance for identifying promising alternatives that merit further development and analysis and (2) to improve local understanding regarding the financial implications of achieving community objectives for transit service. Thus, the feasibility analysis phase is characterized by an evaluation that produces aggregate cost data, aggregate demand or ridership data, and overall estimates of the degree to which each alternative achieves community objectives for transit service.

The detailed evaluation phase of the planning process is characterized by increased detail in cost, demand, and objective attainment analyses. Typically, each alternative is analyzed at the route or area level of detail with respect to costs and patronage. This geographical detail is useful in identifying variations in objective attainment by user groups or market segments and thus enables more detailed assessment of the relative merits of various transit alternatives.

Evaluation during the implementation phase is tailored not only to more detailed cost and patronage analyses but also to the detail associated with the management and organization for achieving objectives. Adjustments to the delivery of service generally require analyses of actual experience, since estimation techniques for more detailed evaluation are beyond the resources of small or medium-sized urban areas and require efforts that are often too elaborate, costly, and time consuming for the benefits obtained.

Among the many evaluation techniques that exist, cost-effectiveness analysis is generally considered the most suitable for a small urban community. Its principal advantage over other techniques[1] is that it depends on a definition of benefit or value explicitly stated by the community and opens the analysis to introspective judgment by policymakers.

In determining whether one alternative is cost effective in relation to other alternatives, both effectiveness and cost must be defined. Effectiveness is defined in terms of the level of objective attainment. Costs typically include net costs for a complete service and, therefore, total operating expense in addition to capital costs less revenues received from fares.

There are several keys to the successful completion of a cost-effectiveness evaluation. The first is a basic understanding of how a cost-effectiveness evaluation is performed. (A brief description of cost-effectiveness analysis techniques is presented below in Section V.B.) The second key is the measurement of the costs and benefits of transit investment and operation. Estimation of transit service ridership is central to the measurement of effectiveness and cost.

As cited in Section III.B, standards of transit system performance are often established as the means to broader community ends or objectives. Transit service objectives may be set in order to achieve such ends as congestion relief or mobility for disadvantaged members of the community. Achievement of transit service objectives, however, is directly related to the success of the transit service in attracting

---

[1] These include benefit cost ratio, rate of return, return on investment, net present value, annual cost method, and variations of these.

riders. Patronage targets are therefore implicit, if not explicit, in a transit system's set of objectives or standards. Patronage estimation is also a major consideration in net cost analysis. For this reason, demand estimation techniques appropriate for small urban communities in a variety of contexts are described in Section V. C.

Finally, a major concern both of the cost-effectiveness evaluation and of a separate financial analysis is the estimation of the costs and financial impacts of the initiation of new transit services or the modification of existing ones. Section V.D provides information and techniques useful in the financial evaluation of transit service alternatives.

B. Cost-Effectiveness Analysis

The concept of cost-effectiveness analysis has been described extensively in the literature[1] and is only summarized briefly in this section.

1. The Cost-Effectiveness Graph

The results of a cost-effectiveness analysis can be displayed on a cost-effectiveness graph (see Figure V-1). When alternatives are displayed on such a graph, some fundamental relations may be observed. In general, certain projects (represented by points C, D, G in Figure V-1) are "dominated" by other projects in the sense that they are either more costly than other alternatives that provide the same level of effectiveness (e.g., alternative C compared to alternative B) or less effective than other alternatives that require the same amount of expenditure (or less) (e.g., alternative C compared to alternative E). By

---

[1] A more extensive discussion of cost-effective analysis can be found in the following:

Edwin N. Thomas and Joseph L. Schofer, Strategies for the Evaluation of Alternative Transportation Plans, National Cooperative Highway Research Program Report #96 (Highway Research Board: 1970).

Morris Hill, Planning for Multiple Objectives: An Approach to the Evaluation of Transportation Plans, Regional Science Research Institute Monograph Series #5 (Philadelphia: 1973).

John Bennett and Arthur Hyder, "A Cost-Effectiveness Approach to Policy Decision-Making," unpublished paper presented at the meeting of the Operations Research Society of America (April 1975).

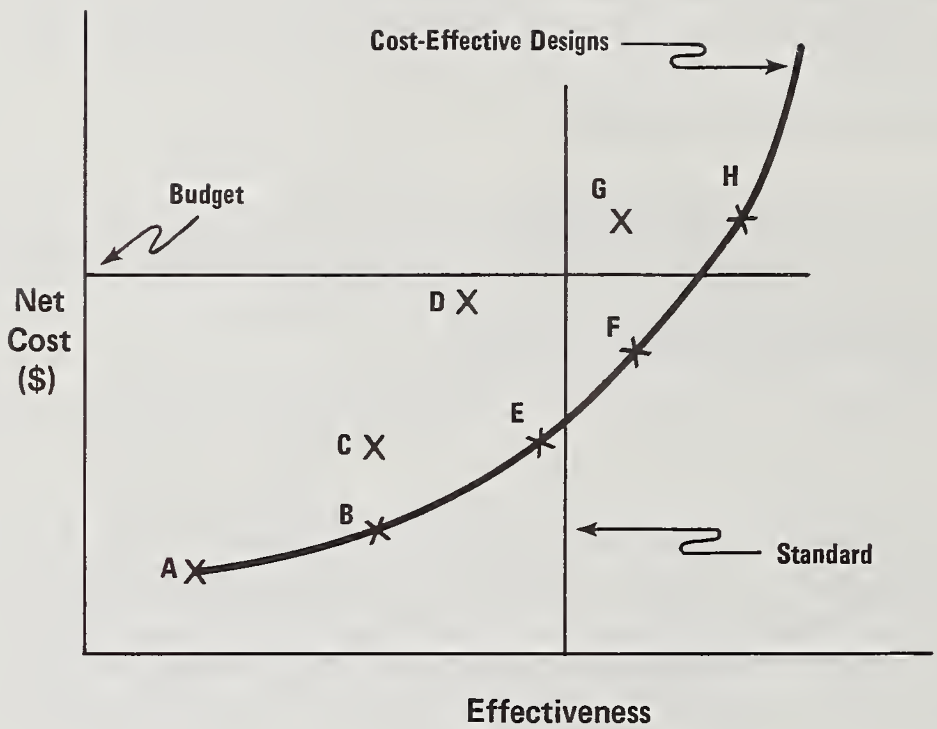


FIGURE V-1: COST EFFECTIVENESS GRAPH

removing the dominated alternatives, a set of cost-effective projects or alternatives (represented by Alternatives A, B, E, F, and H in Figure V-1) can be identified. The best alternative in this group is the one that has the highest level of effectiveness but does not exceed the cost limit or established budget set by the small urban community. In Figure V-1, alternative F would be selected because it achieves the highest level of effectiveness within the community's budget for transit service. When a standard of service has been established by the community, that alternative which meets or just exceeds the standard while not exceeding budget limits is selected.

This simplified example illustrates the need to set standards that are reasonably aligned with budget levels. A standard set too high with respect to a budget commitment results in unachievable expectations. If the community's objectives are not met by any of the alternatives analyzed or if the objectives are met at too high a cost to the community, a reassessment of these objectives should be made, or the community should reconsider its financial commitment to transit. On the other hand, if a number of alternatives satisfy community objectives at a reasonable cost, they should be evaluated further.

Effectiveness is graphed in Figure V-1 as a single-dimension variable when in fact it typically has many dimensions (each dimension is related to one of the transit service objectives). The small community planner or decisionmaker may choose to (1) analyze the transit service alternatives based on each of the effectiveness dimensions individually or (2) determine the relative value of achieving each transit service objective and use these relative values to derive a weighted measure of effectiveness for individual alternatives. In either case, a trade-off between the importance of attaining different objectives is ultimately required in reaching a decision among the various alternatives.

Typically, most alternatives will satisfy some objectives well and other objectives poorly or not at all. The small community planner and decisionmaker must therefore weigh the value of alternative transit objectives to determine the desirability of considering various alternatives further. When weights are assigned to different transit objectives, each alternative can be ranked according to how well it achieves the community's overall objectives for transit service. The following example illustrates one technique for ranking transit service alternatives.

A community has set two objectives for transit service:

1. to provide handicapped residents with transportation to health and medical services in the community; and

2. to provide employed residents with transportation to the Central Business District.

Of these two objectives, the first is considered twice as important as the second.

Three transit service alternatives have been evaluated. The first alternative satisfies the first objective well (90 percent of the handicapped residents are served) and the second objective not at all. The second alternative partially satisfies the second objective (50 percent of the employed residents are served) and the first objective not at all. The third alternative satisfies each objective partially (50 percent of the handicapped residents are served, and 10 percent of the employed residents are served). The financial implications of each alternative are considered reasonable. However, the cost to the community varies as follows:

- Alternative 1 costs $500,000.
- Alternative 2 costs $1,000,000
- Alternative 3 costs $400,000.

Using this information, the small community planner and decision-maker can evaluate these alternatives in the following manner:

	(Objective 1 Achievement (% of Market Served))	X	(Objective 1 Weight)	+	(Objective 2 Achievement (% of Market Served))	X	(Objective 2 Weight)	=	OVERALL OBJECTIVE ACHIEVEMENT
Alternative 1:	(90)	X	(2)	+	(0)	X	(1)	=	180
Alternative 2:	(0)	X	(2)	+	(50)	X	(1)	=	50
Alternative 3:	(50)	X	(2)	+	(10)	X	(1)	=	110

Figure V-2, a graph of these three alternatives, shows that Alternative 2 is dominated by both Alternative 1 and Alternative 3 because it is both more costly and less effective. The selection of Alternative 1 or 3 depends both on budget level and on minimum expectations or standards for each objective. Assuming that a budget level of $500,000 is not unreasonable, Alternative 1 would be selected on the basis of overall effectiveness. However, if standards of 40 and 10 were required for each objective, respectively, only Alternative 3 would be acceptable. If an aggregate standard of 100 were required, Alternative 3 would be acceptable, and Alternative 1 would be selected only if sufficient budget (an additional $100,000) were available and the incremental increase in effectiveness were considered worthwhile for the incremental cost.

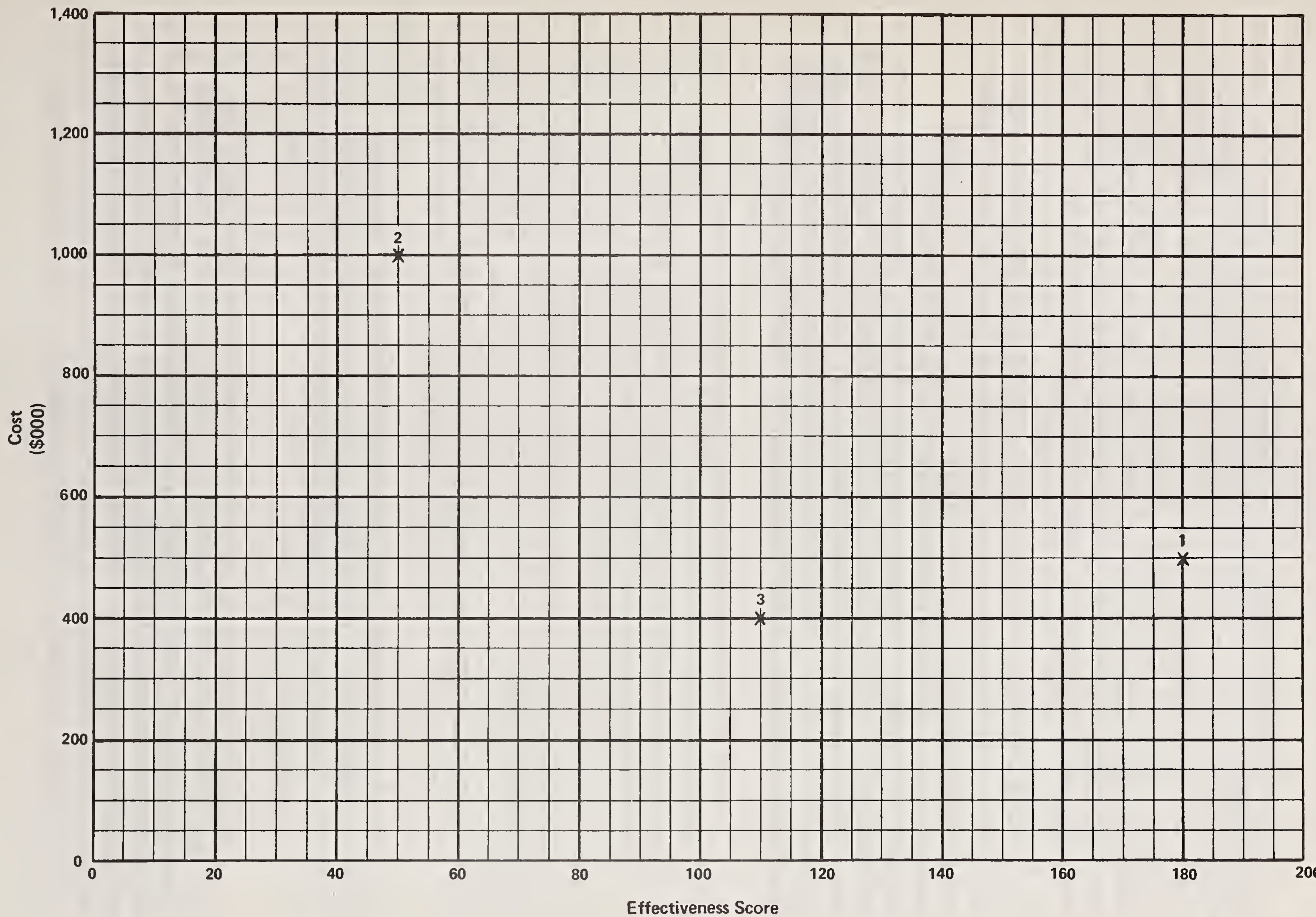


FIGURE V-2: COST EFFECTIVENESS EXAMPLE

2. Measurement of Effectiveness and Cost

As discussed in Chapter III, effectiveness measurement is linked directly to the formulation of objectives, criteria, and standards. The effectiveness of transit service alternatives can only be determined by evaluating one or more criteria for measuring their degree of objective attainment. Standards are typically set as minimum allowable values on the criteria scale and enter the cost-effectiveness analysis to the extent that performance below one or more standards will disqualify an alternative from consideration.

The development of evaluation procedures that use the cost-effectiveness techniques can and should be tailored to the decision-making organization in the community. The cost-effectiveness concept is sufficiently straightforward that it should serve to improve the dialogue between transit service management and the community. Through dialogue and understanding, standards that are consistent with budget levels can be set, and unfulfilled expectations can be avoided. In addition, the cost-effectiveness approach should encourage a dialogue focusing on the following major issues:

- What should the objectives of transit service be?
- What is the appropriate trade-off between different transit service objectives, i.e., the relative value of achieving one objective rather than another?
- What are the cost implications of achieving alternative objectives?
- What are appropriate performance metrics for transit service, i.e., what criteria measure success?
- What is the distribution of benefits derived from the provision of transit services, i.e., who benefits how much and what are the differential benefits by group or geographical area?

An approximation of the relative weights for objectives has been described as one mechanism for determining the trade-offs between objectives. These weights can be determined by various ranking and rating techniques. A range of weights, however, is recommended for use in the analysis so that the evaluation can be used to determine not only which alternative is best for a given set of weights (trade-offs) but also which alternative is best for a range of reasonable weights that can be attributed to the range of divergent opinions in the community. Effectiveness is measured in relation to community objectives established for transit service, and costs should include only the net costs to the community.

The costs included in the cost-effectiveness analysis should include net costs defined as the total operating and capital costs less revenue derived from the fare box. If subsidies from either state or federal sources are to be used in financing the transit service alternatives, their entry in net cost determination will depend on the perspective that is being taken in the evaluation.

When the analysis is performed from a strictly local perspective, only effectiveness measures derived from local community objectives and costs borne directly by the local community should be included. A purely local perspective would therefore deduct federal and state subsidies, and net costs would therefore include only the local community subsidy (i.e., total costs minus both fare box revenues and state and/or federal subsidies).

Realistically, state and federal subsidies were available only under strict regulations that both incur local costs for compliance and, depending on the funding source, require minimum performance standards. These performance standards are, in effect, measures of effectiveness with minimum levels of achievement. Thus, a local community may perform a cost-effectiveness analysis based on the state and federal perspectives by (1) including the (often inferred) measures of effectiveness (planning regulations and reporting requirements) of both the state government and the federal government and (2) calculating net costs as the net of operating revenues only.

Assuming that (1) all federal and state requirements (standards) are met and (2) all projects eligible for state and federal funding are funded, the analyses performed from each viewpoint should result in the same cost-effectiveness graph.

C. Demand Analysis Methods

1. Role of Demand Analysis Methods in the Planning Process.

The techniques described in this section are oriented to the practical planner who requires reasonable estimates of transit ridership as part of an overall evaluation of transit system alternatives.[1] Such estimates are necessary for performing cost-effectiveness analysis and evaluation in each phase of the planning process. In the feasibility analysis phase, patronage forecasts help answer the question of what type of service, if any, should be implemented by the small urban community. Because ridership governs user revenue estimates and the degree to which overall objectives are achieved, it becomes a basic input of the preliminary cost-effectiveness analysis. More detailed estimates of demand are required in the evaluation phase of the planning process; in this phase, the basic need is to determine ridership estimates for alternative system designs. Route or area level patronage estimates are typically required to provide guidance to assist in the design and evaluation of different system alternatives.

The techniques reported here are oriented to the practical planner who requires procedures to estimate transit ridership but has limited data and time to perform a ridership estimation analysis. Figure V-3 presents a list of demand analysis methods designed to meet these requirements. These methods are based on current information describing the transit ridership tendencies of residents of small urban communities who have various types of transit service available to them. Modifications, embellishments, and improvements to these techniques are encouraged should local data or past analyses suggest more appropriate procedures for estimating transit ridership.

2. Characteristics of Demand Analysis Methods

Each demand estimation procedure described in this manual is summarized in Table V-1, which presents a brief description of each demand estimating relation along with the input requirements and output characteristics of each analysis technique.

Direct transit ridership estimation techniques are provided for both conventional fixed-route, fixed-schedule bus transit service and demand responsive transportation service. For fixed-route, fixed-schedule service, systemwide and route level ridership analysis methods are presented. For DRT service, techniques for preparing estimates

---

[1] The literature on theoretical hypotheses, procedures, models, and methods for demand estimation is quite extensive and will not be reviewed here. Although many references are available, the following provides a basic development of travel forecasting suitable for the planner who desires a more complete foundation in this subject matter:
John W. Dickey (senior author), Metropolitan Transportation Planning (Washington, D. C.: Scripta Book Company, 1975).

DIRECT TRANSIT RIDERSHIP ESTIMATION

1. Systemwide ridership — fixed-route, fixed-schedule transit service
2. Route ridership — fixed-route, fixed-schedule transit service
3. Systemwide ridership — demand responsive transportation (DRT) service
    a. DRT and shared-ride taxi service, no competing local transit service
    b. DRT and shared-ride taxi service, competing local public transit service
    c. DRT service exclusively for the elderly and handicapped
    d. DRT service coordinated with local and regional public transit
4. Systemwide ridership by tripmaker stratification — DRT service

MARKET RESEARCH PROCEDURES

5. Basic market research procedure
6. Aggregate work trip modal split curves
    a. Auto ownership work trip modal split model
    b. Family income work trip modal split model

COMPUTERIZED UTPS PROCEDURES

7. Survey Data Processing
8. Transit Network Analysis
9. Demand Estimation
10. Interactive Transit Assignment Model (ITAM)
11. Interactive Graphic Transit Design System (IGTDS)

FIGURE V-3: DEMAND ANALYSIS METHODS

TABLE V-1

ANALYTICAL CHARACTERISTICS OF DEMAND ESTIMATION METHODS

Name of Method	Brief Description	Input	Output
DIRECT TRANSIT RIDERSHIP ESTIMATION			
1. Systemwide ridership — fixed-route, fixed-schedule transit service	Estimates annual systemwide transit ridership for a fixed route and schedule transit system	Annual revenue miles of transit service, population in the service area	Annual ridership per capita
2. Route ridership — fixed-route, fixed-schedule transit service	Estimates annual ridership by route for fixed route and schedule transit system	National average annual ridership per household, empirical adjustment relations for one-way loop service, frequency in peak and base periods, transfer coordination, and weekend service factor	Annual ridership on a route per household in the service area
3. Systemwide ridership — demand responsive transportation (DRT) service	Estimates average daily ridership for a demand responsive transit service in the four situations described. Two sets of estimating relations are provided for each situation.		
a. DRT and shared-ride taxi service — no competing local transit service		1. Population in service area 2. Population in service area, size of area, vehicle hours of service per day, fleet size per service area	1. Average weekday or hourly ridership in the service area 2. Average weekday ridership in the service area
b. DRT and shared-ride taxi service — competing local public transit service		1. Population in service area 2. Population in service area	1. Average weekday or hourly ridership in the service area 2. Average weekday ridership in the service area
c. DRT service exclusively for the elderly and handicapped		1. Fleet size per thousand elderly and handicapped persons served 2. Population density in the service area, service area size and fleet size per sq. mile of service area	1. Average daily ridership per thousand elderly and handicapped persons served 2. Average daily ridership per sq. mile of service area
d. DRT service coordinated with local and regional public transit		1. Population in service area 2. Population in service area, area of service, and total fleet size	1. Average daily ridership 2. Average daily ridership

TABLE V-1 (Continued)

Name of Method	Brief Description	Input	Output
4. Systemwide ridership by trip-maker stratification – DRT service	Estimates trips per week per person for different traveler groups Estimates average daily ridership for a demand responsive transit service in the four situations described. Two sets of estimating relations are provided for each situation.	Average fare level for age group Census data – population by age, percent handicapped, median income, auto ownership; regression method; on-board transit survey captive ridership	Trips per week per person in groups defined by sex, trip purpose (work, shop) and age group (16-24, 25-54, 55 +) Estimated daily captive transit ridership
MARKET RESEARCH PROCEDURES			
5. Basic market research orocedure	Estimates transit trips for different traveler groups	Various data	Transit trips by market classification and origin-destination characteristic
6. Aggregate work trip modal split curves	Estimates transit proportion or market share for work trips using two different relations		
a. Auto ownership work trip modal split model	Modal split for travelers with transit available within six blocks as a function of zonal average automobiles per household	Work trip origin-destination matrix, zonal average value for automobiles per household, and percent of households in zone within 6 blocks of transit service	Work trips stratified by transit and auto plus other modes or stratified by transit, auto driver, and auto passenger plus other modes
b. Family income work trip modal split model	Modal split for travelers with transit available within six blocks as a function of zonal average family income	Work trip origin-destination matrix, zonal values for median family income and percent of households within 6 blocks of transit service, and regional (e.g., SMSA) median family income	Work trips stratified by transit and auto plus other modes or stratified by transit, auto driver, and auto passenger plus other modes
COMPUTERIZED UTPS PROCEDURES			
7. Survey data processing	Assembles, reduces, manipulates, and organizes transit planning data from surveys and previous studies	Survey data (coded on cards or tape) Transportation planning study data Existing computer coded matrices (trip tables or other data)	Printed matrices (trip tables or other data) New or modified matrices
8. Transit network analysis	Edits and builds transit networks, produces network data for analysis, assigns passengers to networks	Transit network description Transit trip table	Computer coded transit Transit network summary reports

TABLE V-1 (Continued)

Name of Method	Brief Description	Input	Output
8. Transit network analysis (Continued)			Transit assignment Transit assignment summary reports
9. Demand estimation	Self-contained default model for trip generation, distribution, and modal split, or Framework for user-specified trip generation, distribution, and modal split	Socio-economic data Transit and highway network data	Daily trip ends generated by purpose Distribution of trips (zone-to-zone trip matrix) Modal split (transit and highway trip tables by purpose)
10. Interactive Transit Assignment Model (ITAM)	Estimates performance of a large number of alternative fixed-route, fixed-schedule transit systems. Given routes and frequencies, ITAM computes travel times, wait times, user and operator costs. User interactively attempts to improve system, provide better system for user, reduce operator cost.	Transit/transit access network Interzonal transit demand trip table Transit vehicle characteristics Series of alternative transit systems (routes, frequencies, vehicle types)	Estimated transit ridership, systemwide and by route Estimated travel times, wait times Transit service costs systemwide and by route Transfers
11. Interactive Graphic Transit Design System (IGTDS)	Estimates modal splits and performance for alternative many-to-one fixed route, fixed schedule transit systems interactively using a PDP-10 or IBM 1130 computer and a cathode ray tube. Predicts ridership and costs by route. User attempts to improve system, provide better service at less cost, with each successive system.	Zonal origin demands to single destination, series of alternative transit systems, parking costs and transit fares, and highway network	Estimated transit ridership, required vehicles, headways costs

of systemwide ridership are presented for four different operating environments. Techniques are also provided to determine the probable response of different types of potential user groups (market segments) to the initiation of DRT services.

Next, the specification of a market-oriented procedure which focuses more on understanding the potential user of the transit service is presented. Because it provides design insight for the appropriate geographical distribution of different types and levels of transit service, this procedure is most useful to the planner and decisionmaker in the detailed evaluation phase of the planning process. Market research demand estimation procedures are described, and a set of relations is presented for use in determining the aggregate modal split or transit market share for the work-trip market.

Finally, the Urban Transportation Planning System (UTPS) and Urban Transportation Planning Programs (PLANPAC) contain computer software that can be suitable for transit planning in small urban areas, even when the basic process is manual. UTPS is a battery of computer programs developed and distributed jointly by FHWA and UMTA. PLANPAC is FHWA's older battery of transportation planning programs.

Both software packages are typically used in medium-sized and large urban areas, but elements of their modular structures can be appropriately applied in small urban areas to perform:

- processing of on-board transit surveys;
- development and analysis of transit networks;
- short-range transit demand estimation;
- transit network assignment; and
- evaluation of transit alternatives.

A small urban area planner may find individual UTPS or PLANPAC programs useful for one or more components in the planning process for which the use of a computerized method could be expedient. This manual provides guidance for selecting appropriate elements of the UTPS or PLANPAC batteries. It does not, however, describe how to use these individual elements. Complete information regarding the application and use of the UTPS model system and the battery itself are available from UMTA or FHWA; PLANPAC is available from FHWA.

Table V-2 summarizes the characteristics of each of the demand estimation methods described above to allow the planner to select one or more appropriate methods. The table summarizes resource requirements and characteristics of application and gives a brief assessment of each method.

TABLE V-2

IMPLEMENTATION CHARACTERISTICS OF DEMAND ESTIMATION METHODS

Category, Name of Method, and Description	RESOURCE REQUIREMENTS				
	Time	Cost	Staff	Computer	Input Data
DIRECT TRANSIT RIDERSHIP ESTIMATION					
1. Systemwide ridership – fixed-route, fixed-schedule transit service Estimates systemwide transit demand (annual transit passengers per capita) on fixed-route fixed-schedule system as a function of transit supply	Immediate – 1-2 hours	Negligible	1 technician	None	Total revenue bus miles for transit system
2. Route ridership – fixed-route, fixed-schedule transit service Estimates annual ridership by route on fixed-route, fixed-schedule system based on established transit tripmaking rates and very general transit system characteristics	Rapid – ½-2 days	Minimal	1 planner	None	Dwelling units by subarea proposed transit system routes, schedules
3. Systemwide ridership – demand responsive transportation (DRT) service Estimates daily DRT ridership as a function of current transit tripmaking rates plus latent demand rates from other cities	Rapid – ½-2 days	Minimal	1 planner	None	Current transit ridership data, if any, latent demand conditions

TABLE V-2 (Continued)

Category, Name of Method, and Description	RESOURCE REQUIREMENTS (Continued)				
	Time	Cost	Staff	Computer	Input Data
DIRECT TRANSIT RIDERSHIP ESTIMATION (Continued)					
4. Systemwide ridership by tripmaker stratification – demand responsive transportation service Estimates daily DRT ridership by tripmaker age, sex, trip purpose (work, shop) based on DRT results in other cities	Rapid – ½-2 days	Minimal	1 planner	None	Total population stratified by 3 age groups and sex
MARKET RESEARCH PROCEDURES					
5. Basic market research procedure Individual subsets of the population which constitute potential transit markets identified. Total market is estimated and transit's potential share is identified by means of logical assumptions and simple calculations. Transit demand is estimated for each market. Stratification approach estimates demand by location and time.	Moderate to long – ½-4 weeks for an analysis of one or two alternatives simultaneously depending on member of markets analyzed or time spent in developing estimates	Low-moderate depending on data collection effort	1 planner with excellent city knowledge 1 technician possibly small survey crew	None	Determined by user – generally requires CBD and large office/factory/commercial center employment, population by subarea, by age, school enrollments

TABLE V-2 (Continued)

Category, Name of Method, and Description	RESOURCE REQUIREMENTS (Continued)				
	Time	Cost	Staff	Computer	Input Data
6. Aggregate work trip modal split curves Estimate percent of work person-trips made by transit as a function of auto ownership (models a, c, d), median zonal income (b), distance to available public transportation (a, b, c, d), and work trip distance (d). All models also estimate auto driver percentage.	Rapid ½-2 days	Minimal	1 technician	None	CBD (or major generator) total work trips by subarea (can be estimated from employment data) Proposed transit service alternatives Subarea population, median income or auto ownership, distance to CBO.
COMPUTERIZED PROCEOURES					
7. Survey data processing Assembles, reduces, manipulates and organizes transit planning data from surveys and previous studies	Varies with application and UTPS/PLANPAC knowledge	Varies with application and UTPS/PLANPAC knowledge	1 transportation planner, 1 programmer/analyst	IBM S/360 or S/370 OS (package available from vendors or UMTA/FHWA; contact UMTA/FHWA)	Raw survey data or existing transportation planning study data
8. Transit network analysis Edits and builds transit networks, produces network data for analysis, assigns passengers to networks	Varies with application and UTPS knowledge; minimum of 1 week for coding and building a network	Varies with application and UTPS knowledge	1 transportation planner, 1 programmer/analyst	IBM S/360 or S/370 OS (package available from vendors or UMTA; contact UMTA	Transit network description Transit trip table
9. Demand estimation Self-contained default model for trip generation, distribution, and modal split; or framework for user-specified trip generation, distribution, or modal split.	Varies with application and UTPS knowledge; minimum of 2 weeks for coding and running default model.	Varies with application and UTPS knowledge	1 transportation planner, 1 programmer/analyst	IBM S/360 or S/370 OS (package available from vendors or UMTA/FHWA; contact UMTA/FHWA)	Zonal socioeconomic data Transit and highway network descriptions

TABLE V-2 (Continued)

Category, Name of Method, and Description	RESOURCE REQUIREMENTS (Continued)				
	Time	Cost	Staff	Computer	Input Data
10. Interactive transit assignment Model (ITAM) Estimates performance of many alternative fixed-route, fixed-schedule transit systems (routes, frequencies) interactively using a mini-computer and a Tektronix cathode ray tube terminal. User attempts to improve system, provide better service at less cost, with each successive system.	Initial installation and learning experience 1-2 weeks; coding network and trip tables 1-2 weeks depending on complexity of area and ease of generating transit trip table. Runs – immediate results	Low to moderate depending on availability and cost of computer	1 planner 1 technician (1 programmer to install program)	Mini-computer, minimum of 32K 16 bit words, Tektronix (4012 or 4014) cathode ray tube terminal	Multimodal network (links which transit and pedestrians can use; one link can have different speeds for each mode) Transit demand origin – destination trip table; Transit vehicle characteristics; Parametric transit service alternatives (routes, frequencies, vehicle types)
11. Interactive graphics transit design system (IGTDS) Estimates modal splits and and performance for alternative many-to-one fixed-route, fixed-schedule transit systems interactively using a PDP-10 or IBM 1130 computer and a cathode ray tube. Predicts ridership and costs by route. User attempts to improve system, provide better service at less cost, with each successive system.	Initial installation and learning experience. 1-2 weeks rapid for alternatives testing – ½ day per alternative	Low to moderate depending on availability and cost of computer	1 planner – 1 technician (1 computer programmer to install, train users)	Tektronix 4012 cathode ray tube terminal; PDP-10 (Optional package available from vendors if 4012 and acoustic coupler available; contact UMTA)	Origin zone demands; Transit vehicle data; Transit and highway user costs; Demand model coefficients (default can be used) Proposed transit service alternative

TABLE V-2 (Continued)

Category, Name of Method, and Description	CHARACTERISTICS OF APPLICATION				
	Process Phase	Urban Area Size	Scale	Mode Types/Types of Improvements	Availability of Existing Service
1.	Feasibility	20,000-200,000	Areawide	Fixed-route, fixed-schedule transit; institution of new system or drastically revamped existing system	No existing or very simple system
2.	Feasibility Evaluation of alternative systems	50,000-300,000	Areawide Corridor Route	Fixed-route, fixed-schedule transit; institution of new system or considerably revised existing system	Service may or may not exist
3.	Feasibility of many-to-many DRT in small city or subarea of large city Evaluation of many-to-many DRT compared to other service concepts Determination of service area size	10,000-60,000 (service area population)	DRT service area — citywide for small urban area (sub-area (2-26 sq. mi.) in medium or large urban area	Many-to-many demand responsive transit service	No existing service or minimal service (to be replaced by DRT)
4.	Feasibility of many-to-many DRT in small city only	10,000-60,000	Citywide	Many-to-many demand responsive transit service for a small city not contained in another city's urbanized area	No existing service or minimal (to be replaced by DRT)
5.	Evaluation of alternative transit systems or improvements System design	10,000-500,000	Areawide corridor route subareas	Any, best suited for institution of new service	No requirement but best suited institution of new service

TABLE V-2 (Continued)

Category, Name of Method, and Description	CHARACTERISTICS OF APPLICATION (Continued)				
	Process Phase	Urban Area Size	Scale	Mode Types/Types of Improvements	Availability of Existing Service
6.	Feasibility Evaluation of alternative fixed-route, fixed-schedule systems System design	50,000-500,000	Areawide Citywide Route	Fixed-route, fixed schedule institution of new service or major service extensions	No existing service or minimal service exists and service extensions are being considered
7.	Feasibility Evaluation of alternative transit systems or major improvements	50,000-any	Areawide	Any, primarily used to analyze fixed-route, fixed-schedule service	Service may or may not exist
8.	Feasibility Evaluation of alternative transit systems or major improvements System design	50,000-any	Areawide	Fixed-route, fixed-schedule service	Service may or may not exist
9.	Evaluation of alternative transit systems or major improvements	50,000-any	Areawide	Any; default model used for fixed-route, fixed-schedule service analysis	Service may or may not exist (service must exist if default model parameters are to be modified)
10.	Evaluation of alternative transit systems or major improvements System design	50,000-any	Areawide Corridor	Fixed-route, fixed-schedule transit, bus, express bus and rapid transit	Service may or may not exist
11.	Feasibility Evaluation of alternative systems or major improvements System design	50,000-any	Areawide Corridor	Any many-to-one service; primarily used to evaluate CBD-oriented fixed-route, fixed-schedule alternatives with or without locations of park and ride lots; can be used for many-to-one pre-arranged ride sharing, feeder service design	No requirements — service may or may not exist

TABLE V-2 (Continued)

Category, Name of Method, and Description	ASSESSMENT		
	Effectiveness	Merits	Disadvantages
1.	Produces extremely gross systemwide results but effectively negligible cost	Simple, rapid and cheap to use; satisfactory results if no data, time or staff is available; particularly useful if proposed new fixed-route, fixed-schedule system is being compared to other service concepts.	Extremely limited output; not sensitive to transit service quality — coverage, scheduling; indirectly sensitive to frequency, service hours; no specific users or user benefits can be identified; not sensitive to orientation of transit demand; no estimate of auto trips diverted to transit
2.	Produces good results by route at minimal cost	Simple, rapid and cheap to use; includes level of service variables — frequency, route circuity, ease of transferring, service area coverage; minimal data requirements; performance of individual routes can be evaluated	Not sensitive to all service variables — travel time, service hours, fares; not sensitive to orientation of transit demand; no specific users or user benefits can be identified; no estimate of auto trips diverted to transit
3.	Satisfactory results if conditions of subject service can be matched with manuals; should be satisfactory for rough estimate; minimal cost	Simple, rapid and cheap to use; good for rapid feasibility test or determination of DRT service area;	Low confidence in results because given rate is based on very limited data to date and/or specific conditions which vary from location to location; not sensitive to service characteristics of DRT system not same as base cases, no estimate of auto trips diverted to transit.
4.	Accuracy of results not known; should be more accurate than previous method because analysis is finer and limited to small cities only where variance of conditions is less; minimal cost	Simple, rapid and cheap to use; gives notion of who users will be based on experience in other cities	Moderate confidence in results is based on very limited data
5.	Suitable for detailed testing of one or two alternative service concepts simultaneously Excellent results when assumptions are well based and logical; excellent for planner who has a good feel for the urban area; identifies in detail system users. Effective when particular markets must be served	Gives planner best notion of who will use system; specifically identifies users who will benefit; tailored to specific area; results can be adjusted for system changes; data collection efforts determined by user; planners with city knowledge can use to advantage	Assumptions are often arbitrary estimates; double counting of people in more than one market segment — calculations and accounting could become tedious or confusing

TABLE V-2 (Continued)

Category, Name of Method, and Description	ASSESSMENT (Continued)		
	Effectiveness	Merits	Disadvantages
6.	Good estimate of transit CBD work trips quickly and cheaply; can also assess impact of transit on highway system; estimates vast majority of peak period transit trips for design purposes	Rapid, easy, cheap to use; Calibrated on national data Estimates transit and highway impacts relatively	No level of service sensitivity except system coverage
7.	Powerful data handling capability Requires good planner judgment and knowledge to get useful results; tool rather than procedures Installation and learning experience could be expensive	Large volume of data can be processed efficiently Flexible data management capabilities, can present data in many ways; good presentation of tabulations	Installation and learning experience could be expensive; requires computer skills and access to computer
8.	Powerful transit network analysis capability Requires good planner knowledge to get useful results Installation, learning experience and network coding could be expensive	Powerful transit network analysis capability Good output for system design	Installation, learning experience and network coding could be expensive; requires computer skills and access to computer
9.	Flexible framework for user specified demand modeling Default model is an excellent, efficient self-contained demand model which performs trip generation, distribution and modal split; no calibration although user can modify any or all parameters to suit local application; any or all steps can be run at once	Flexible framework for user-specified demand modeling Complete self-contained default model which requires no calibration; user can modify any or all steps of model Requires minimal input for such a complete model	Requires network coding; installation and learning experience could be expensive

TABLE V-2 (Continued)

Category, Name of Method, and Description	ASSESSMENT (Continued)		
	Effectiveness	Merits	Disadvantages
10.	Rapid transit assignment for a large number of alternatives; excellent system output useful for comparative evaluation (service and cost-effectiveness of alternative) and system design. Runs are low cost but network coding, learning model and obtaining trip table may be expensive	Efficient transit assignment program; Excellent performance, operating and service data output for comparative evaluation and system design; Rapid assignment for a large number of alternatives; Single multimodal networks for transit and pedestrian modes; Immediate computer turnaround and input of new alternatives; Relatively easy program to learn; no programming experience necessary, conversational features facilitate program use	Transit trip table may be difficult to obtain; several trip tables can be run assuming varying modal splits; Network coding may be time consuming Hardware may be difficult to find locally Must install package and learn how to use program
11.	Rapid estimation of demand for large number of alternatives once initial effort made to install and learn program (considerably less data and experience required than for UTPS)	Rapid estimation of a large number of alternatives. Good output useful in systems design and evaluation — detailed demand by origin, user and operator costs; low cost computer program after learning experience; Relatively easy program to learn; no programming experience required	Must install package and learn how to use program (not difficult); hardware might be difficult to find locally

3. Method 1: Systemwide Ridership - Fixed-Route, Fixed-Schedule Transit Service

a. Description

This patronage estimation technique is based on the use of a graph that illustrates the estimated demand for fixed-route, fixed-schedule transit service expected to result from the supply of a given level of fixed-route, fixed-schedule transit service. Data from transit systems in small and medium-sized cities throughout the United States and Canada indicate that, for fixed-route, fixed-schedule systems, a high degree of correlation exists between the supply rate of bus service provided (expressed as annual revenue bus-miles operated per person residing within the transit service area) and the demand rate for bus service (expressed as annual revenue passengers per person residing within the transit service area). This relation can be used to forecast transit patronage on those proposed new fixed-route, fixed-schedule transit systems that are expected to be fairly typical of most small urban area transit systems.

The following characteristics of a "typical" small urban area conventional transit system serve as a guide for determining if this method is appropriate for a particular application:

- Fixed-route, fixed-schedule transit service is proposed, with radial routes emanating from the city's CBD.
- The city's CBD is the major generator of transit trips: between 30 and 70 percent of all transit trips have at least one trip-end in the CBD, and no other major generator produces or attracts as many trips as the CBD.
- Sixty to ninety percent of the population of the urbanized area resides within 1/4 mile of a bus route.
- Peak period headways range from 15 to 30 minutes; off-peak headways vary from 30 to 90 minutes.
- Transit fares range from \$. 20 to \$. 40.

- No special services (such as express buses, fringe parking, exclusive bus lanes, or DRT service) are proposed.

Only two measures of service are required to use this method for transit demand estimation: the number of revenue bus-miles to be operated annually and the population residing within the proposed service area (the service area is defined as that area within 1/4-mile of a bus route). Consequently, this method is simple to apply and requires a minimum of data as input. It does not, however, reflect variations in transit service levels, including fares, bus routing, bus amenities, service dependability, and coordination of scheduling; service frequency is reflected only indirectly by incorporating revenue bus-miles. Nonetheless, this method provides a reasonable estimate of transit demand where new service is contemplated and planning resources (such as time, staff, and budget) and data sources are severely limited. Its primary application is to determine the feasibility of a proposed system; to compare a wide range of proposed new fixed-route, fixed-schedule systems; or to provide measures for evaluating a proposed fixed-route, fixed-schedule transit system in comparison with another service concept such as DRT service.

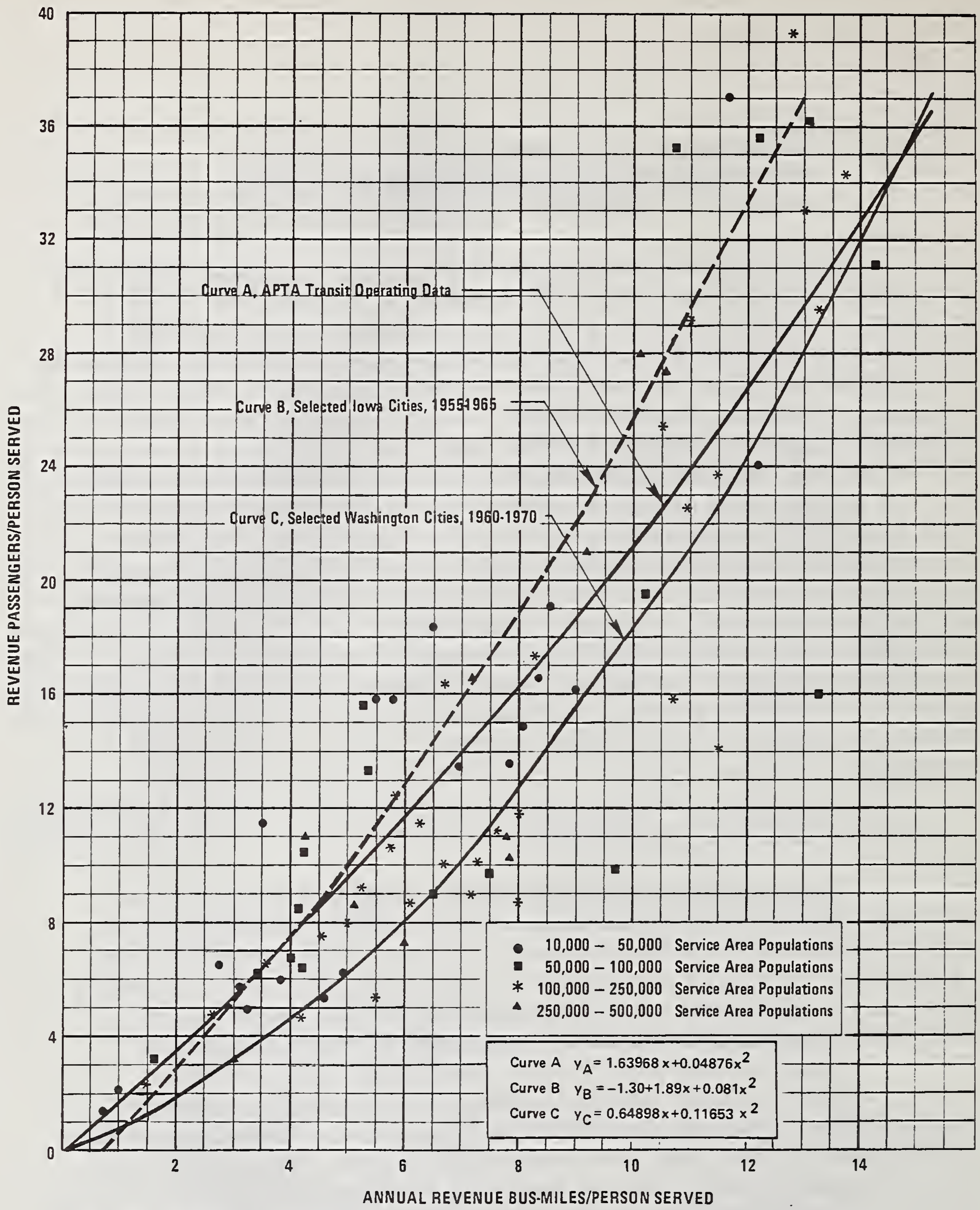
b. Development and Theory

The use of the transit propensity curve is based on the premise that an individual is likely to make more transit trips on a system that provides more service, i.e., one which operates more revenue bus-miles. It is reasonable, therefore, to predict ridership based on the propensity of persons residing within a transit service area to use transit in relation to the amount of service provided.

Three transit ridership propensity curves for small and medium-sized cities are presented in Figure V-4. These curves were derived from a wide variety of transit operations. They relate the observed rate of annual transit revenue passengers per person residing within a 1/4-mile service area of a transit network to the reported annual revenue bus-miles per person in the service area (a 1/4-mile service area refers to the area within 1/4-mile of either side of a transit route). Curve A illustrates a relation[1] between the transit

---

[1]Based on multiple regression curve fitting results.



SOURCES: 1973 and 1974 APTA Transit Operating Reports; Studies conducted by W. C. Gilman and Co., VTN, Washington, Inc.; Iowa State University

NOTES:

$$\frac{V}{P} = f\left(\frac{R}{P}\right)$$

where:
- V = annual transit revenue passengers (excludes transfer and charter passengers)
- P = persons residing within a transit service area, assumed to be within ¼ mile of a transit route
- R = annual bus-miles operated in revenue service (excludes non-revenue or "deadhead" and charter operation)
- f = one of three transit ridership propensity curves shown

FIGURE V-4: TRANSIT RIDERSHIP PROPENSITY CURVES demand and supply experience of transit systems in various small and medium-sized cities based on the most recent reliable data. Data for these cities, reported to the American Public Transit Association in 1973 and 1974[1] and in several transit studies[2] are shown as points on Figure V-4. Curve B illustrates the relation between the transit demand and supply experience of small and medium-sized cities from 1955 to 1965.[3] Curve C represents transit ridership propensity for several small and medium-sized cities in Washington state.[4] Curve A represents the most recent data and, as the middle curve, should be used for the "average" estimate of annual ridership. The other two curves suggest an envelope which can be used to provide a range for high and low ridership estimates.

The use of these curves should be limited to situations in which the supply rate is less than 15 annual revenue bus-miles per person served. The curves specifically are not intended for sensitivity analysis to estimate a change in ridership per person served as a function of a change in bus miles per person served.

c. Application

The use of the transit ridership propensity curve is based on a straightforward procedure which involves the following steps:

(1) Determine whether the transit ridership propensity curve is appropriate for the particular planning application:

- Does the application involve testing the feasibility of one or more proposed new fixed-route, fixed-schedule transit systems or evaluating fixed-route, fixed-schedule transit service in comparison with another service concept?

- Are the criteria described in the introduction to this method met?

---

[1] 1973 and 1974 Transit Operating Report (Washington, D.C.: American Public Transit Association).

[2] "Ridership Revenue Forecasting," Appendix B to A Five-Year Transit Improvement Program for Sheboygan, Wisconsin (Chicago: W.C. Gilman and Co., 1973).

[3] R. L. Carstens and L. H. Csanyi, "A Model for Estimating Transit Usage In Iowa Cities," Highway Research Record #213 (1968), pp. 42-49.

[4] Dennis Neuzil, "Preliminary Transit Patronage Estimation for Small Urban Areas via Transit Service Factor," Traffic Engineering (August 1975), pp. 32-35.

(2) Sketch the proposed fixed-route, fixed-schedule transit service system or alternative systems on a base map or overlay. Using small area zones, estimate the total population residing within 1/4 mile of the proposed routes. Do not count an area more than once, regardless of how many routes serve it.

(3) Compute the number of bus-miles proposed to be operated in revenue service[1] annually. Compute the daily weekday revenue bus-miles (round-trip miles times the proposed number of weekday round trips for each route) and multiply by 255 (the average number of nonholiday weekdays per year). Add Saturday revenue bus-miles if Saturday service is proposed (Saturday round-trip miles times proposed number of Saturday round trips times 52). Similarly, add Sunday and holiday revenue busmiles if such service is proposed.

(4) Compute proposed systemwide annual revenue bus-miles per person served by dividing the result from Step 3 by the results from Step 2.

(5) Enter the result from Step 4 on the x axis of Figure V-4. Go up to Curve A and obtain result on the y axis, or substitute the result from Step 4 in the transit ridership propensity curve equation and compute y:

$$\text{Curve A:} \quad y_A = 1.63968x + 0.04876x^2$$

(6) Multiply the result from Step 5 (y value) times the result of Step 2 (population served) to obtain the total annual estimated transit revenue ridership. Each transfer passenger is considered to be one revenue passenger regardless of the number of transfers made.

(7) Annual revenue estimates may be calculated by multiplying the result from Step 6 times the average fare proposed. To obtain average fare assume a mix of passengers (full fare adult, reduced fare senior citizen, reduced fare child, etc.) and a proposed fare structure.

---

[1]Bus-miles operated in revenue service excluding charter and school operations.

(8) Daily transit patronage may be estimated by apportioning the total annual estimated transit revenue ridership in proportion to the weekday, Saturday, and Sunday revenue bus-miles calculated in Step 3.

(9) Compute upper and lower estimates for total annual estimated transit ridership, annual revenue, and daily transit patronage by repeating Steps 5 through 8, using Curve B for the high estimate and Curve C for the low estimate. The respective equations for these curves are:

$$\text{Curve B:} \quad y_B = -1.30 + 1.89\,x + 0.081x^2$$

$$\text{Curve C:} \quad y_C = 0.64898\,x + 0.11653x^2$$

d. Example

A fixed-route, fixed-schedule transit system is proposed for a city of 38,000 population within the corporate city limits. Five routes having a composite 1/4-mile service area that includes 85 percent of the population are proposed. In addition, two routes extend beyond the city's corporate boundary and serve an additional 1,500 people. Service on the five proposed routes and the calculation of estimated annual ridership are presented in Table V-3.

TABLE V-3

TRANSIT DEMAND ESTIMATION USING TRANSIT RIDERSHIP PROPENSITY CURVES

<table>
<tr><th>Step</th><th>Procedure</th><th>Result</th></tr>
<tr><td>1</td><td>Determine whether transit ridership propensity curves are appropriate.</td><td>Fixed-route, fixed-schedule transit system, CBD-oriented city, no other major generators as large as CBD; proposed service covers 60 to 90 percent of population; no special services. Method is appropriate for feasibility testing.</td></tr>
<tr><td>2</td><td>Estimate population within ¼-mile service area.</td><td>Population within corporate city limits:
38,000 x 0.85 = 32,300
Add population beyond city limits: 1,500

Total = 33,800</td></tr>
<tr><td>3</td><td>Compute number of annual revenue bus-miles to be operated.</td><td>
<table>
<tr><th rowspan="2">Route</th><th rowspan="2">Round-Trip Mileage</th><th colspan="2">Number of Round Trips</th><th colspan="2">Calculation of Annual Revenue Bus-Miles</th></tr>
<tr><th>Weekday</th><th>Saturday</th><th>Weekday</th><th>Saturday</th></tr>
<tr><td>1</td><td>3.6</td><td>24.6</td><td>12.6</td><td>3.6 x 24.6 = 88.6</td><td>3.6 x 12.6 = 45.4</td></tr>
<tr><td>2</td><td>5.6</td><td>16.0</td><td>4.0</td><td>5.6 x 16.0 = 89.6</td><td>5.6 x 4.0 = 22.4</td></tr>
<tr><td>3</td><td>4.0</td><td>20.2</td><td>8.2</td><td>4.0 x 20.2 = 80.8</td><td>4.0 x 8.2 = 32.8</td></tr>
<tr><td>4</td><td>10.0</td><td>12.4</td><td>–</td><td>10.0 x 12.4 = 124.0</td><td>–</td></tr>
<tr><td>5</td><td>6.2</td><td>18.0</td><td>–</td><td>6.2 x 18.0 = 111.6</td><td>–</td></tr>
<tr><td></td><td></td><td></td><td></td><td>TOTAL 494.6
x 255 = 126,123</td><td>100.6
x 52 = 5,231</td></tr>
<tr><td colspan="6">TOTAL = 131,354</td></tr>
</table>
</td></tr>
<tr><td>4</td><td>Compute systemwide revenue bus-miles per person.</td><td>131,354 ÷ 33,800 = 3.89</td></tr>
<tr><td>5</td><td>Estimate expected ridership per person from Curve A on Figure V-4.</td><td>Enter 3.89 on x axis or substitute for x in Curve A equation
y = 7.25</td></tr>
<tr><td>6</td><td>Compute estimated annual transit ridership.</td><td>7.25 annual revenue passengers/person served x 33,800 persons served
=245,050 annual revenue passengers</td></tr>
<tr><td>7</td><td>Compute annual revenue estimates.</td><td>Assume 70 percent of riders pay adult fare (25 cents)
15 percent of riders pay student fare (15 cents)
15 percent of riders pay senior citizen fare (15 cents)
245,050 x .70 x .25 = $42,884
245,050 x .15 x .15 = 5,514
245,050 x .15 x .15 = 5,514
Total estimated annual revenue $53,912</td></tr>
<tr><td>8</td><td>Estimate daily patronage.</td><td>Weekday service = 96 percent of revenue bus-miles
Saturday service = 4 percent of revenue bus-miles

Estimated weekday ridership = (245,050 x 0.96)/255 weekdays = 923
(Assume even distribution over all weekdays)
Estimated Saturday ridership = (245,050 x 0.04) /52 Saturdays = 189
(Assume even distribution over all Saturdays)</td></tr>
<tr><td>9</td><td>Compute high and low estimates for annual transit ridership, revenue, and weekday and Saturday ridership from Curves B and C respectively on Figure V-4.</td><td>
<table>
<tr><th></th><th>High
(from Curve B,
y = 7.2)</th><th>Low
from Curve C,
y = 4.3</th></tr>
<tr><td>Annual Ridership</td><td>7.4 x 33,800
= 250,120</td><td>4.3 x 33,800
=145,340</td></tr>
<tr><td>Annual Revenue</td><td>250,120 x .70 x .25 = $ 43,771
250,120 x .15 x .15 = 5,628
250,120 x .15 x .15 = 5,628
$55,027</td><td>145,340 x .70 x .25 = $25,435
145,340 x .15 x .15 = 3,270
145,340 x .15 x .15 = 3,270
$31,975</td></tr>
<tr><td>Weekday Ridership</td><td>(250,120 x 0.96) / 255 days
= 942</td><td>(145,340 x 0.96)/255 days
=547</td></tr>
<tr><td>Saturday Ridership</td><td>(250,120 x 0.04) / 52 days
= 192</td><td>(145,340 x 0.04)/52 days
= 112</td></tr>
</table>
</td></tr>
</table>

4. Method 2: Route Ridership - Fixed-Route, Fixed-Schedule Transit Service

a. Description

This demand estimation method produces estimates of annual transit revenue passengers on a route-by-route basis. It requires a minimum of information regarding the route structure, the level of service to be provided along the route, and the characteristics of the service area. The service area characteristics, used to determine the base annual ridership on a route, may be measured in one of two ways: (1) estimate the number of dwelling units within the 1/4-mile service area of each route or (2) estimate the total population and population over 65 years of age within the 1/4-mile service area of each route. With either of these input characteristics, an estimate of annual transit ridership can be developed.

This procedure is applicable under the following conditions:

- The urban area is less than 200,000 residents.
- Only fixed-route, fixed-schedule transit service is planned.
- Except in the CBD area, there is minimal overlap of route service areas.

Because the procedure is not sufficiently sensitive to be used to estimate ridership changes that are due to small changes in the level of transit service, it is most appropriate for a situation where no service currently exists.

b. Development and Theory

This method has been adapted from a procedure used to estimate ridership for proposed new transit service in areas where none previously existed.[1] Refinements to the basic method are based on regression analyses using data from Clarksburg, West Virginia; Boise, Idaho; and Des Moines, Iowa to estimate annual transit ridership as a function of:

---

[2]Carl H. Buttke, "Estimating Ridership on Small Systems," Passenger Transport (January 2, 1976). (Procedure used by DeLeuw Cather Company)

- dwelling units in the service area;
- peak period headways;
- base period headways;
- percent of route on one-way loops; and
- total population and population 65 years of age and older.

The user is encouraged to either incorporate additional service factors if they are particularly relevant in a specific situation or to not use one or more of the factors suggested above if they are considered insignificant. The method is structured such that each individual factor represents a percent increase or decrease from the base annual ridership.

c. Application

Application of this technique involves the following sequence of steps:

(1) Determine the applicability of the method.

(2) Lay out the proposed fixed-route system on a base map or overlay; sketch the service area within 1/4 mile of each route.

(3) Estimate the base annual ridership for each route. Use as input variables either the number of dwelling units in each route's service area (Figure V-5) or both total population and population over 65 years of age within each route's service area (Figure V-6). The latter is preferable if the necessary data are available.

(a) The number of dwellings within a 1/4-mile service area of each route can be estimated from aerial photographs, route reconnaissance, U.S. Geological Survey maps, plat maps, or a combination of these. Each unit of apartment buildings should be counted as one dwelling unit. Equivalent dwelling units should be estimated for group quarters (notably university dormitories), based on resident population and a reasonable estimate of persons per dwelling unit (2.8 to 3.8; the national average is 3.2 persons per dwelling unit). If there is an overlapping of route service areas outside the CBD or other central transfer point, allocate the

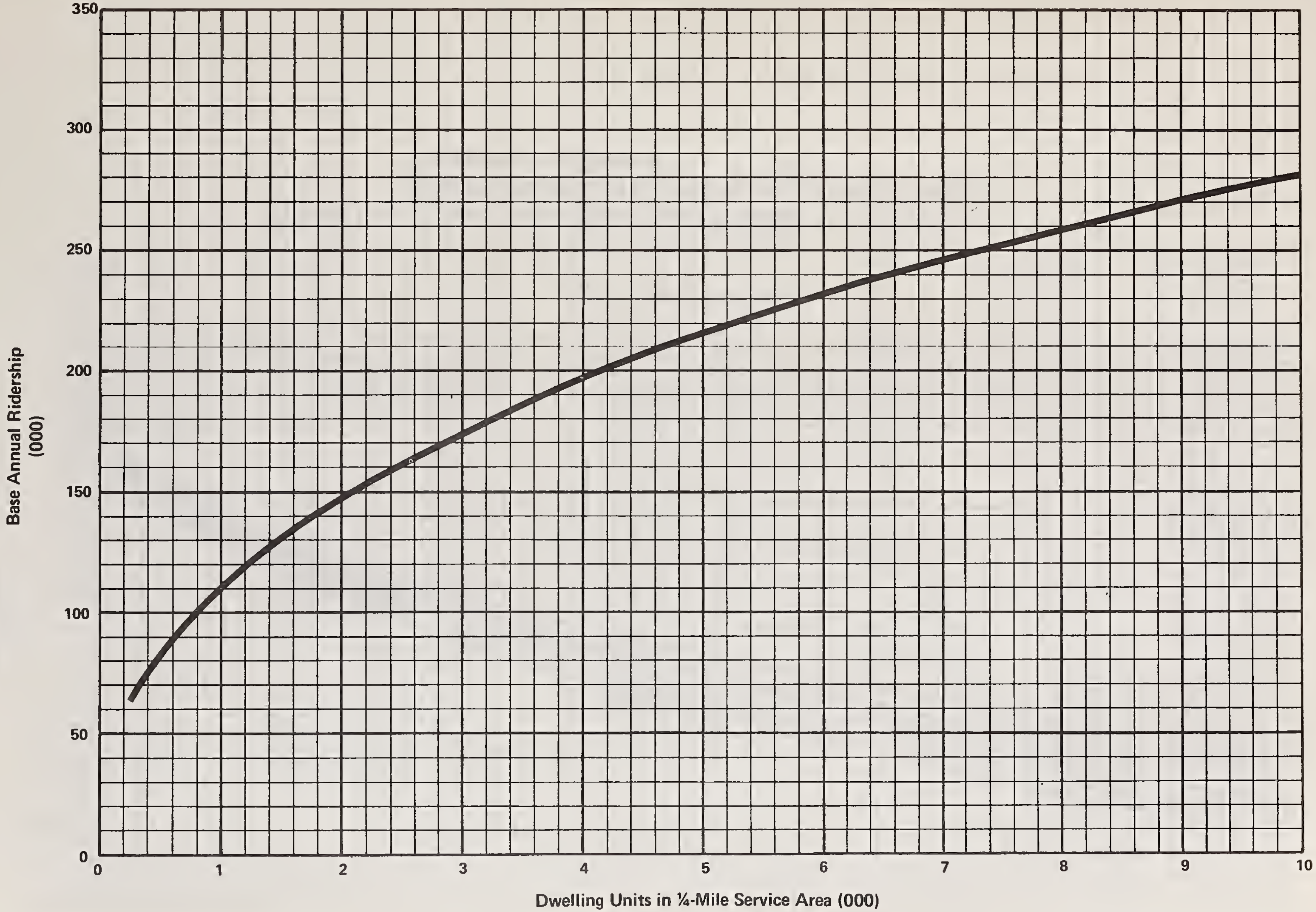


FIGURE V-5: DIRECT DEMAND ESTIMATION FOR FIXED-ROUTE, FIXED-SCHEDULE TRANSIT SERVICE/BASE ANNUAL RIDERSHIP/METHOD A

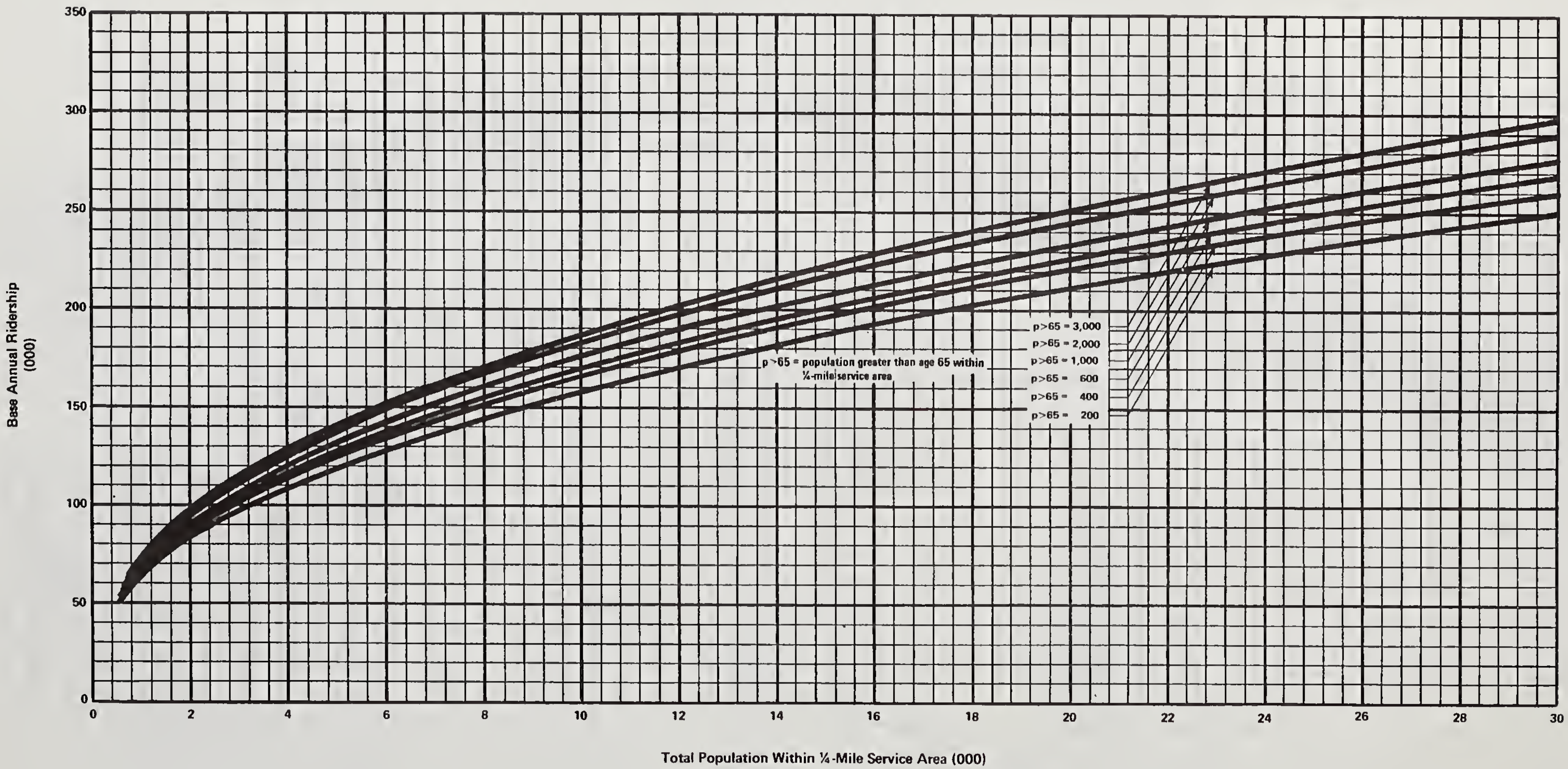


FIGURE V-6: DIRECT DEMAND ESTIMATION FOR FIXED-ROUTE, FIXED-SCHEDULE TRANSIT SERVICE/BASE ANNUAL RIDERSHIP/METHOD B service level (frequency) provided by each route; if the overlapping of service areas is minimal, no such allocation procedure is necessary.

(b) The total population and the population over 65 years of age within the 1/4-mile service area can be estimated by applying the same rules as above for overlapping service areas.

(c) If dwelling units are used (Method A), enter the curve on Figure V-5. If population and population over 65 are used (Method B), enter the curve on Figure V-6.

(4) Estimate a one-way loop factor for each route (a "one-way loop" is any portion of a route where service in one direction is not on the same street as service in the opposite direction). Empirical evidence has shown that one-way loops on bus routes are deterrents to transit ridership. Persons residing on that portion of a route to which access is more circuitous in one direction than the other have a lower propensity to use transit.

(a) To estimate the one-way loop factor for each route, estimate the number of dwelling units or total population determined in Step 3 whose service is 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 those dwelling units or persons on the outside of the loop and still within the 1/4-mile service area.

(b) To compute the percent of dwelling units or persons served by a one-way loop, divide the result of Step 4a by the result of Step 3a or 3b (dwelling units or population, respectively), and multiply by 100.

(c) To obtain the one-way loop factor for each route, enter the curve on Figure V-7. Empirical evidence has shown that the one-way loop factor should not exceed 1.5 even if an entire route is two-way.

(5) Estimate the headway factors for each route. The headway factors account for the fact that as bus service frequency increases, ridership increases. Ridership is more sensitive to service frequency in peak hours because of the high proportion of riders who must arrive at or leave work at a specified time. Therefore, two factors are estimated.

(a) Determine the proposed level of service for each route in terms of headways for peak and base periods for Monday through Friday service.

(b) To obtain both peak and base headway factors for each route, enter the curves on Figure V-8.

(6) Estimate the transfer coordination factor for each route. Ridership increases as system coordination increases because transit passengers can travel between points or different routes. To estimate the transfer coordination factor for each route:

(a) Use 1.0 if the schedule for each route permits easy transfer to all other routes at a central transfer point (i.e., pulse scheduling where all buses meet at the central point at the same time).

(b) Use 1.0 if the central area is the dominant major trip generator in the city and a very low transfer percentage might be expected even if routes were to be completely coordinated.

(c) Use 0.80 if no route coordination is proposed.

(d) Select a factor between 0.80 and 1.00 for any other case. Use 0.90 if transfer conditions are good but not coordinated between all lines.

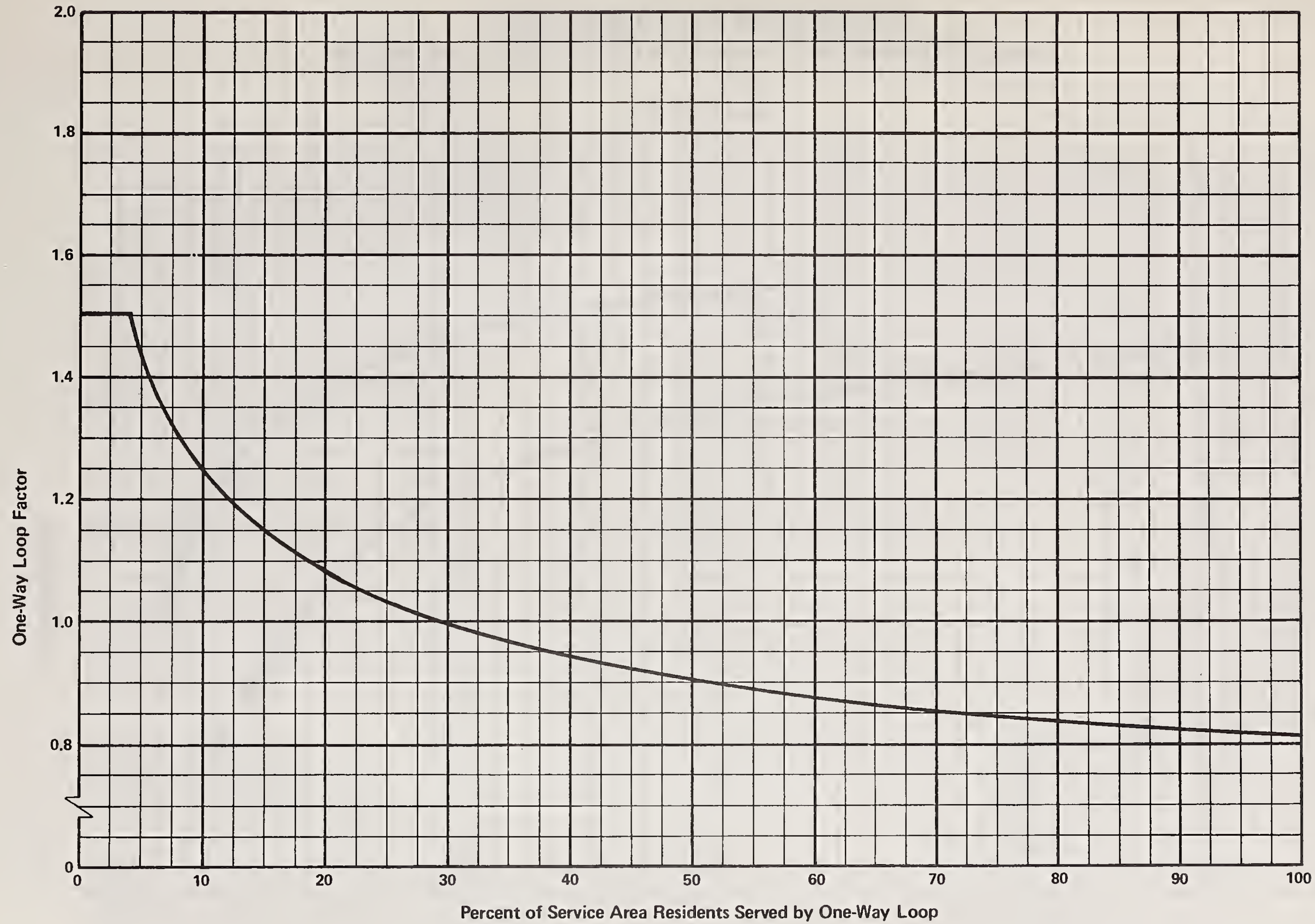


FIGURE V-7: DIRECT DEMAND ESTIMATION MODEL FOR FIXED-ROUTE, FIXED-SCHEDULE TRANSIT SERVICE/ONE-WAY LOOP FACTOR

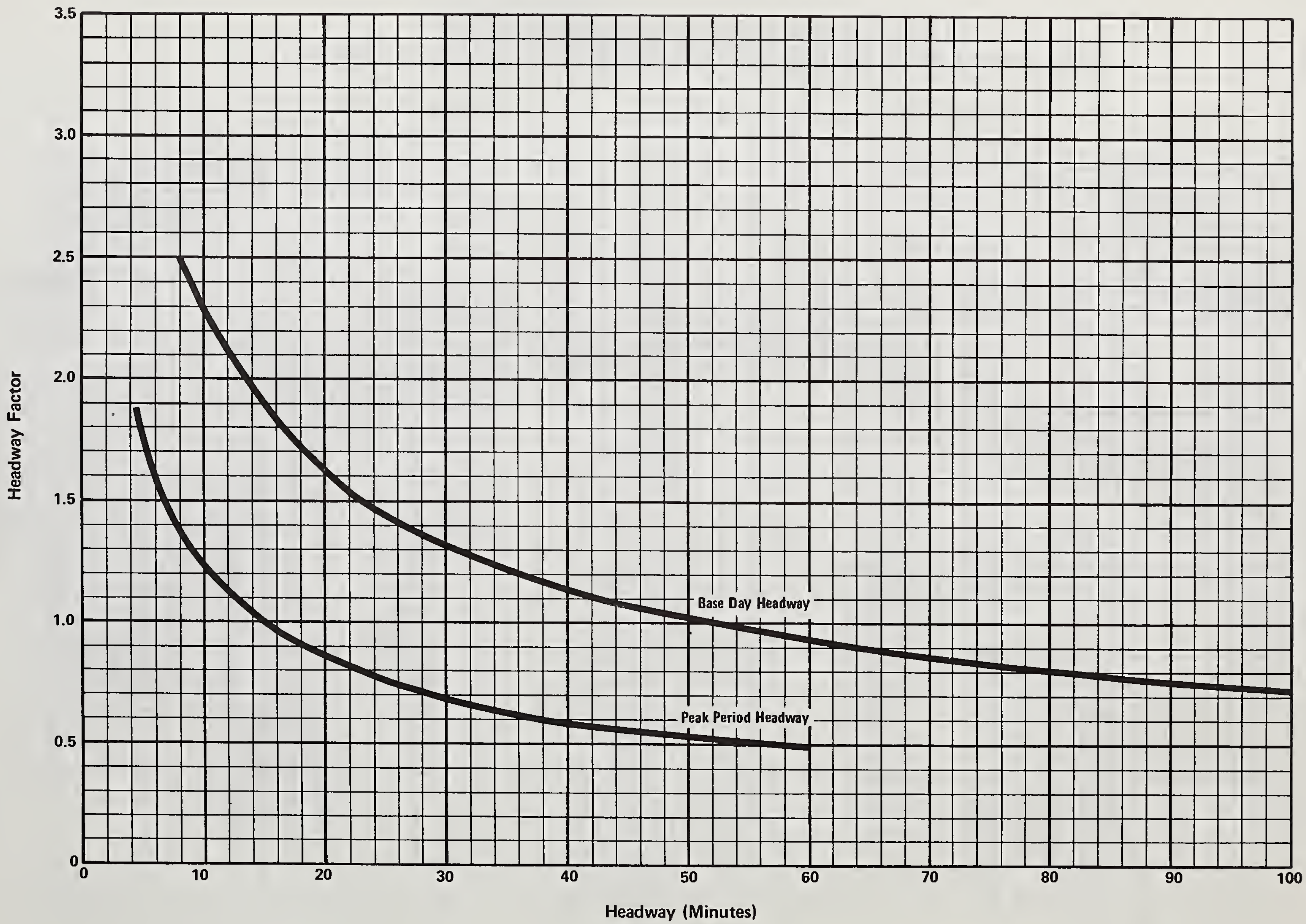


FIGURE V-8: DIRECT DEMAND ESTIMATION FOR FIXED-ROUTE, FIXED-SCHEDULE TRANSIT SERVICE

(7) Estimate a weekend service factor for each route based on Monday through Saturday service:

(a) If only Monday through Friday service is proposed for a route, use 0.90.

(b) If Monday through Sunday service is proposed for a route, use 1.04.

(8) Estimate annual revenue passengers (excluding transfer passengers) for each route. Multiply the base ridership by the product of all factors:

Total annual revenue passengers, route x =

(base annual ridership, route x: Step 3)

x (one-way loop factor, route x: Step 4)

x (base headway factor, route x: Step 5)

x (peak period headway factor, route x: Step 5)

x (transfer coordination factor, route x: Step 6)

x (weekend service factor, route x: Step 7)

d. <u>Example</u>

A city is proposing a three-route system, and moderate coordination between each line in the CBD is planned. Ridership by route is estimated as shown in Table V-4.

TABLE V-4

SYSTEMWIDE RIDERSHIP – FIXED-ROUTE, FIXED-SCHEDULE TRANSIT SERVICE: APPLICATION EXAMPLE

Input	Route		
	1	2	3
Dwelling Units in Service Area	3,200	4,800	2,050
One-way Loop Percentage	15	10	25
Peak Headway Percentage	30	20	30
Base Headway Percentage	45	30	60
Saturday Service	Yes	Yes	No
Sunday Service	No	Yes	No
Output			
Base Annual Ridership (Figure A)	178,000	211,000	150,000
One-way Loop Factor (Figure V-7)	1.14	1.24	1.04
Peak Headway Factor (Figure V-8)	0.68	0.86	0.68
Base Headway Factor (Figure V-8)	1.07	1.32	0.93
Transfer Coordination Factor (Step 6)	0.90	0.90	0.90
Weekend Service Factor (Step 7)	1.00	1.04	0.90
Annual Revenue Passengers	133,000	278,000	80,000

Total annual revenue passengers on system = 491,000

5. Method 3: Systemwide Ridership - DRT Service

a. Description

This method provides estimates of average daily transit ridership for DRT systems (described in Chapter IV). Estimating relations are described for four different DRT operating environments:

- areawide or citywide many-to-many DRT service and shared-ride taxi service with no other competing local public transit service available.

- areawide or citywide many-to-many DRT service and shared-ride taxi service with competing local public transit service (e.g., model cities programs, publicly subsidized and private shared-ride taxi service) available.

- DRT service exclusively for the elderly and handicapped.

- zone and feeder DRT services: feeder systems to regional or other local public transit service, but not competing with these services. Most services like these also provide many-to-many DRT service within zones with service to a central point within each zone, to the CBD, or to a regional transit station.

These patronage estimating methods are suitable for the following general applications in the feasibility phase of the planning process:

- determining the feasibility of DRT or shared-ride taxi service in a candidate area by providing ridership and necessary resource estimates;

- comparing DRT or shared-ride taxi service with other service concepts, particularly fixed-route and fixed-schedule service; and

- screening candidate service areas for DRT or shared-ride taxi services.

b. Development and Theory

The demand curves that are the foundation of this method were derived from data reported for DRT and shared-ride taxi systems in each operating environment discussed above.[1] These procedures are based on methods previously proposed by The MITRE Corporation for

---

[1]Eight sources of data were used to develop these relations as follows:

(1) Lea Transit Compendium: Para-transit. Vol. 1, No. 8. Huntsville, Alabama: N.D. Lea Transportation Research Corporation, 1974.
(2) Bert Arrillaga and George E. Mouchahoir, Demand-Responsive Transportation System Planning Guidelines (McLean, Virginia: the MITRE Corporation, 1974).
(3) Transportation Systems Center, Demand-Responsive Transportation: State-of-the-Art Overview (Cambridge, Massachusetts: U.S. Department of Transportation, 1975).
(4) Frank W. Davis, Jr., Kenneth W. Heathington, Richard T. Symons, Stephen C. Griese, Roger W. Alford, and David P. Middendorf, Economic Characteristics of Privately Owned Shared-Ride Taxi Systems (Knoxville, Tennessee: Transportation Center, the University of Tennessee, 1974).
(5) David R. Shilling and G. J. Fielding, "La Habra Dial-a-Ride Project," New Transportation Systems, Transportation Research Record #522.
(6) Michigan Department of State Highways and Transportation, Dial-a-Ride Transportation: Michigan DART Program Status Report (Lansing, Michigan: Michigan Department of State Highways and Transportation, Bureau of Urban and Public Transportation, 1976).
(7) Cranston Transvan (Providence, Rhode Island: Duffy and Shanley, Inc., 1975).
(8) Florida State Department of Transportation, Transportation of the Elderly (TOTE): Interim Report (Springfield, Virginia: National Technical Information Service, 1974).

The use of the data sources for each operating environment described above was as follows:

1, 3, 5, 6: - DRT and shared-ride taxi service alone

1, 2, 3, 4: - DRT and shared-ride taxi service in a competitive environment with local transit service

1, 3, 7, 8: - elderly and handicapped service only

1, 6 : - coordinated DRT and other transit for the analysis of DRT systems. The results of these analyses are presented in the form of two or three graphs and one equation for each individual operating environment. The graphs illustrate the relations between estimated transit ridership rates and transit supply rates. When data are available, an additional graph shows estimated demand directly as a function of transit supply.

In the first graph for each operating environment, the supply rate is expressed as total proposed fleet size of the DRT or shared-ride taxi operation per 1,000 persons in the proposed service area. The demand rate in the first graph is expressed as expected average daily ridership per 1,000 persons in the proposed service area. Total fleet include all operating vehicles whether they operate all or only part of an average weekday.

In the second graph for each operating environment, the supply rate is expressed as total proposed fleet size of the DRT or shared-ride taxi operation per square mile of proposed service area. The demand rate in the second graph is expressed as expected average daily ridership per square mile of proposed service area.

The operating environments with no competing transit service and coordination with local service also have graphs of expected average daily and hourly ridership as a functon of vehicle-hours of service operated.

Each graph shows a line which best fits the observed data. In addition, each graph shows high and low estimate lines between which all or nearly all observed data points lie. The best fit line should be used to estimate average ridership. A range of expected ridership can be estimated by using the high and low estimate lines.

All graphs for a particular operating environment can and should be used for a single application. The use of all graphs shows sensitivity of expected ridership to varying service area populations and service area sizes. An annotation on each graph shows the range of service area characteristics observed in each operating environment. The use of these graphs is most appropriate in the feasibility analysis phase of the planning process.

An equation describing demand as a function of both demographic and supply variables for DRT and shared-ride taxi services is also provided for each of these operating environments. These equations are appropriate for the evaluation and system design phase of the planning process.

(1) DRT and Shared-Ride Taxi Service/No Competing Local Transit Service

For the situation where DRT service is supplied in an area that has no other public transit service, Figures V-9 and V-10 relate transit supply rates to expected average ridership rates. Figure V-11 shows expected daily and hourly average ridership directly as a function of average vehicle-hours of service operated per day.

The following regression equation relates ridership data to the characteristics of service based on data from DRT systems and shared-ride taxi services in this operating environment:

$$ADR = -8.55 + 0.00245SAP - 4.635SA + 5.736VHPD + 40.075FS$$

where:

ADR = average daily ridership,

SAP = service area population,

SA = service area in square miles,

VHPD = vehicle hours per day, and

FS = fleet size per square mile of service area

(2) DRT and Shared-Ride Taxi Service/Competing Local Public Transit Service

For DRT systems competing with local public transit service, Figures V-12 and V-13 relate transit supply rates to expected average transit ridership. There is considerable variability in Figure V-12, and results should therefore be used only in preliminary feasibility applications. The following equation describing the relations between ridership, service area characteristics, and supply of service is based on data from DRT systems and shared-ride taxi services in this operating environment.

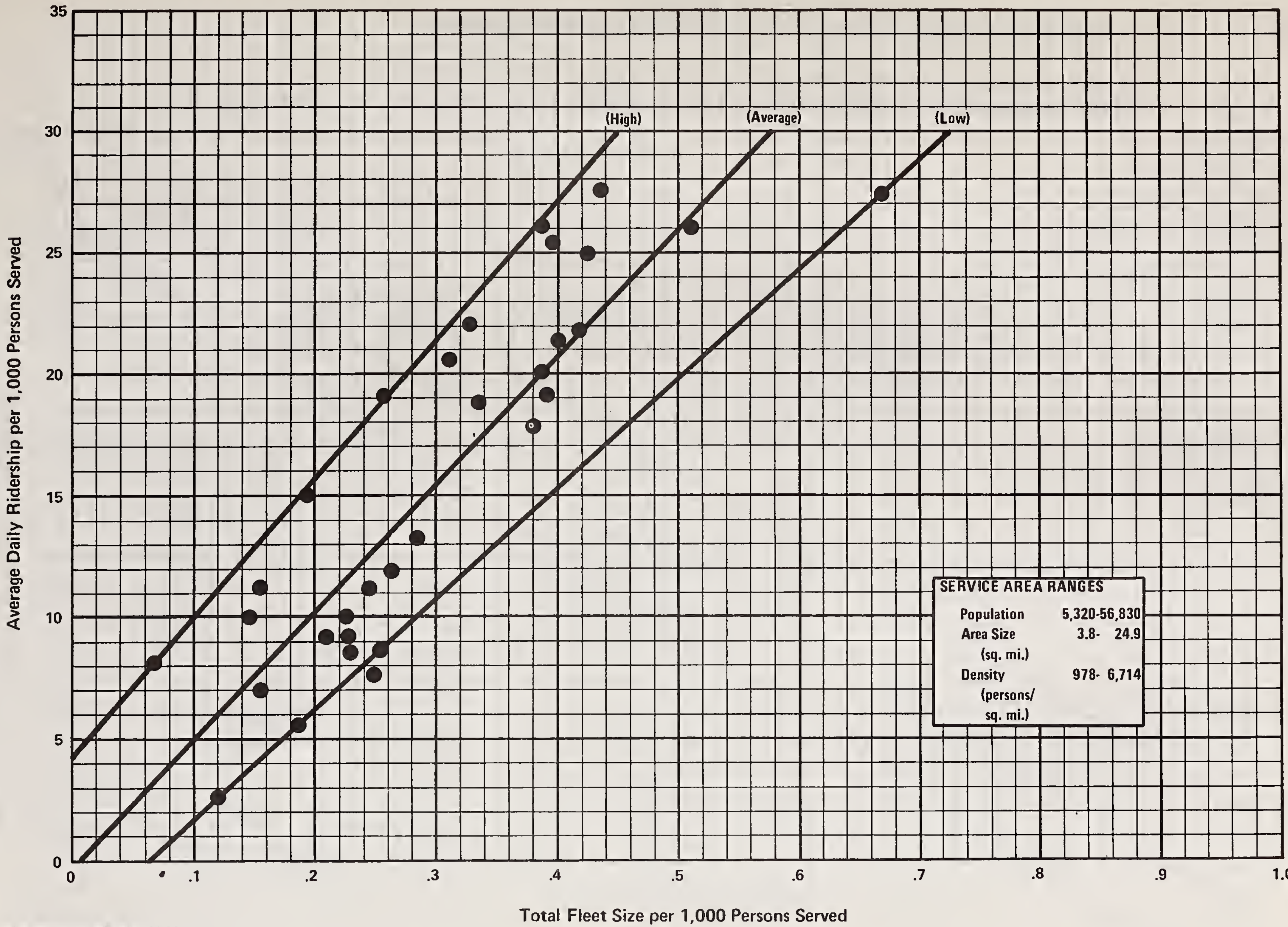
$$ADR = -50.06 + 0.00087SAP + 16.48SA + 25.91TFS;$$

where:

ADR = average daily ridership,

SA = service area (square miles), and

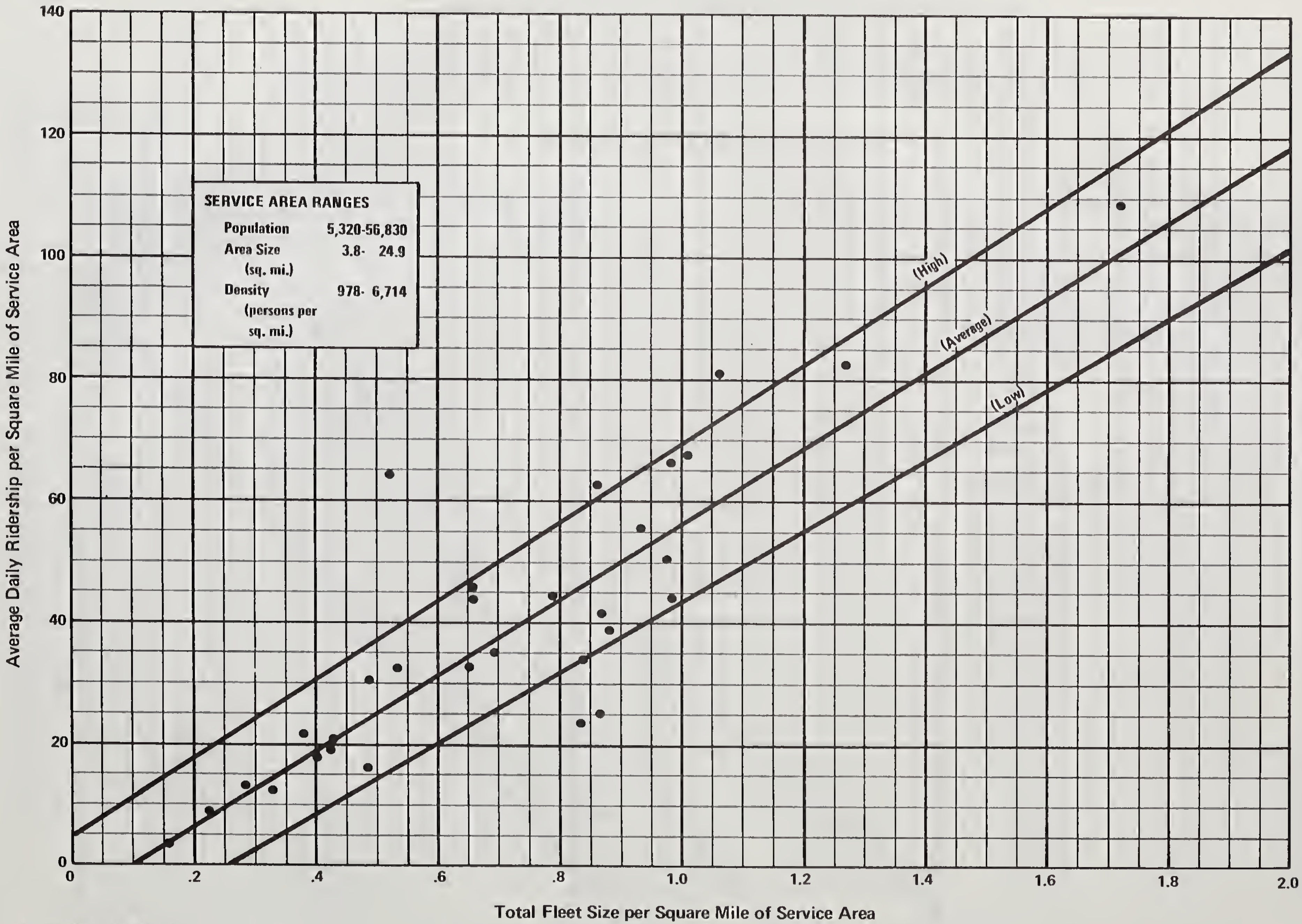
TFS = total fleet size.



Data Sources: See page V.44

FIGURE V-9: AVERAGE DAILY RIDERSHIP PER 1,000 PERSONS SERVED VERSUS TOTAL FLEET SIZE PER 1,000 PERSONS SERVED

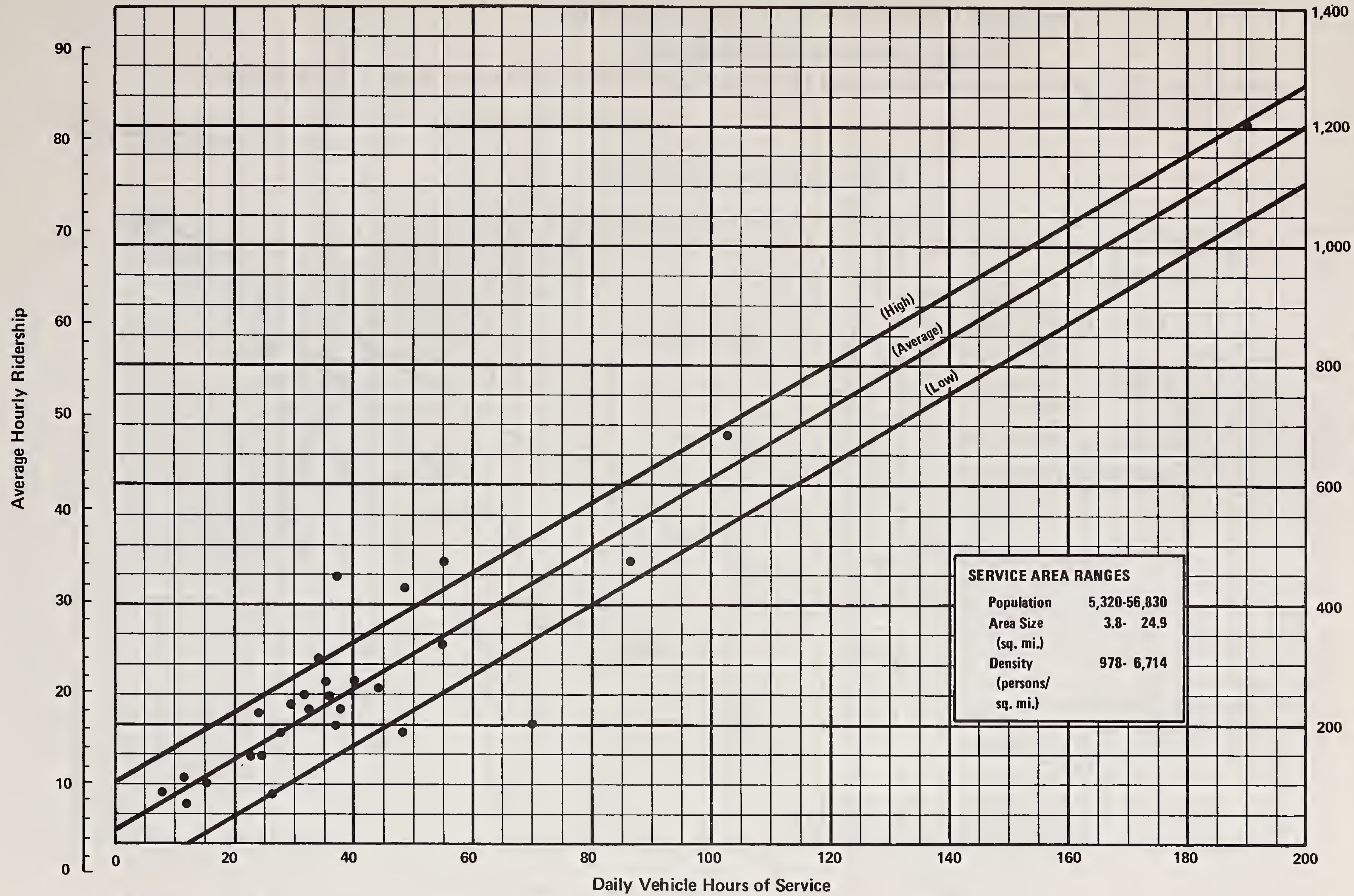
Demand Responsive Transportation and Shared-Ride Taxi Service/No Competing Local Transit Service



Data Sources: See page V.44

FIGURE V-10: AVERAGE DAILY RIDERSHIP PER SQUARE MILE OF SERVICE AREA VERSUS TOTAL FLEET SIZE PER SQUARE MILE OF SERVICE AREA

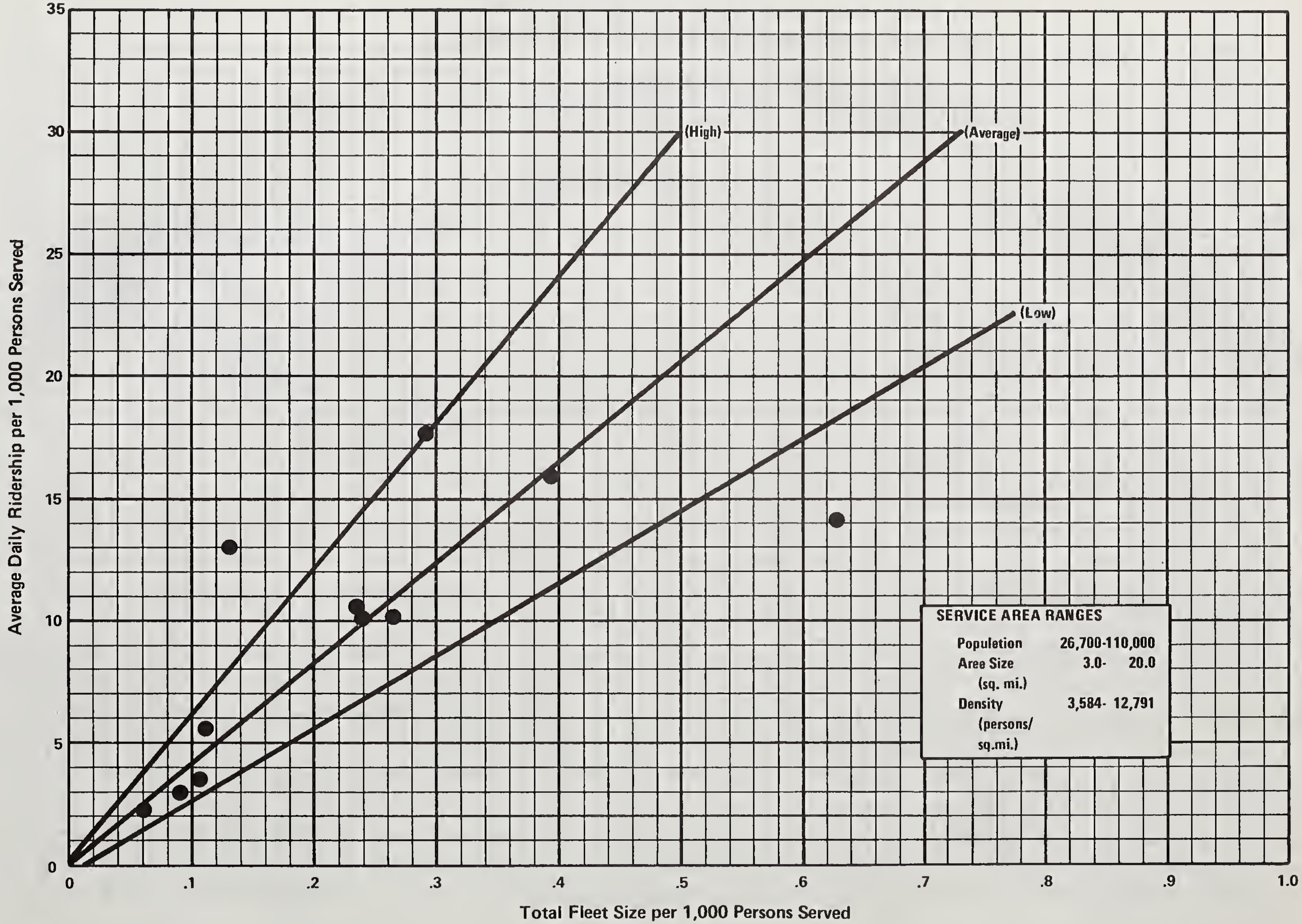
Demand Responsive Transportation and Shared-Ride Taxi Service/No Competing Local Transit Service



Data Sources: See p. V.44

FIGURE V-11: AVERAGE DAILY AND HOURLY RIDERSHIP VERSUS DAILY VEHICLE HOURS OF SERVICE

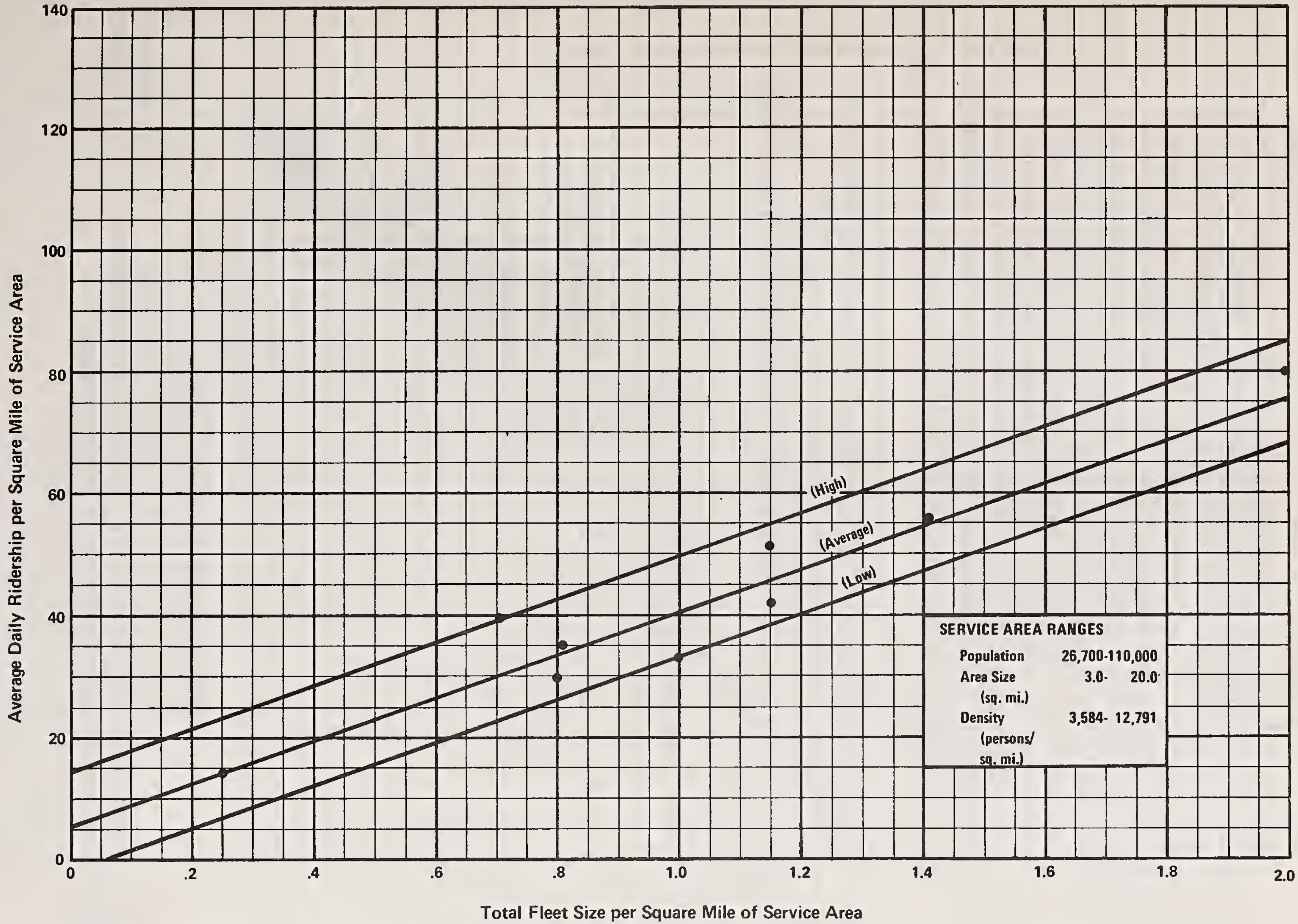
Demand Responsive Transportation and Shared-Ride Taxi Service/No Competing Local Transit Service



Data Sources: See p. V.44

FIGURE V-12: AVERAGE DAILY RIDERSHIP PER 1,000 PERSONS SERVED VERSUS TOTAL FLEET SIZE PER 1,000 PERSONS SERVED

Demand Responsive Transportation and Shared-Ride Taxi Service/Competing Local Public Transit Service



Data Sources: See p. V.44

FIGURE V-13: AVERAGE DAILY RIDERSHIP PER SQUARE MILE OF SERVICE AREA VERSUS TOTAL FLEET SIZE PER SQUARE MILE OF SERVICE AREA

Demand Responsive Transportation and Shared-Ride Taxi Service/Competing Local Public Transit Service

(3) DRT Services Exclusively for Elderly and Handicapped

Data for elderly and handicapped demand responsive transportation services are quite limited. Nevertheless, Figures V-14 and V-15 are presented to illustrate the basic pattern of demand response to service supply and the relation between service supply and transit ridership. Figure V-14 provides high, low, and average estimates of daily ridership response per thousand eligible elderly and handicapped persons served, assuming a planned level of transit service (measured by fleet size per thousand elderly and handicapped users). This relation should be used if the number of elderly and handicapped persons in the service area can be estimated. Alternatively, Figure V-15 provides estimates of daily ridership response per square mile, assuming a planned level of transit service (measured by fleet size per square mile).

A linear relation between ridership, service, and service area characteristics derived from the data available is as follows:

$$ADRSM = -3.7727 + 0.00035SAPD + 0.06575SA + 20.508\ TFSSA;$$

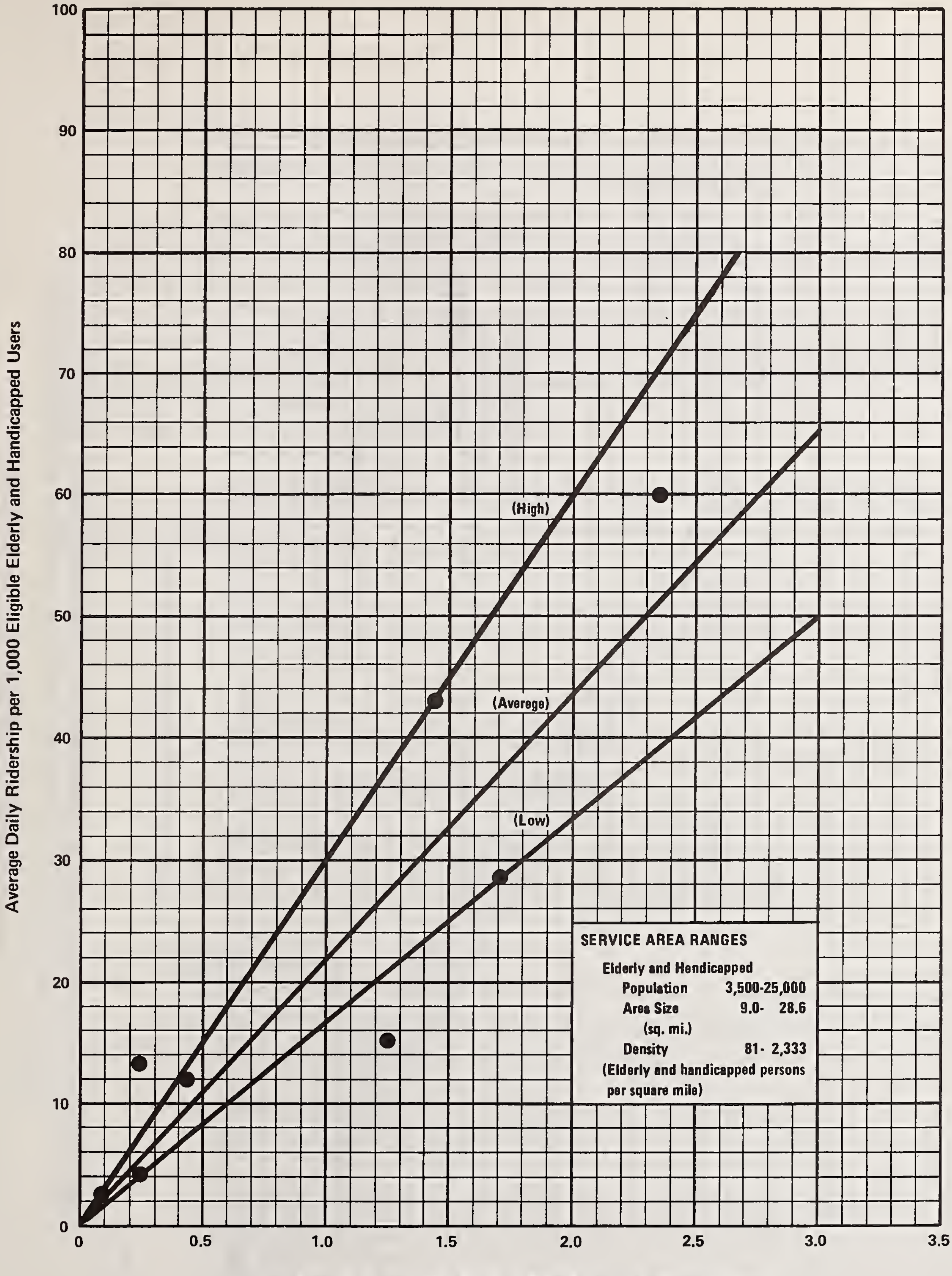
where:

ADRSM = Average daily elderly and handicapped ridership per square mile of service area

SAPD = Service area population density (eligible users per square mile)

SA = Service area

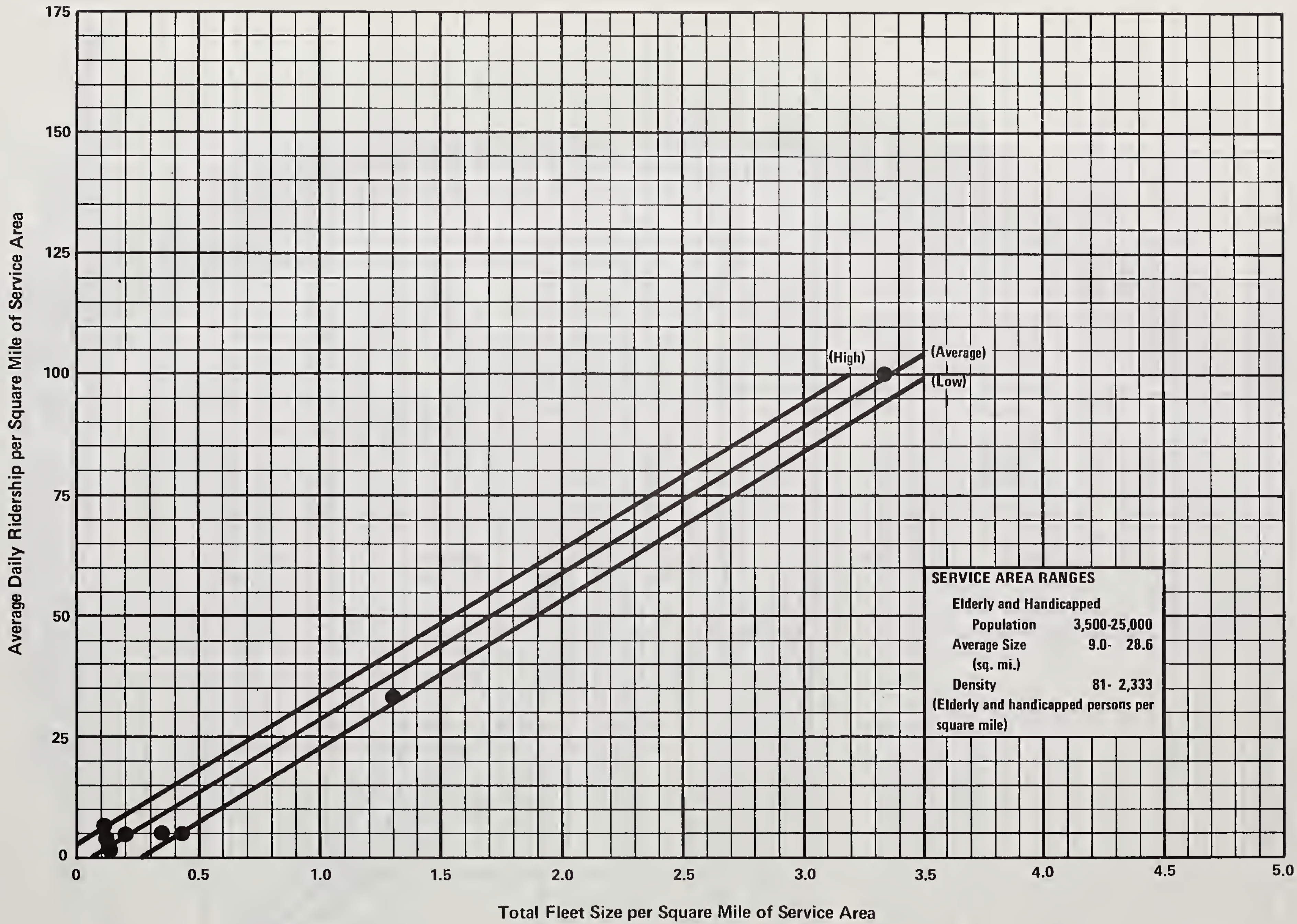
TFSSA = Total fleet size per square mile of service area



Data Sources: See p. V.44

FIGURE V-14: AVERAGE DAILY RIDERSHIP PER 1,000 ELIGIBLE ELDERLY AND HANDICAPPED USERS VERSUS TOTAL FLEET SIZE PER 1,000 ELIGIBLE ELDERLY AND HANDICAPPED USERS

Demand Responsive Transportation Service
Exclusively for the Elderly and Handicapped



Data Sources: See page V.44

FIGURE V-15: AVERAGE DAILY RIDERSHIP PER SQUARE MILE OF SERVICE AREA VERSUS TOTAL FLEET SIZE PER SQUARE MILE OF SERVICE AREA

Demand Responsive Transportation Service Exclusively for the Elderly and Handicapped

(4) DRT Service Coordinated with Local and Regional Public Transit

For DRT systems coordinated with other local and regional public transportation service, Figures V-16 and V-17 relate transit supply rates to expected average ridership rates. Figure V-18 shows expected daily and hourly average ridership as a function of average vehicle-hours of service operated per day. These graphs provide an estimate of the range of transit ridership levels and are suitable for preliminary feasibility analysis of alternative system plans. Clearly, the range of experience is quite varied.

The following linear relation between transit ridership, service supply, and service area characteristics was derived from data for DRT systems in this operating environment:

$$ADR = 172.16 + 0.0291SAP - 91.075SA + 75.84TFS$$

where:

ADR = Average daily ridership;

SAP = Service area population;

SA = Service area (square miles); and

TFS = Total fleet size.

c. Application

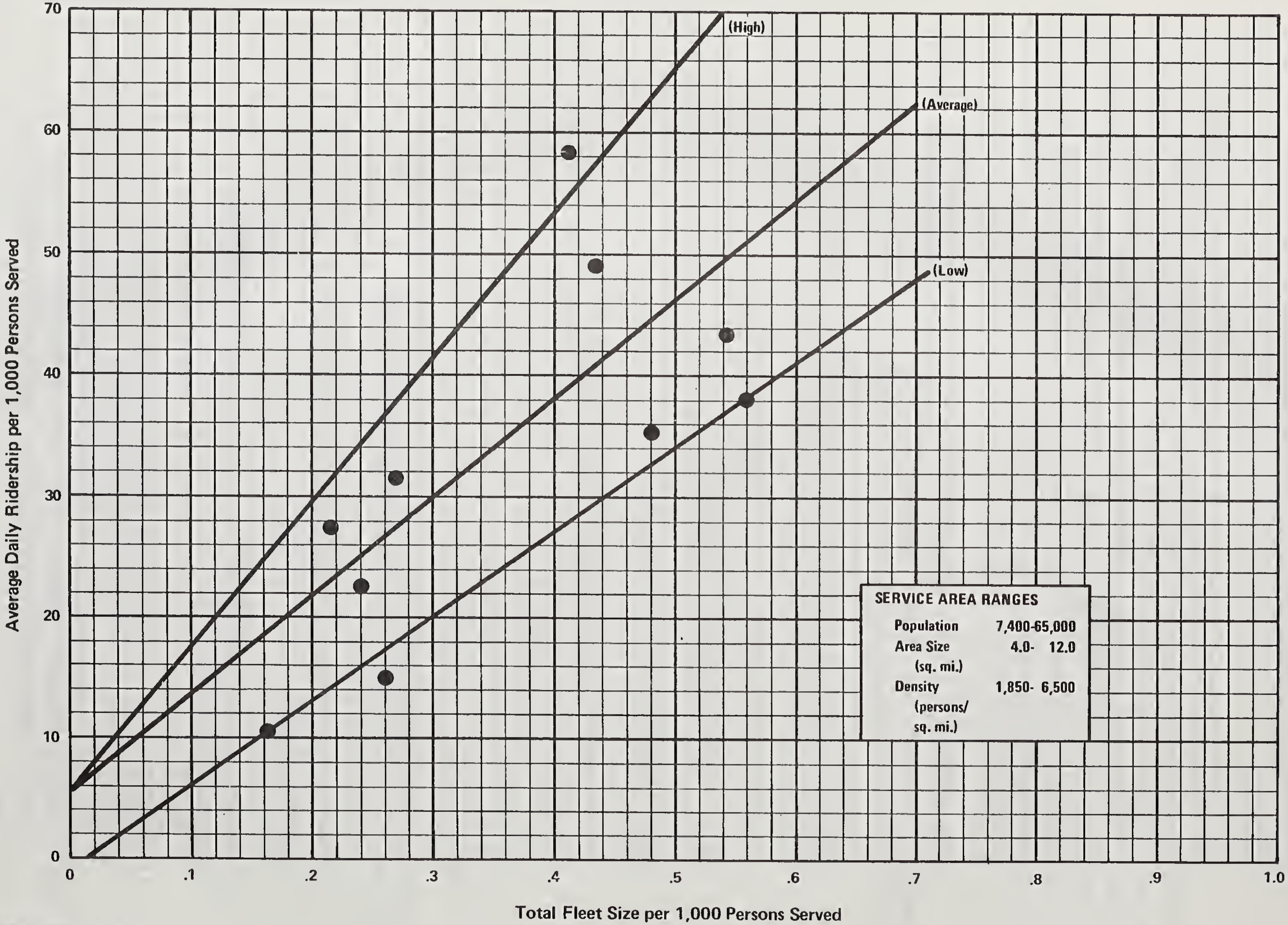
Use of the graphs and relations for preliminary feasibility is straightforward and consists of the following basic steps:

(1) Determine which of the four DRT situations is appropriate for the analysis.

(2) Select a trial total fleet size for the DRT or shared-ride operation.

(3) Measure the service area population and/or size for one or more candidate service areas.

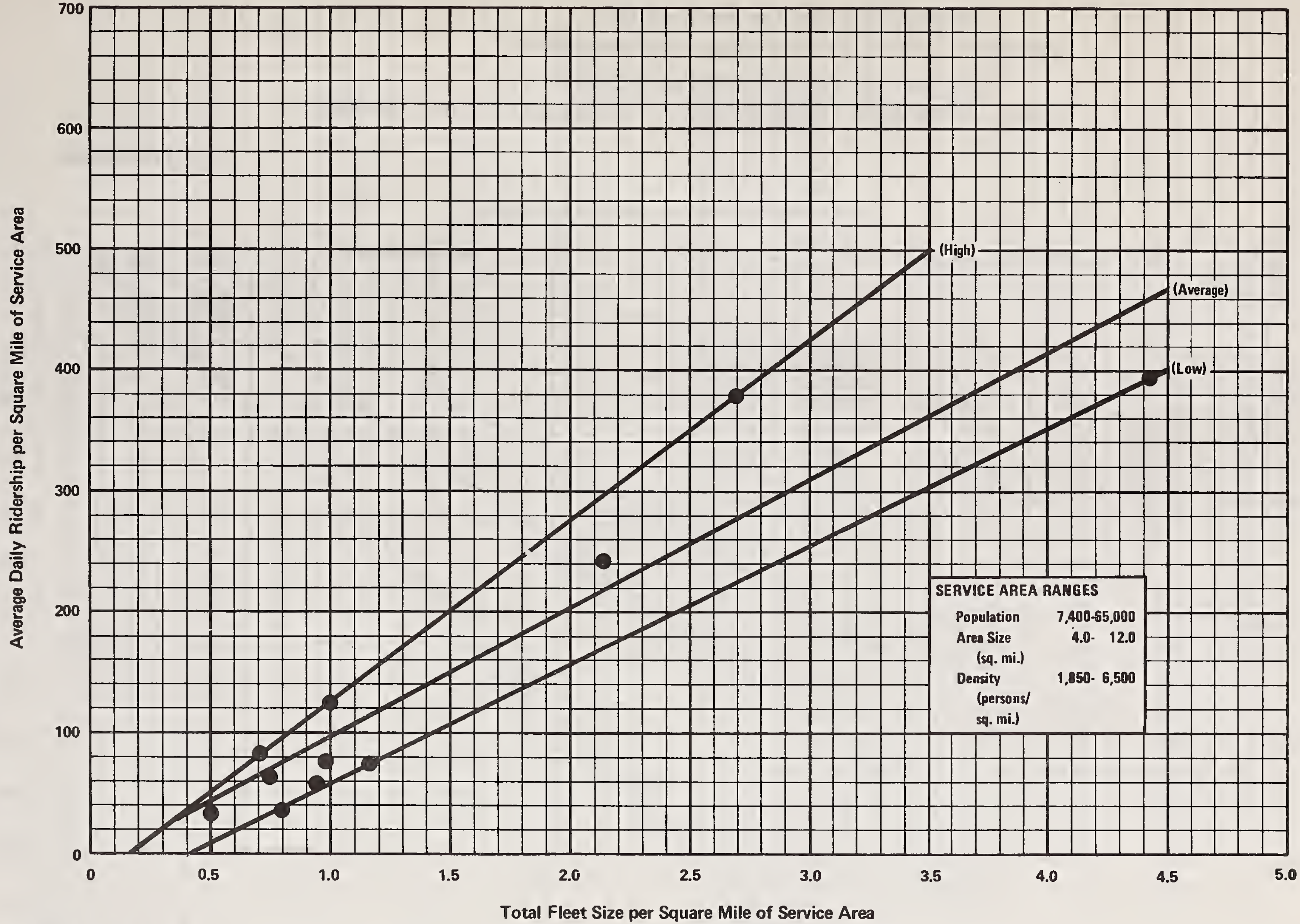
(4) Compute transit supply rate(s) and total fleet size per 1,000 persons served and/or per square mile of service area.



Data Sources: See p. V.44

FIGURE V-16: AVERAGE DAILY RIDERSHIP PER 1,000 PERSONS SERVED VERSUS TOTAL FLEET SIZE PER 1,000 PERSONS SERVED

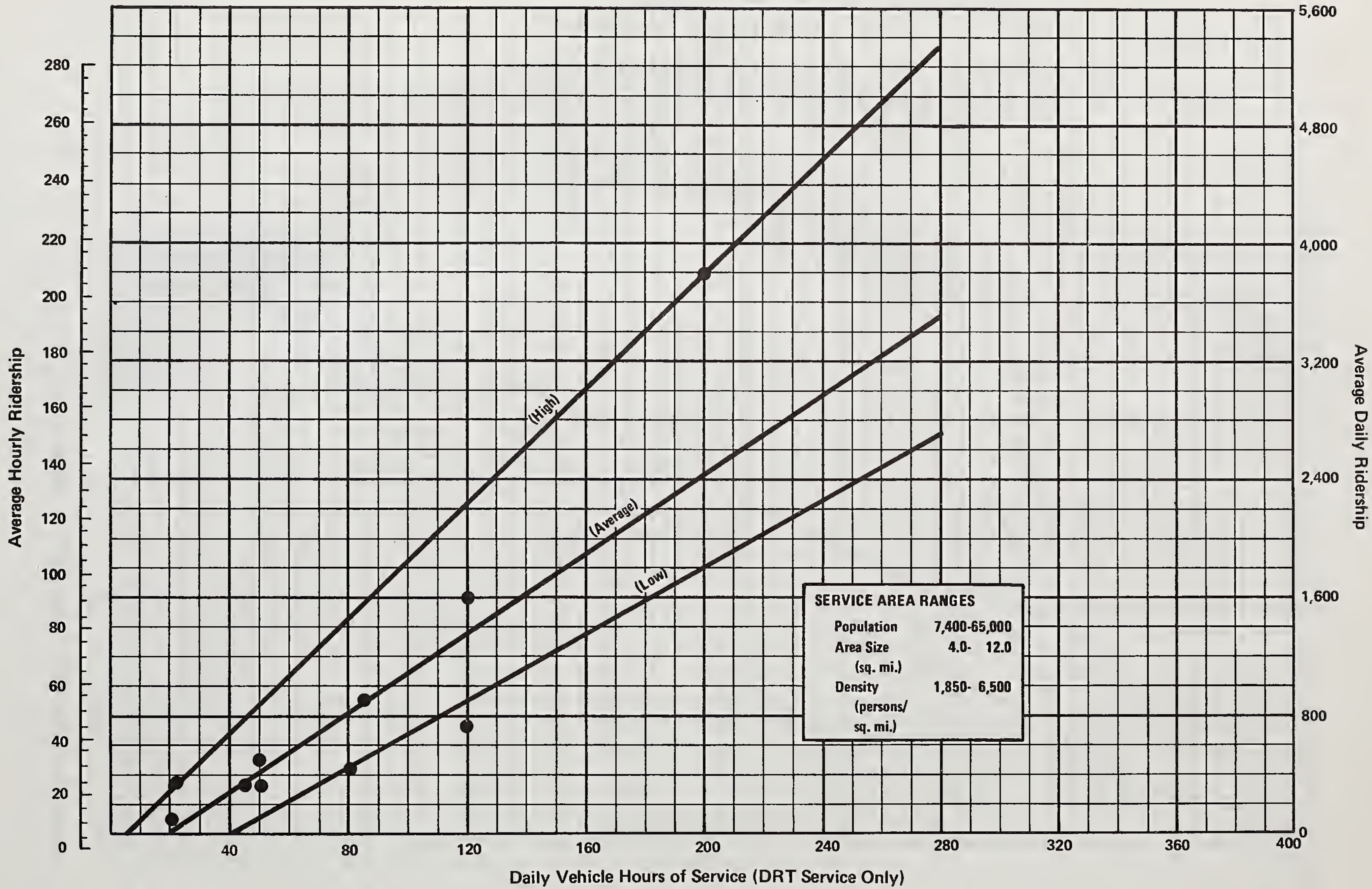
Demand Responsive Transportation Service Coordinated with Local and Regional Public Transit



Data Sources: See page V.44

FIGURE V-17: AVERAGE DAILY RIDERSHIP PER SQUARE MILE OF SERVICE AREA VERSUS TOTAL FLEET SIZE PER SQUARE MILE OF SERVICE AREA

Demand Responsive Transportation Service Coordinated with Local and Regional Public Transit



Data Sources: See p. V.44

FIGURE V-18: AVERAGE DAILY AND HOURLY RIDERSHIP VERSUS DAILY VEHICLE HOURS OF SERVICE

Demand Responsive Transportation Service Coordinated with Local and Regional Public Transit

(5) Enter the appropriate graphs to obtain high, low, and average transit ridership rates.

(6) Compute the estimated ridership by multiplying the rate times the service area population or service area size as appropriate.

(7) Repeat steps 2 through 6 for varying fleet sizes or services areas.

(8) For Figures V-11 and V-18, estimate vehicle-hours rather than fleet size. Obtain ridership estimates directly from graphs. Repeat for varying service levels.

Considerable variability is reflected in the graphs, and, to appreciate the range of potential experience, this variability should be carried through the estimation process. An alternative procedure is to use each of the equations relating ridership to service areas and service area characteristics, although this method assumes that initial concepts of fleet size have been developed.

6. Method 4: Systemwide Ridership by Tripmaker Stratification - DRT Service

a. Description

This method estimates the daily and weekly patronage for a small urban area (5,000 to 25,000 population) DRT system. It is based on the assumption that transit tripmaking propensities for persons in various age and sex stratifications are similar among small urban areas. The method produces satisfactory results when applied to cities with populations between 5,000 and 25,000. Total travel on a DRT system is estimated by multiplying the trip rates for each stratum in the population by the number of people in each stratum. The procedure is applicable only in a small city that has no competing local public transportation system. It is primarily for use in analyzing a many-to-many DRT System; it is also appropriate for point and route deviation service since transit tripmaking propensity in a small urban area is more a function of user characteristics than of service characteristics.[1] The method is quick and easy to apply, requiring only population stratifications and proposed fare structure for input. Because of the structure of the curves, sensitivity to fares can be tested.

b. Development and Theory

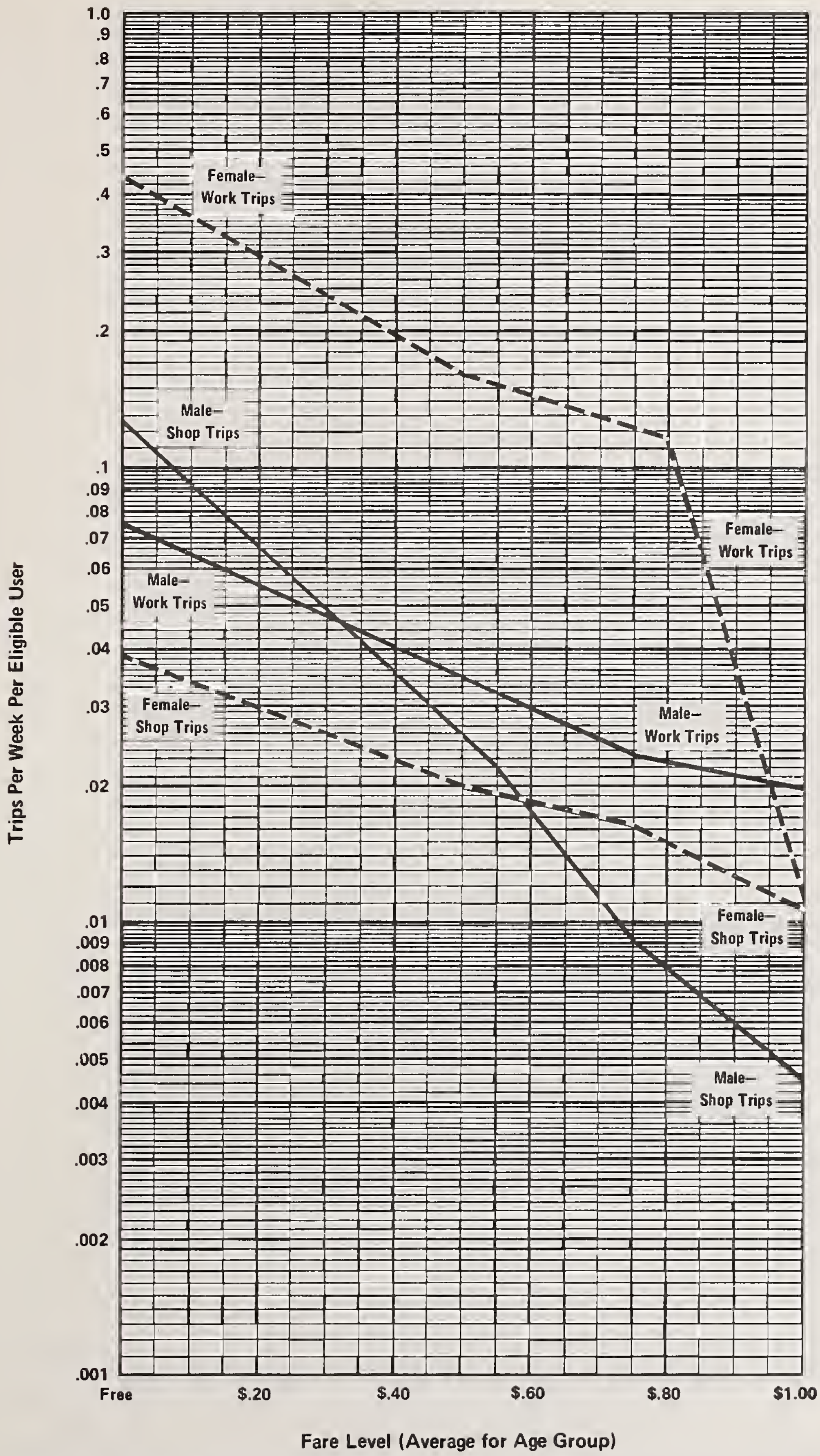
In Figures V-19, V-20, and V-21, curves are developed for each age, sex, and purpose category in the service area. These curves are based on ridership surveys in Batavia and Oneonta, New York; they have been applied to populations in several Michigan cities where DRT systems operate and have been found to be appropriate for estimating total DRT ridership. The procedure was found to be most accurate, however, for predicting total weekly ridership.[2]

Finally, daily ridership can be estimated as a percentage of the weekly ridership, depending on the number of days during the week that a system normally operates. If Saturday service is provided, average

---

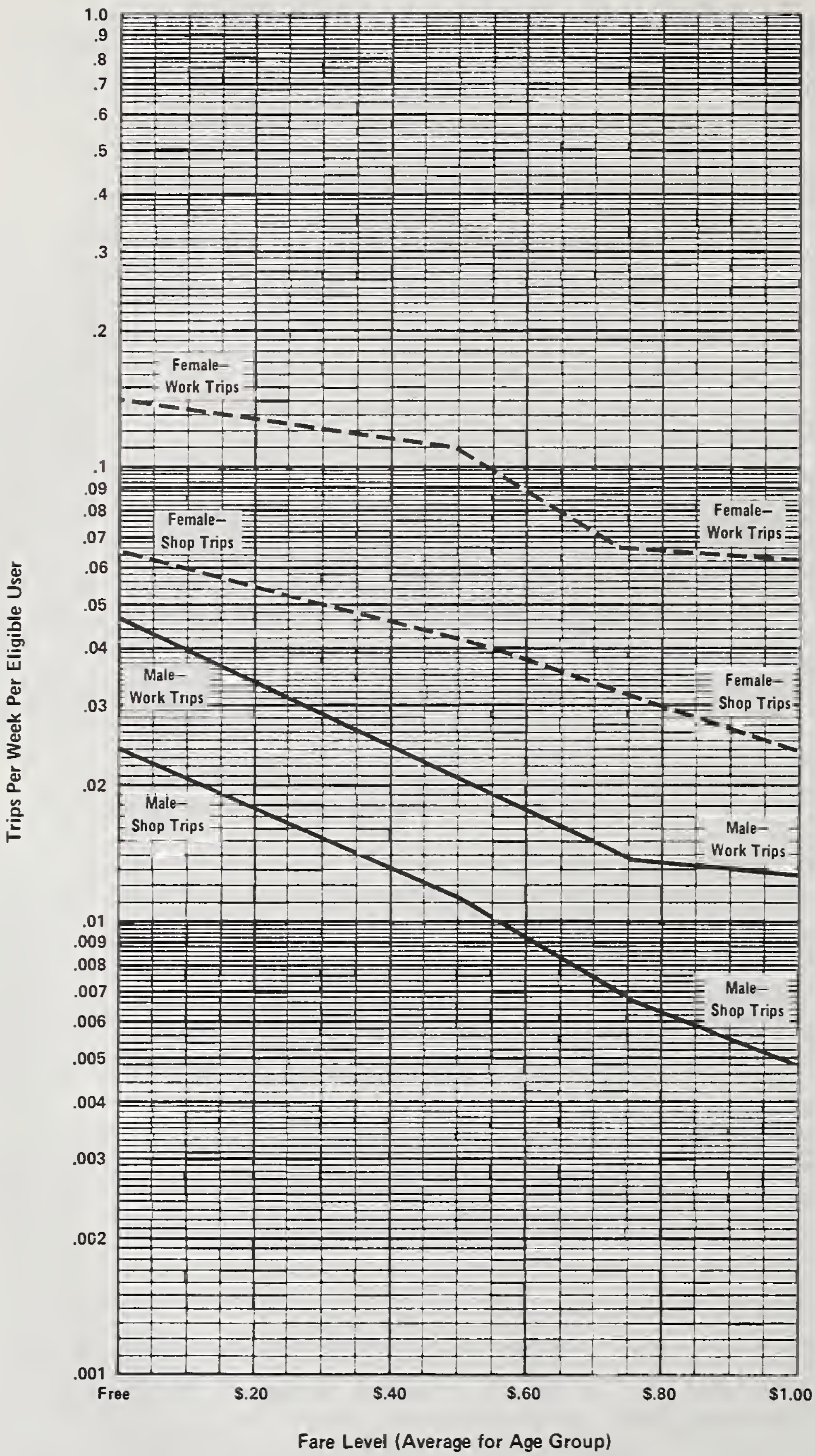
[1]Kenneth W. Kloeber and Stephen M. Howe, "Marginal Weighting Procedures for Expanding Small Sample Surveys," Preliminary Research Report #97 (New York State Department of Transportation, November 1975) and David T. Hartgen and Carol A. Keck, "Forecasting Dial-a-Bus Ridership in Small Urban Areas," Preliminary Research Report #60 (New York State Department of Transportation, April 1974).

[2]Michigan Department of State Highways and Transportation, Michigan Dial-a-Ride Transportation Program Status Report (February 1976).



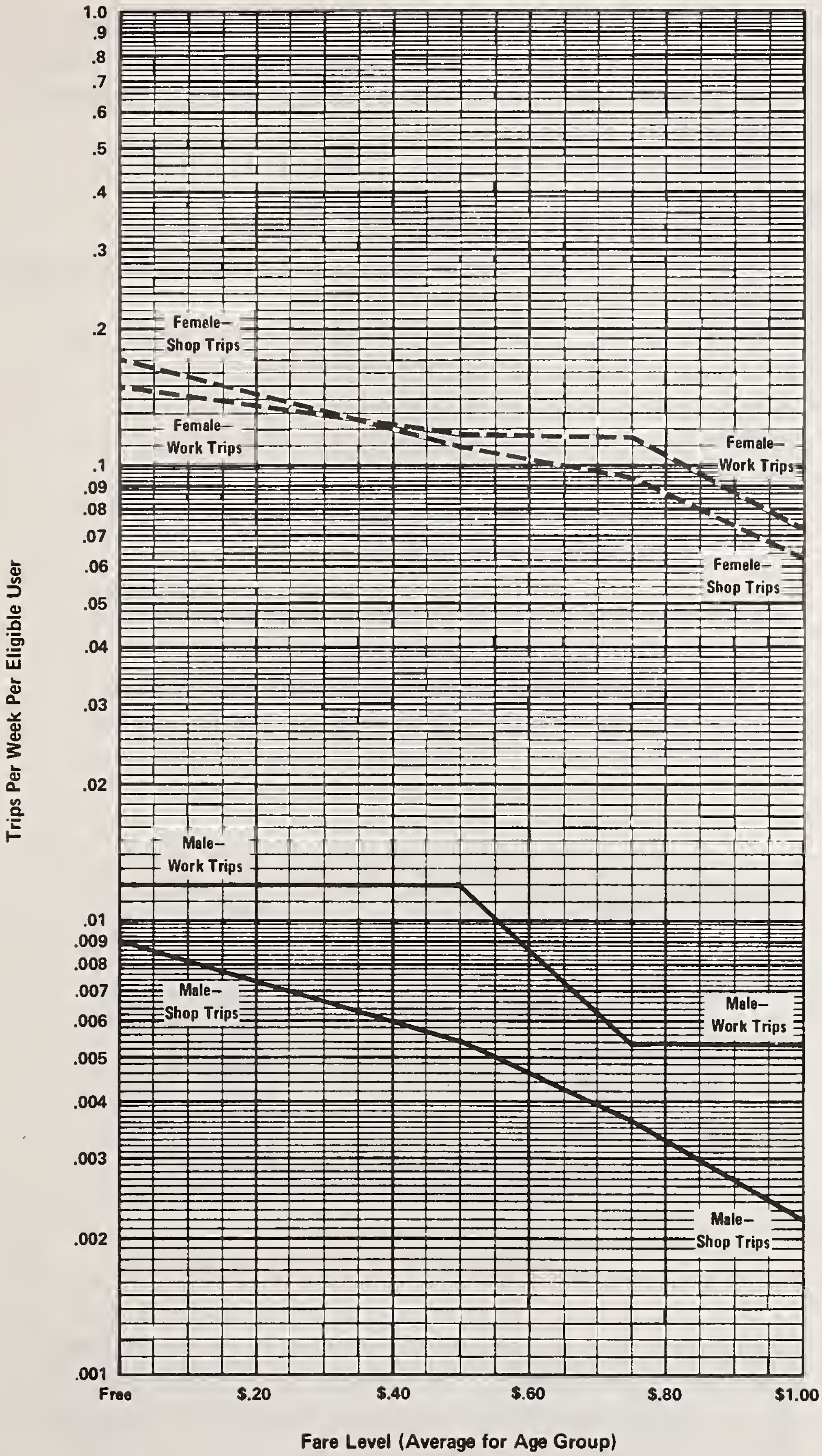
SOURCE: New York State Department of Transportation
Preliminary Research Report 97.

FIGURE V-19: ESTIMATED DRT RIDERSHIP FREQUENCY–
AGE GROUP 16-24 YEARS



SOURCE: New York State Department of Transportation
Preliminary Research Report 97.

FIGURE V-20: ESTIMATED DRT RIDERSHIP FREQUENCY– AGE GROUP 25-54 YEARS



SOURCE: New York State Department of Transportation
Preliminary Research Report 97.

FIGURE V-21: ESTIMATED DRT RIDERSHIP FREQUENCY– AGE GROUP 55+ YEARS

weekday volumes should be estimated as 18 percent of weekly volume, and Saturday volume should be estimated as 10 percent of weekly volume. If no Saturday service is provided, the average weekly volume is simply 20 percent of the weekly ridership.

c. Application

The application of this procedure is straightforward and consists of the following steps:

(1) Determine the applicability of the method. Is the application for a small city (5,000 to 20,000 population)? Is there no other local public transportation service? Is the service proposed a many-to-many DRT, point deviation, or route deviation service?

(2) Obtain service area population characteristics data. Define the proposed service area or alternative service areas, and, for the entire service area, obtain estimates of the following population strata:

	SEX	AGE
(a)	male	16-24
(b)	male	25-54
(c)	male	55+
(d)	female	16-24
(e)	female	25-54
(f)	female	55+
(g)	both	5-15

(3) Determine the proposed fare structure or alternative fare structures. Construct a trial fare structure, and estimate the average fare for classifications (a) through (f) above.

(4) Estimate weekly trip rates for work trips and shop trips by strata (a) through (f) from Figures V-17, V-19, and V-20.

(5) Multiply the trip rates for work and shop trips for each category by the population in each category. Sum the total of all trips.

(6) Apply a factor to estimate child ridership; use the following factor: one plus the fraction of the population between 5 and 15 years of age (g).

(7) Estimate daily ridership. Use 18 percent of weekly estimate and 10 percent for Saturday if Saturday service is operated, or use 20 percent of weekday estimate for average weekly ridership if no Saturday service is provided.

d. Example

(1) Service area population 16,000, no existing service, many-to-many DRT proposed.

(2) Population distribution:

AGE		POPULATION
5-15	(male and female)	3,800
16-24	male	1,600
25-54	male	2,200
55+	male	1,450
16-24	female	1,650
25-54	female	2,400
55+	female	1,800

(3) Proposed fare structure:

Adult	$0.60
Students (under 18)	$0.25
Senior Citizens (over 65)	$0.25

Assume the following average fares for each age group:

AGE	FARE
16-24	\$0.34 (assume 75 percent of the riders aged 16-24 will be under 18) (.75 x .25) + (.25 x .60) = 0.34
25-54	\$0.60
55+	\$0.34 (assume 75 percent of the riders aged 55+ will be over 65) (.75 x .25) + (.25 + .60) = 0.34

(4) Estimate trip rates from Figures V-19, V-20, and V-21.

Age	Trips per week per resident			
	Male		Female	
	Work Trip	Shop Trip	Work Trip	Shop Trip
16-24	.046	.043	.235	.026
25-54	.0176	.0091	.09	.037
55+	.012	.0064	.13	.128

(5) Estimate weekly ridership for each group and sum:

Age	Weekly Ridership			
	Male		Female	
	Work Trip	Shop Trip	Work Trip	Shop Trip
16-24	74	69	388	43
25-54	39	20	216	89
55+	17	9	234	230

Subtotal = 1,428

(6) Expand by factor for child ridership:

$$1{,}428\left(1 + \frac{3{,}800}{16{,}000}\right) = 1{,}767 \text{ weekly riders}$$

(7) Estimate average daily ridership

If Saturday service is operated:

1,767 x 0.18 = 318 riders, average weekday
1,767 x 0.10 = 177 riders, Saturday

If Saturday service is not operated:

1,767 x 0.20 = 353 riders, average weekday

7. Method 5: Basic Market Research Procedure

Increasing attention is being paid to marketing approaches for improving public transportation ridership and service. This approach is most prevalent in the context of modifying existing service to improve ridership, although it is applicable to situations where no service currently exists. The approach may be summarized as having five basic steps:

- defining the market to be served;
- designing transit service to the serve the market;
- evaluating market response to alternative changes in service;
- selecting the service alternative; and
- communicating the service changes to the public.

a. Description

Key components to this process are the definition of markets and the evaluation of market response (ridership) to a service change. These components are described here as a market research approach to demand forecasting. The market research approach attempts to finely subdivide the total existing and potential transit market into a number of market segments characterized by a set of transportation needs and desires which are applicable to the individual members of each market segment. The more finely the total market is stratified, the more homogeneous each group becomes and the better each can be described and characterized. Most importantly, the more information and understanding one has about a market segment, the less sophisticated is the technique required to estimate the response of the market to changes in transit service; assumptions and estimates can be substituted for rigorous analytical methods.

Demand analysis using a market research approach consists of defining the market segments, estimating the quantity of travel by these segments, and estimating the share of this travel that will use transit services. Since the process is not formalized in the sense of a mathematically specified travel demand model, it requires considerable insight on the part of the user. Section III. C of this manual, a suggested set of market segments is described for purposes of describing and assessing the local market for transit services. This set of 17 selected market segments is used as the basis for the market research demand analysis approach.

b. Development and Theory

Table V-5 describes the step-by-step procedure for analyzing each of the 17 market segments introduced in Chapter III. Typical data and approaches are presented as a reference, although the unique characteristics of each community and the availability of data may suggest better techniques.

Data input and approaches are labeled fair, good and best using the following criteria:

- suitability for estimation of market segment size;
- ease of acquiring data; and
- data quality (reliability, degree of difficulty with which data are updated, etc.).

Using these criteria, approaches and data inputs labeled fair would be characterized by:

- procedures and assumptions adapted from other data sources (previous studies, locally available data);
- assumptions based on experience in other cities;
- data that may be out of date; and
- procedures that are only marginally suited for estimating the size of market segments but that are very inexpensive and/or for which very little data collection effort and no special-purpose surveys are required.

Data inputs and approaches labeled good are characterized by:

- procedures and assumptions generally developed for another purpose but which are suitable for market segment estimation;

TABLE V-5

PROCEDURES TO DETERMINE THE SIZE OF 17 TYPICAL TRANSIT MARKETS IN SMALL URBAN COMMUNITIES

Market Segment	Procedure for Estimating the Potential Size of the Transit Market	Technique (Date Used)		
		Fair	Good	Best
1. Workers – CBD	1. Estimate total CBD employment (divide CBD into zones if CBD is larger than 1.0 square mile)	Pedestrian counts at large employment center entrances, exits Data from previous transportation study	Sample employer survey 1970 Census journey-to-work* Sample employee survey	Complete employer survey City or county small area employment data
	2. Estimate percentage of CBD workers whose residence zone is beyond possible transit service area limits (or urbanized area)	Data from previous transportation study (study area cordon survey) Parking survey CBD cordon survey	Sample employer survey 1970 Census journey-to-work Sample employee survey	Complete employer survey City or county employment data
	3. Subtract CBD workers whose residence is beyond possible transit service area limits (or urbanized area) from total CBD employment			
	4. Estimate daily one way work-trips produced by CBD workers residing in study area traveling to/from each zone	Use 1.7 times employment (0.85 round trips per employee per day)**		Employer survey (estimate factor)
	5. Estimate distribution of CBD work trips to residence zones a. by corridor, sketch corridors on map; estimate population in each corridor, distribute CBD workers to each corridor according to corridor population distribution	Existing transit ridership by route and traffic volumes in each corridor	1970 Census of population Parking survey	Small area population updates (city or planning agency)

TABLE V-5 (Continued)

Market Segment	Procedure for Estimating the Potential Size of the Transit Market	Technique (Date Used)		
		Fair	Good	Best
			Sample employee survey Previous transportation survey origin-destination trip table	
	b. areawide, by concentric rings or by small area; distribute CBD workers according to areas indicated in survey or previous study	Parking survey Sample employee survey Previous transportation study origin-destination trip table		Distribute trips between CBD and zones based on population distance from CBD, income, etc.
2. Workers – non CBD large employment centers, e.g., large factories, office complexes, industrial parks, shopping centers, universities, hospitals	1. Estimate non-CBD employment in zones (census tracts, enumeration districts, traffic zones, or survey zones)	Pedestrian counts at large employment center entrances, exits Data from previous transportation study	1970 Census journey-to-work	Sample employer survey City or county small urban area employment data
	2. Estimate percentage of workers at each large employment center whose residence zone is beyond possible transit service area limits (or urbanized area)	Parking survey	1970 Census journey-to-work Sample employee survey	Sample employer survey City or county employment data (labor force data)
	3. Subtract workers whose residence is beyond possible transit service area limits (or urbanized area) from total employment for each large employment zone			

TABLE V-5 (Continued)

Market Segment	Procedure for Estimating the Potential Size of the Transit Market	Technique (Date Used)		
		Fair	Good	Best
	4. Estimate daily one-way work-trips produced by workers in each large employment zone	Use 1.7 times employment (0.85 round trips per employee per day)		Employer survey (estimate factor for work-trips per employee per day)
	5. Estimate distribution of large employment zone workers to residence zones	1970 Census of population	Parking survey Home interview survey Sample employee survey Previous transportation study origin-destination trip table	Trip distribution (Section IV-G-7)
	Alternative Procedure 5A (replaces 1-5) Use 1970 Census journey-to-work trip table; select those zones whose destination are large employment zones			1970 Census journey-to-work Urban Transportation Planning Package
3. Workers – employment in nearby regional centers	1. Estimate main portion of total market from boarding counts on regional line-haul system to regional center (commuter rail, rail rapid transit express bus, or intercity bus)		Commuter rail ticket sales by station	On/off counts for regional line-haul system (by station or bus stop)
	2. Estimate portion of total market not currently using regional line-haul system		1970 Census journey-to-work	City cordon survey Previous transportation study data
	3. Survey regional line-haul system commuters at boarding points for residence, current access mode, trip purpose, intended use of transit service		Parking lot survey (mail-back survey at commuter rail station)	Boarding point survey (interview or mail-back)

TABLE V-5 (Continued)

Market Segment	Procedure for Estimating the Potential Size of the Transit Market	Technique (Data Used)		
		Fair	Good	Best
	4. For each regional line-haul system boarding point, estimate number of commuters residing over 6 blocks from station; sketch areas on base map or overlay (areas from boarding points should not overlap)		Parking lot survey	Boarding point survey
	5. Estimate percent of commuters from each potential service area. Use 35 to 60% of intended use as determined from survey, depending on parking availability and wording of survey		Parking survey (intended tranist use)	Boarding point survey (intended transit use)
4. Workers – dispersed employment opportunities (e.g., domestic workers)	1. Estimate percent of domestic workers residing in each zone (enumeration district or census tract); select low income residential zones; estimate total number of domestic workers in each zone (percent times population)	Home interview survey On-board transit survey		1970 Census – Population tion Census Tract Report – Table P.3 (labor force characteristics)
	2. Distribute domestic worker population to areas where they are assumed to work; sketch desire lines on base map or overlay	Telephone or home interview survey in low income zones	1970 Census-Compute weighting factor: Weight = (pop.) X (median family income); distribute domestic worker trips according to zonal weights	
5. Shop Trips (non-grocery)	1. Estimate number of daily one-way trips at large shopping activities (CBD, regional shopping center, major neighborhood shopping areas)	Previous transportation study area	Pedestrian counts at major stores Shopping center survey (obtain shopping trip rate per household)	

TABLE V-5 (Continued)

Market Segment	Procedure for Estimating the Potential Size of the Transit Market	Technique (Data Used)		
		Fair	Good	Best
	2. Estimate major retail trade area for each shopping activity; sketch on base map or overlay (trade areas may overlap)		Sketch areas based on experience, location of competition with similar areas Parking survey (CBD, shopping centers)	Marketing study for each shopping activity
	3. Distribute trips throughout retail trade area; sketch trip desire lines on base map or overlap or build resultant zone-to-zone trip table (one-way trips)		By zone: percent of trips to each shopping activity from each zone proportional to population and, inversely, proportional to distance from shopping activity	Parking survey (CBD, shopping centers) Pedestrian interviews (CBD, shopping centers)
6. Shop Trips (grocery)	1. Locate major supermarkets on map; size of each (gross floor space), retail trade area for each (map overlap)		Retail trade areas based on location of competition, parking supply	City/county data Directory of Supermarkets
	2. Estimate number of daily one-way trips to each supermarket		Trip generation factor (from spot surveys at several stores of varying sizes)	Pedestrian counts (in/out) at each supermarket
	3. Distribute trips throughout each market's retail trade area; sketch desire lines on base map or overlay or estimate zone-to-zone and intrazonal trips (each supermarket trip is two one-way trips)		Distribute to zones by population distribution	Pedestrian or parking survey at a sample of supermarkets (ask residence)

TABLE V-5 (Continued)

Market Segment	Procedure for Estimating the Potential Size of the Transit Market	Technique (Date Used)		
		Fair	Good	Best
7. School Trips – students age 12 to 17 years old	1. Obtain school enrollments by school, junior high school and senior high school	1970 Census of population	City/county data	Board of Education data
	2. Determine area of influence for each school, sketch on base map or overlay: color-code as required for clarity		City/county data (school districts)	Board of Education data (school districts)
	3. For each school, subtract number of students for whom bus service is provided		School bus ridership (school bus operators)	Board of Education data
	4. For each school, subtract number of students who live within 8 blocks (1 mile) of school		Sketch 1 mile circle around each school; determine proportion of influence area within circle; multiply by number of students remaining after step 3	School records – sample of students; proportion of addresses within 1 mile Sample survey in selected schools
8. School Trips – university students	1. Obtain university enrollment, stratified as full-time or part-time, resident on-campus or off-campus; other data, if available (e.g., concentration of off-campus residences, times of classes)		1970 Census of population (Table P-2) Knowledge of city	University data University cordon survey
	2. Indicate concentration of off-campus student residences on a base map or overlay; show volume of university students by zone		1970 Census of population updated, if possible	University data University cordon survey
	3. Draw connectors between major campus destinations and concentrations of off-campus housing (indicate potential residence concentration if transit service provided), i.e., desire lines			

TABLE V-5 (Continued)

Market Segment	Procedure for Estimating the Potential Size of the Transit Market	Technique (Data Used)		
		Fair	Good	Best
	4. Estimate number of students who drive to campus			University parking data
	5. For each area of student residence concentration over 8 blocks (1 mile) from campus, estimate trips to/from campus per day	Use 1.2 to 2.0 one-way trips per day depending on class scheduling system		Small sample survey in student residence areas or on campus (classes) University cordon survey
9. Nonschool Trips – residents aged 12 to 17 years Shop Medical/dental Social/Recreational Personal business	1. Locate residences of persons aged 12 to 17 years; estimate number by zone of residence (survey zone, traffic zone, census tract, block group, or enumeration district)		1970 Census of population Home or telephone interview survey	1970 Census of population updated by city or county School records – number of students by zone or residence
	2. Locate probable destinations on base map or overlay; designate shopping centers and business districts in one color, special recreational areas (pools, skating rinks, parks, amusement parks, beaches, community centers) in another		Home or telephone interview survey	Maps, telephone book, and knowledge of city
	3. Locate a centroid of population in each zone on base map or overlay; connect each zone centroid to nearest shopping/business area and recreation area of each general type; eliminate connections less than 8 blocks (1 mile)			
	4. Estimate a weekly trip rate for each activity (shopping and recreation by type), if possible		Assumptions based on experience; demand rates at recreational facilities (persons using facility per resident in the facility service area)	

TABLE V-5 (Continued)

Market Segment	Procedure for Estimating the Potential Size of the Transit Market	Technique (Date Used)		
		Fair	Good	Best
	5. Estimate the number of weekly one-way trips on each desire line sketched. Multiply weekly trip rate from Step 4 by concentration of students age 12 to 17 years in each zone, if possible. Otherwise, make order-of-magnitude estimates of trips connecting highest concentrations of student residences to shopping/business areas and recreational facilities to get a rough idea of market segment potential.		Home or telephone interview survey	
10. Social/Recreational Trips Entertainment – sport events, special events, museums, theaters, movies, restaurants	1. Treat high-volume special events and sport events separately; estimate total patronage for each event; estimate percent of patronage expected to come from beyond study area, subtract from total			Attendence of special events, sport events (high school, college, exhibition, semi-professional, professional)
	2. Distribute remaining trips according to zonal population distribution in appropriate area (e.g., school district for high school events); sketch desire lines on base map or overlay		1970 Census of population	1970 Census of population, updated
	3. For other entertainment areas, designate concentration of entertainment areas, if any, on base map or overlay			Telephone directory Knowledge of city
	4. Estimate daily one-way person-trips attracted to and from each area		Land use, size of movies, restaurants, theaters, museums	Actual patronage counts
	5. Estimate distribution of trips determined in Step 5.; sketch desire lines on base map or overlay or build zone-to-zone trip table	Distribute by population, distance from entertainment area	Home interview survey	Small sample survey in

TABLE V-5 (Continued)

Market Segment	Procedure for Estimating the Potential Size of the Transit Market	Technique (Date Used)		
		Fair	Good	Best
11. Trips by Tourists and Business Visitors	1. For tourist estimates, estimate total visitors to city (annual, by season, or weekly); designate points of interest likely to be visited; estimate daily or weekly visitor volume at each			City Chamber of Commerce or information bureau
Social/Recreational				Counts at points of interest
Shop				Estimates from sources representing point of interest
Personal Business	2. Designate areas tourist stay or might stay if transit service were provided	Assumptions based on knowledge of city	Hotel registration volumes	City Chamber of Commerce or information bureau
	3. Estimate number of daily or weekly tourist trips made between points of interest and lodging		Distribute volumes from Step 1 according to concentrations determined in Step 2	Small sample survey at points of interest
	4. For business visitors, designate concentrations of destinations (major office buildings, industrial parks, plants) on base map or overlay; estimate business visitor volumes at each		Interviews at major office buildings, industrial parks, plants	
	5. Designate concentrations of business visitor lodging	Assumptions based on knowledge of city	Hotel registration volumes (with business affiliation)	
	6. Connect business visitor lodging concentrations with destinations; estimate daily or weekly one-way trip volumes	Assumptions based on results of Steps 4 and 5		Small sample survey of business visitors
12. Trips Made for Access to/from Intercity Terminals	1. Obtain passenger arrival and departure counts (total and by time of day for each terminal)		Counts at terminals, timetables	Carrier data, boarding and alighting counts

TABLE V-5 (Continued)

Market Segment	Procedure for Estimating the Potential Size of the Transit Market	Technique (Date Used)		
		Fair	Good	Best
Bus stations	2. Estimate existing terminal access modal split for each terminal, percent encumbered with luggage		Previous transportation study	Observation
Railroad stations				Small sample survey at terminal
Airports	3. Estimate percent of travelers who would definitely not use proposed transit service, (i.e., non-transit captives), subtract from total	Assume percent of non-transit captivity for each current access mode (e.g., auto 60-90%, taxi 60-90%, rental car 85-95%, limousine 40-80%)		Small sample survey at terminal
	4. Determine distribution of origins and destinations to and from each terminal; sketch major origins/destinations on base map or overlays	Assumptions based on knowldege of city; hotels, major commercial areas; assume distribution of home-based trips based on population and income, depending on intercity mode		Small sample survey at terminal
13. Small Goods Movement (package delivery)	1. Estimate total potential package delivery market; determine need for service; estimate number of packages per week potential demand if service were available			Interview sample of potential users, cross section of business offices, computer service bureaus, pharmacies, inter city transportation terminal
	2. Determine package delivery origins and destinations, demand distribution by time of day	Assumptions about potential users		Interview sample of potential users

TABLE V-5 (Continued)

Market Segment	Procedure for Estimating the Potential Size of the Transit Market	Technique (Date Used)		
		Fair	Good	Best
14. Trips by Elderly Residents Shop Medical/dental Social/recreational Personal business Church	1. Estimate population in each zone (traffic zone, survey zone, census tract, block group, or enumeration district) over age 65	Previous transportation or planning study (use Table V-6)	1970 Census of population (Census tract reports, printout for block groups or enumeration districts) Home interview or telephone survey	Social Security records 1970 Census of population updated by city or county City planning department
	2. Estimate tripmaking rate total and by purpose		Previous transportation study Use Table IV.C.8	Home or telephone interview survey
	3. Estimate daily trips made by elderly, total and by purpose, produced in each zone; multiply rate by elderly population			
	4. Indicate likely destinations for elderly population – (shopping, medical, and community centers) a. sketch desire lines on base map or overlay, connecting concentrations of elderly population and likely destinations or b. distribute daily trips by elderly to likely destinations according to function of destination (i.e., shopping trips to shopping areas, social/recreational trips to community centers, medical trips to medical centers)			

TABLE V-5 (Continued)

Market Segment	Procedure for Estimating the Potential Size of the Transit Market	Technique (Date Used)		
		Fair	Good	Best
15. Trips by Low Income Residents Work	1. Estimate low income family (below poverty level or below specified income level) population in each zone (traffic zone, survey zone, census tract, block group, or enumeration district)	Previous transportation or planning study	1970 Census of population (census tract reports, printout for block groups or enumeration districts) Home interview survey	1970 Census of population updated by city or county
Shop Medical/dental	2. Estimate tripmaking rate (total and by purpose)		Use Table V-7	Home interview survey
Social/recreational Personal business	3. Estimate daily trips made by low income family residents (total and by purpose) produced in each zone; multiply rate by low income family population			
	4. Indicate likely destinations for low income family residents (clinics for medical trips, large employment centers for work trips, shopping areas for shopping trips) a. sketch desire lines on base map or overlay connecting concentrations of low income population and likely destinations or b. distribute the daily trips by low income family residents to likely destinations according to function of destination			
16. Trips by Physically Handicapped Residents	1. Obtain estimates of total number of physically handicapped persons in study area	Use Table V-8 (multiply rates by sex, age, or income time population)		City and county agencies, hospital records

TABLE V-5 (Continued)

Market Segment	Procedure for Estimating the Potential Size of the Transit Market	Technique (Date Used)		
		Fair	Good	Best
Work	2. Determine special transportation requirements of the physically handicapped		Use Figure V-22	Survey based on city or county agency data
School	3. Determine residences of physically handicapped			City and county agencies, hospital records
Shop	4. Determine weekly trip rates of physically handicapped		Use Table V-9	Survey based on city or county agency data
Social/recreational Medical/dental Personal business Church	5. Estimate total weekly trips made by physically handicapped population; multiply trip rates by handicapped population determined in Step 1 or use survey results			Survey based on city or county agency data
17. Trips by Mentally Handicapped Residents	1. Obtain estimates of mentally handicapped persons in area, locations of residences, if possible		City or county social service agencies	Interview with mental retardation center staff, families of mentally retarded residents
Medical/dental Social/recreational	2. Determine programs offered for mentally handicapped persons in area, locations and times of programs		City and county agencies	Interview with mental retardation center staff, families of mentally retarded residents
Shop School	3. Determine potential for special pre-arranged transit service to transport mentally handicapped persons to programs			Interview with mental retardation center staff, families of mentally retarded residents

TABLE V-5 (Continued)

Market Segment	Procedure for Estimating the Potential Size of the Transit Market	Technique (Date Used)		
		Fair	Good	Best
18. CBD Circulation Trips Combination of: Work Shop	1. Outline CBD on base map or overlay; designate all existing and proposed major generators (department stores, major office buildings, hotels); designate existing and proposed fringe parking lots		Telephone directory	Existing and proposed land use – city planning department
Personal business	2. Estimate distances between logical connections (fringe parking lots to major generators, between offices and major stores and restaurants)			
Medical/dental Social/recreational	3. Estimate daily person-trips between logical connections over 8 blocks (1 mile)	Assumption		Small sample pedestrian survey in CBD

- data that can generally be acquired from some local agency or from Census reports (although some data manipulation may be required); and

- better reliability than the techniques labeled fair.

The best techniques are characterized as:

- procedures and assumptions designed for market segment analysis;

- procedures generally requiring data collection designed specifically for market segment analysis; and

- procedures that are most reliable and current.

The market research demand estimation procedures are normally applied at the preliminary design and evaluation phases of the planning process. They can be applied at an areawide or subarea level of detail and can be readily modified in response both to the information and data available and to the community objectives for transit service. The data requirements are determined by the planner, and ad hoc or special surveys are implemented to embellish or augment existing data as needed for the particular markets being analyzed. The principal advantages of this method are the flexibility in procedure and adaptability to existing circumstances. Disadvantages include the need to rely on expert judgment for many aspects of the analysis as opposed to validated and objective techniques.

Data and statistics to assist in the determination of the potential transit market for elderly, low income, and physically handicapped residents are presented in Tables V-6 through V-9 and in Figure V-22.

TABLE V-6

ESTIMATED TRIPMAKING RATES FOR ELDERLY PERSONS
(Aged 65 years or more)

Trip Purpose	Average Number of Trips Per Person Per Day
Work	.125
Shop	.218
School/Church	.101
Other	.504
Total (excludes walk trips)	.948

SOURCE: Nationwide Personal Transportation Study, Federal Highway Administration (1969).

NOTE: Entire NPTS sample used to prepare these estimates.

TABLE V-7

ESTIMATED TRIPMAKING RATES BY INCOME STRATIFICATION

Annual Family Income (1969)	Trips per day per person				
	Work	Shop	School/Church	Other	Total
< $3,000	0.234	0.217	0.174	0.603	1.228
$3,000 – $5,999	0.370	0.262	0.243	0.762	1.637
$6,000 – $9,999	0.402	0.284	0.224	0.840	1.750
$10,000+	0.352	0.239	0.226	0.709	1.526

SOURCE: Nationwide Personal Transportation Study, Federal Highway Administration (1969).

NOTE: Entire NPTS Sample Used to Prepare These Estimates.

TABLE V-8

DISTRIBUTION OF TRANSPORTATION – HANDICAPPED RESPONDENTS* AND ESTIMATED NUMBER OF TRANSPORTATION – HANDICAPPED PERSONS IN URBAN POPULATION BY SEX, AGE, AND FAMILY INCOME

Sex, Age, and Family Income	Percent of All Transportation – Handicapped Respondents	Number of Transportation – Handicapped in U.S. (Thousands)	Number of Transportation – Handicapped per 1,000 Urban Residents
Both sexes	100.0	5,105	36.9
Male	33.3	1,702	25.9
Female	66.7	3,403	46.8
All ages over 5 years	100.0	5,105	36.9
6–16 years	2.8	143	4.4
17–44 years	12.0	613	10.2
45–64 years	32.3	1,649	52.0
65 years and over	52.9	2,701	193.0
All family incomes	100.0	5,105	36.9
Less than $3,000	9.8	500	76.8
$3,000– $5,999	21.8	1,113	63.3
$6,000– $9,999	22.4	1,144	43.5
$10,000–$14,999	18.4	939	26.8
$15,000 or more	27.6	1,409	26.6

*Includes only chronic conditions; excludes acute and tamporary conditions such as fractures, dislocations, sprains, strains, musculoskeletal diseases, and latter stages of pregnancy.

SOURCE: Description of the Transportation Handicapped Population, Raport No. 2, Research on the Transportation Problems of the Transportation Handicapped, Survey conducted by Paat, Marwick, Mitchell & Co. in mid-1974 (Octobar 1975).

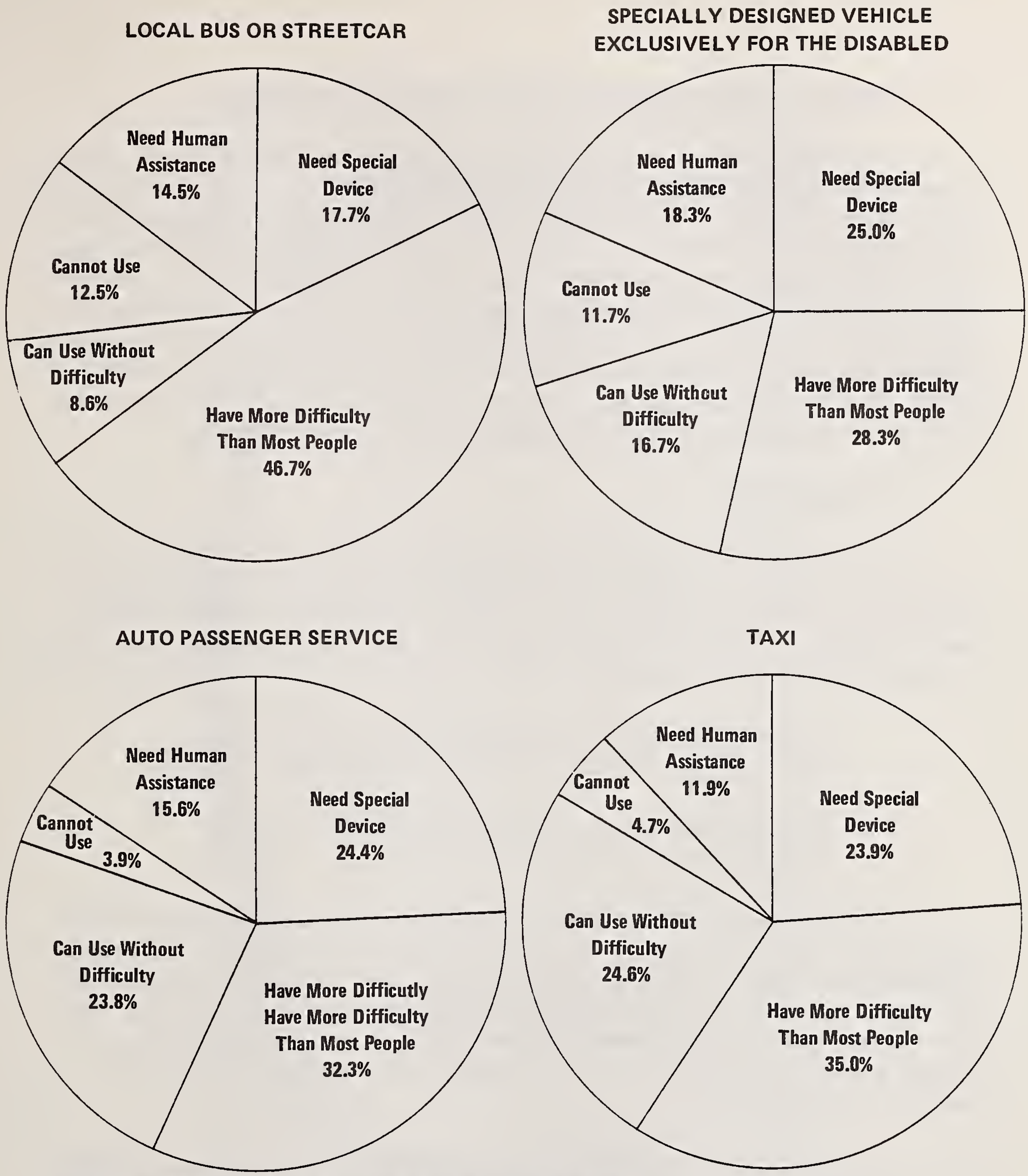
TABLE V-9

FREQUENCY OF TRAVEL OF TRANSPORTATION – HANDICAPPED PERSONS

	Overall Average Trips per Week	PERSONS MAKING AT LEAST ONE TRIP FOR STATED PURPOSE	
		Percent	Average Trips per Week
Trip Purpose			
Work	0.9	10.0	8.7
Shop	1.6	46.9	3.5
Medical	0.9	35.8	2.4
Social, recreational, and other*	1.8	47.1	3.8
Total	**5.2**	**67.6**	**7.7**
Ability to Drive			
Able to drive	8.5	83.7	10.2
Unable to drive	3.3	59.7	5.5
Availability of Transit			
Available	6.0	72.3	8.3
Unavailable	4.4	63.0	7.0

*Excluding school trips.

SOURCE: Description of the Transportation Handicapped Population, Report No. 2, Research on the Transportation Problems of the Transportation Handicapped, Survey conducted by Peat, Marwick, Mitchell & Co. in mid-1974 (October 1975).



NOTE: Data and statistics are based on the results of a nationwide mail survey conducted on a random sample of households drawn from the Consumer Mail Panel maintained by Market Facts, Inc. Of the 7,000 households receiving the questionnaire, 5,783 households (14,165 household members over 5 years of age) responded.

SOURCE: Based on survey conducted mid-1974, Description of the Transportation Handicapped Population, Report No. 2, Research on the Transportation Problems of the Transportation Handicapped, Peat, Marwick, Mitchell and Co., October, 1975.

FIGURE V-22: ABILITY OF THE TRANSPORTATION-HANDICAPPED TO USE TRANSPORTATION SERVICES

8. Method 6: Aggregate Work Trip Modal Split Curves

The transit share of the total work travel market is of particular importance to the transit planner for three reasons. First, work travel occurs almost entierly during peak hours, and a reasonable estimate of the transit share of this market will provide a good estimate of peak period ridership and a sound basis for estimating transit fleet requirements. Second, reduction in auto travel, if it is to have any impact on congestion or highway needs, must be made during peak period travel. Finally, for most systems work travel is a major component of all travel, and estimates of transit's share of the market can be factored to annual ridership estimates required for revenue analysis.

a. Description

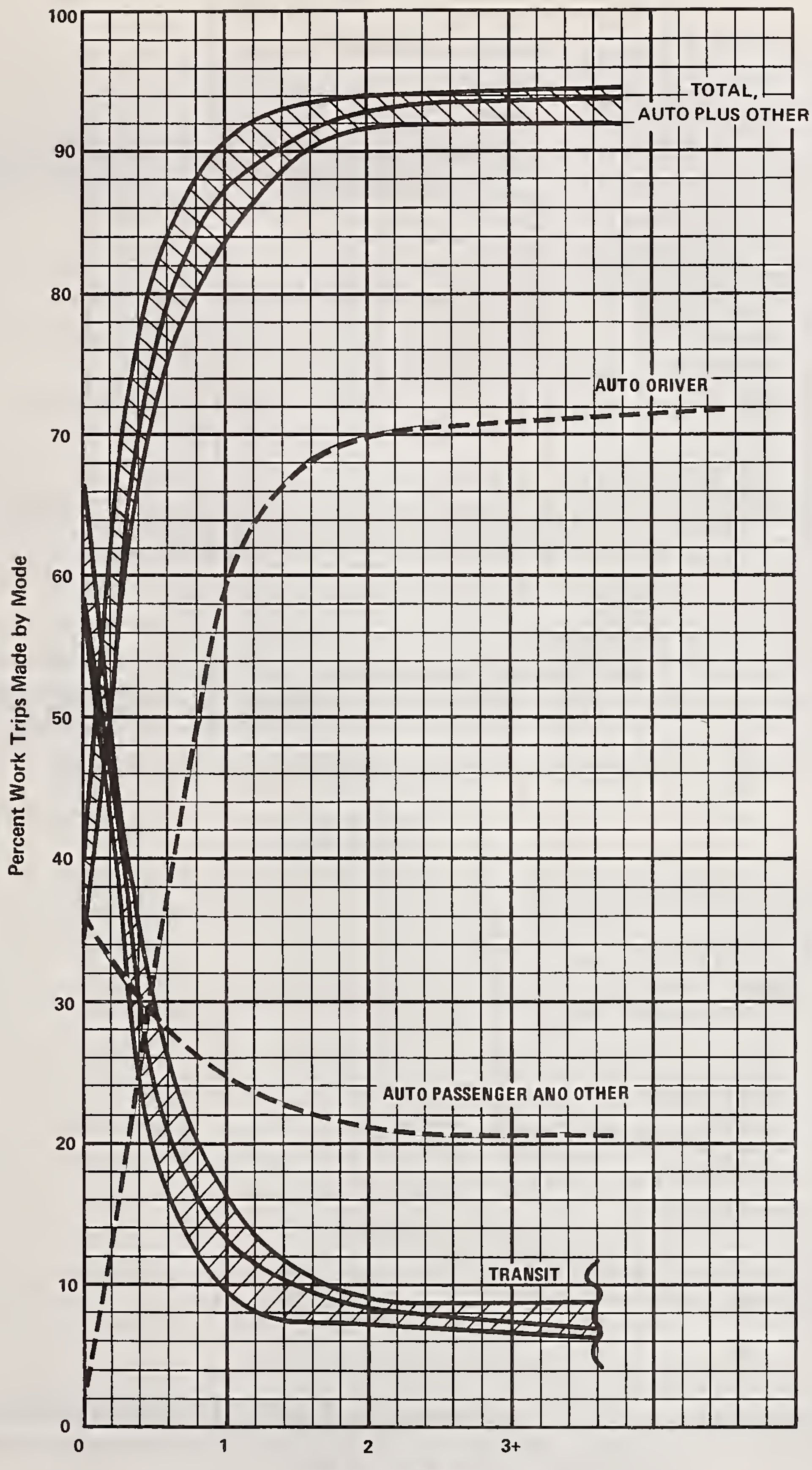
Two separate models are presented which can be used to estimate transit modal split; the models differ only in the terms used to describe the characteristics of the traveler and in the transit system characteristics. Either or both could be used. The following variables are used in these two models:

- auto ownership per househould and public transportation availability for work trip (Model 1); and
- median family income and availability of public transportation for work trip (Model 2).

The first model is displayed in Figure V-23. The work trip modal split for two modes (automobile and transit) and for three modes (automobile driver, automobile passenger, and transit passenger) is expressed as a function of automobile availability per household. The curve assumes that fixed-route, fixed-schedule transit service to a worker's place of employment is available within 6 blocks of the traveler's residence.

The second model (Figure V-24) relates modal share to zonal median family income. It has the same restrictions of transit availability as does Model 1.

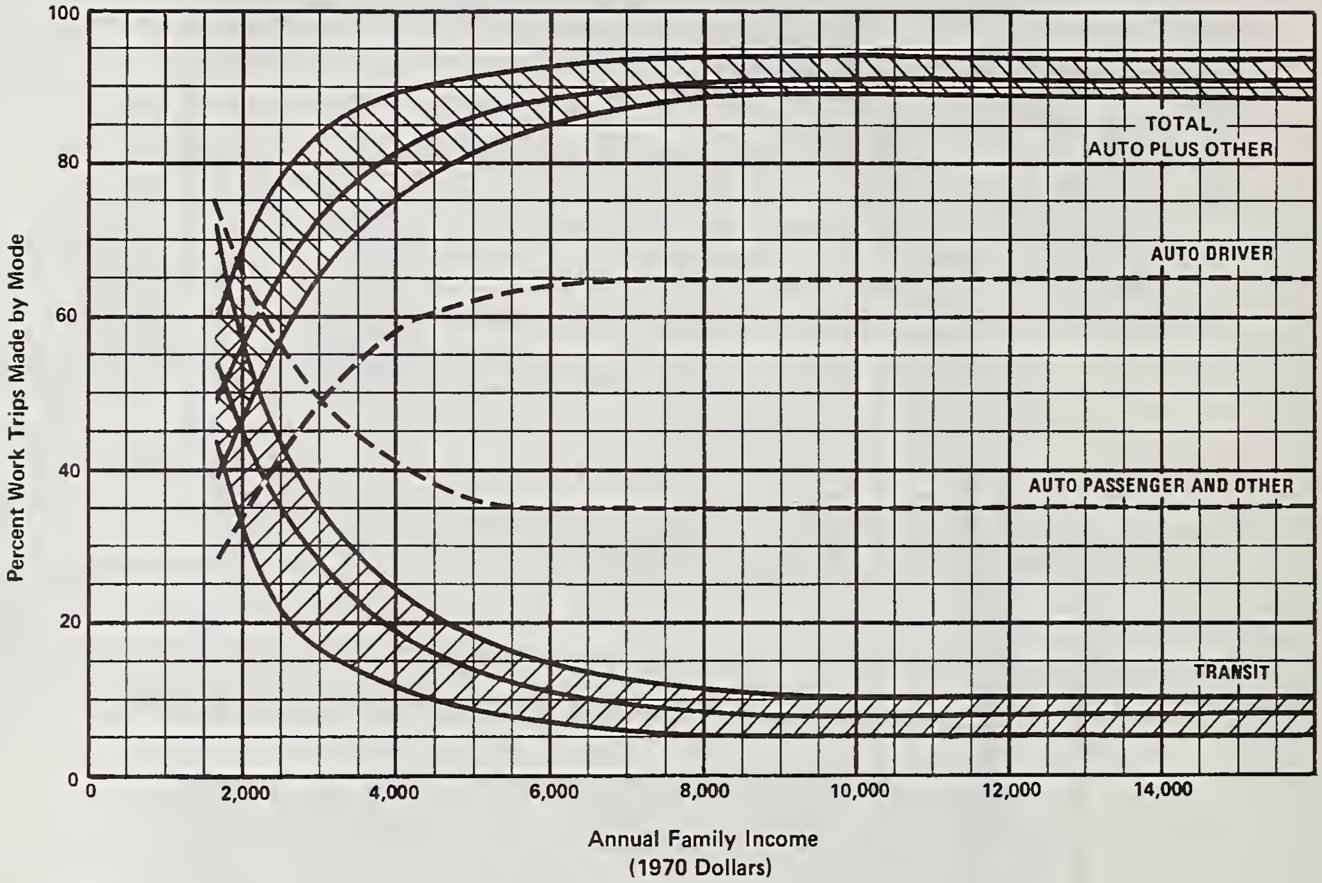
Both models estimate modal split, or the percent of work trips made via auto, transit, and other modes on a trip interchange basis, i.e., total work person trips made between zones are split between transit, walk, and auto plus other modes. The user must therefore generate or obtain a work trip table and zonal values for the input variables. For small urban areas, an abbreviated work trip table is suffi-



NOTES:

1. Relationship is for small urban ereas only.
2. Trensit servica for the trip to work must ba available within 6 blocks of residance.
3. Transit service must be fixed-route, fixed-schedule service only.
4. Other moda includes truck, motorcycle, bicycle, and texi end excludes walk.
5. Curves ere darived from small urban area deta from the 1970 Nationwide Parsonal Transportation Study.

FIGURE V-23: AGGREGATE WORK TRIP MODAL SPLIT MODEL 1–MODAL SHARE AS A FUNCTION OF AUTOMOBILE AVAILABILITY



NOTES:

1. Relationship is for small urban areas only.
2. Transit service for the trip to work must be available within 6 blocks of residence.
3. Transit service must be fixed-route, fixed-schedule service only.
4. Other mode includes truck, motorcycle, bicycle, and taxi and excludes walk.
5. Curves are derived from small urban area data from the Nationwide Personal Transportation Study.
6. 1970 consumer price index was 116.3 in constant 1967 dollars. To determine annual family income in constant 1970 dollars, multiply the current family income by the ratio of the 1970 consumer price index to the current year consumer price index. For example, if annual family income was $10,000 in 1974, to determine the purchasing power of this income in constant 1970 dollars, multiply $10,000 by (116.3 - 1974 consumer price index), i.e., $(\$10,000)\left(\frac{116.3}{147.7}\right) = \$7,874$.
7. The value of the current year consumer price index can be obtained by referring to a current edition of the Survey of Current Business published monthly by the U.S. Department of Commerce, Bureau of Economic Analysis.

FIGURE V-24: AGGREGATE WORK TRIP MODAL SPLIT MODEL 2 – MODAL SHARE AS A FUNCTION OF ANNUAL FAMILY INCOME cient for the travel information requirements. This would consist of daily trip interchanges between each residence zone and only the dominant employment zones, notably the CBD, industrial parks, large factories, large office complexes, universities, hospitals, and shopping centers where transit potential exists.

The models are most useful for obtaining estimates of peak period transit ridership in the feasibility analysis and detailed evaluation phases of the planning process.

b. Development and Theory

The modal split curves were all derived using small urban area data from the 1970 National Personal Transportation Study. Tabulations were made for both suburban and separate communities to derive modal share ranges for each level of the independent variables. The resulting range in values has been preserved in the bi-modal plots and can be assumed appropriate for high and low estimates. The two different models were developed to increase the planner's flexibility with respect to data availability.

c. Application

The models are easily applied in a small urban area which has neither a comprehensive data base nor the resources or need to perform a major transit study. The inputs required are a daily work person trip table and data for each analysis zone as required for the model selected. Analysis zones may be any convenient subdivision of the urban area for which data are available, generally employing census tracts, enumeration districts, or block groups. The model is applied by estimating modal split for each trip interchange on either a "zonal average" or a "disaggregate" basis. To use the former method, the user requires zonal averages for the appropriate socioeconomic input variable, median family income, or auto ownership. Although preferable, the latter method requires a finer level of detail of data. The distribution of each variable, i.e., percent of households with zero autos, one auto, etc., within each zone must be input. It should be noted that bus service availability is the only level of service variable in these models. Because other variables, such as travel times and service frequency, are not included, the models are not sufficiently sensitive to permit evaluation of system improvements or alternatives other than service coverage.

A general procedure for implementing this method would take the following steps:

1. Obtain or generate work person trip table. If none is available, use Census data, residential population, and employment location information to develop a best estimate of a trip table.

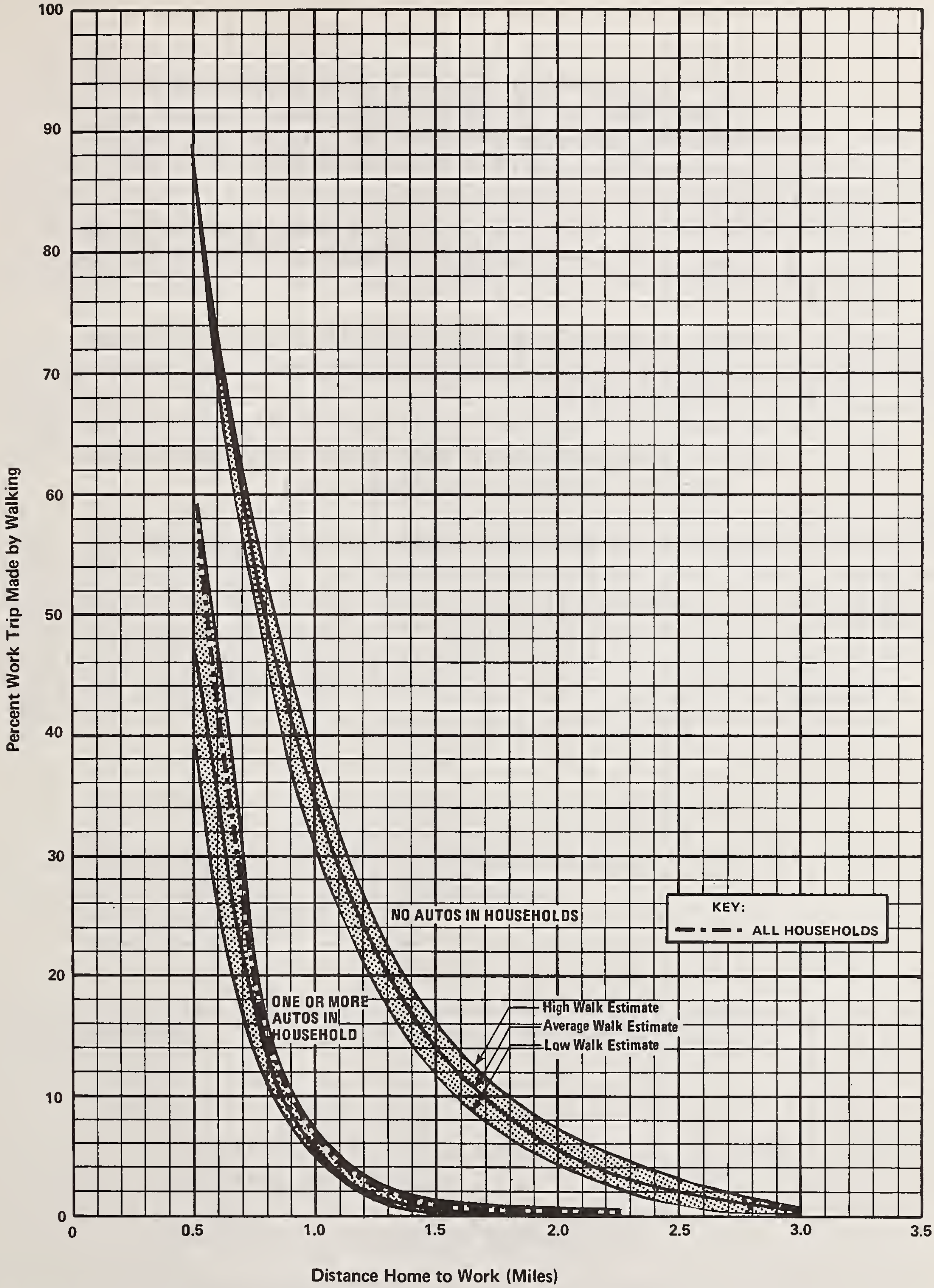
2. Lay out proposed fixed-route, fixed-schedule bus service on base map or overlay; shade areas within 6 blocks on either side of proposed transit service.

3. Consider only zonal trip interchanges involving CBD and large employment centers by transit; estimate percents of zones partially served by transit.

4. Select appropriate model; collect input data (zonal auto ownership or income). For each zone, use either zonal averages or, preferably, distribution of households in zones (i.e., percent zero, one, two, three and more autos per household).

5. Subtract walk trips from each interchange using walk mode split relationship in Figure V-25. Next, for any zones in which the area within six blocks on either side of a proposed transit route covers only a portion of the zone, subtract a percent of trips from each trip interchange involving that zone. The percent of trips is equal to the proportion of the zone outside the six-block coverage area.

6. Apply model by trip interchange; enter either zonal average or distributional values (e.g., zero, one, two auto househould volume) in appropriate model. Read off percent transit, percent total auto plus other, and percent auto driver. Use high, average, and low estimates of percent transit to get modal split range. Multiply each trip interchange by percent auto drivers to get interzonal volume of vehicle trips.



SOURCE: 1970 Nationwide Personal Transportation Study.

FIGURE V-25: WALK MODE SPLIT AS A FUNCTION OF DISTANCE TO WORK

7. Add estimates for each trip interchange to get total high, low, average daily transit demand estimate. Multiply by 260 to get total annual transit work trip estimate.

8. Estimate daily route work trip ridership by "assigning" each interchange to a route; total the estimates by route.

9. Estimate total daily systemwide ridership by dividing by percent work trips (Estimate or use Table in Chapter VII.).

10. Estimate peak period ridership. (Estimate or use distributors shown in Chapter VII.)

11. Cross-check, using another model or method.

9. Method 7: Processing of Survey Data

This is the first of five computerized methods suitable for use in small urban areas under certain conditions. Unlike the previous methods, the simplified computerized methods are not described here in sufficient depth to allow the planner to use the methods. Rather, these methods are described to provide the planner with sufficient information about the method to determine their applicability for the local situation.

Several programs in the UTPS and PLANPAC transportation planning packages may be appropriate for small urban area transit planning. The first set of programs may be used to assemble, reduce, manipulate, and organize data for transit planning. The most likely application is the processing of data obtained from an on-board transit survey.

The use of UTPS or PLANPAC programs requires access to a computer and the package itself. UTPS is maintained and distributed by UMTA and FHWA; PLANPAC is maintained and distributed by FHWA. Both may be obtained at no cost to any public or nonprofit agency. Various slide-type presentation and training courses are available for those interested in learning both what the UTPS program battery does and how to use it. Inquiries regarding UTPS or the two PLANPAC programs discussed here and requests for the program battery itself should be addressed to:

Dr. Robert B. Dial, Director
Office of Planning Methods and Support, UTP-10
Urban Mass Transportation Administration
U. S. Department of Transportation
400 Seventh Street, S. W.
Washington, D. C. 20590

Four UTPS and two PLANPAC programs are available for survey data processing. Their functions are described as follows:

a. TRPTAB - Trip Table Builder (PLANPAC):

- builds trip tables from survey data trip records or other trip tables;
- merges or unmerges trip tables; and
- converts skim trees (a computer format for travel times or distances) to a trip table format.

b. PRKTAB - Parking (or other data sets) Tabulation (PLANPAC): formats and prints tabulations and cross-tabulations from survey data records.

c. UFMTR - Matrix Examination (UTPS):

- prints one or more data matrices separately or combined; and

- prints a trip length frequency distribution from a trip table and an interzonal time matrix.

d. UMATRIX - Matrix Manipulation (UTPS):

- combines data matrices; and

- performs arithmetic and logical operations on one or more data matrices.

e. USQUEX - Matrix Compressor or Expander (UTPS):

- compresses zone-to-zone data matrices to district-to-district data matrices; and

- expands district-to-district data matrices to zone-to-zone data matrices.

f. UMCON - Matrix Conversion (UTPS): applies a FRATAR-like expansion to estimate a future trip table from an existing one.

10. Method 8: Transit Network Analysis

Four UTPS programs are available to build, analyze, and load transit networks. The small urban area planner may find it appropriate to use the network analysis process at two points in the planning process.

First, one or more candidate transit networks can be coded for analysis and built by the computer. With inputs of routes, transit speeds, and frequencies, a network analysis program can produce interzonal travel times for the urban area. The planner can use total travel times and transit and access components of travel times in two ways: (1) the travel times can provide a general measure of transit system performance, and (2) the travel times can provide input to a manual or computerized demand estimation model.

Second, the planner can load passengers onto a transit network to determine peak period and daily loadings on individual routes and the total system. The resultant network loading, a transit assignment, can be used to test major system changes and to design transit system elements. One possible application would be to determine whether one or more proposed major service changes better serves existing transit travel by assigning the trips observed from an on-board transit survey to the proposed alternative networks.

The four UTPS transit network analysis programs perform the following functions:

a. UNET - Transit Network Description Builder:

- builds a transit network;
- provides output for network editing; and
- provides transit line descriptions.

b. UPATH - Transit Path Finder: determines shortest zone-to-zone paths through a transit network.

c. UPSUM - Transit Path Summarizer: produces data matrices and reports containing interzonal travel times, wait times, transfer times, total travel times, and number of transfers.

d. ULOAD - Transit Passenger Loading: assigns transit passengers to a transit network.

See the previous section for further information about the UTPS battery and the acquisition, installation, and use of the package.

11. <u>Method 9: Demand Estimation</u>

The UTPS battery has two programs, UMODEL and UMATRIX, that are used for travel demand estimation. Two primary applications in a small urban area are to determine the impact of future development on the transit system and to estimate the demand resulting from major system changes. A planner could, for example, expand an on-board transit survey to a 5-year forecast based on population and employment growth. One could also develop a trip table to estimate the demand for one or more new routes, based on an existing trip table from an on-board survey.

The main program used for demand estimation is UMODEL, which contains both a calibrated complete self-contained set of demand models and the framework for a user-specified set of demand models.

The calibrated set of demand models in UMODEL is known as the default model. The planner can, in a single default model application, use any or all of the four submodels in the default model: trip generation, trip distribution, modal split, and auto occupancy. All parameters in the model have default values which the user can modify if more appropriate local data are available. The user inputs socioeconomic data, transit and highway travel time components, and any model parameters he wishes to modify.

The UMODEL program also provides a structure in which a planner can insert a user-specified trip generation, distribution, and modal split model. It provides a flexible tool designed specifically to perform the data analysis typically used for demand modeling, but its application would primarily be transportation planning in larger urban areas.

A second UTPS program, UMATRIX, performs simple arithmetic and logical operations on a data matrix. A planner can use this capability to apply a simple user-specified modal split model.

See Method 8 for further information about the UTPS battery and the acquisition, installation, and use of the package.

12. <u>Method 10: Interactive Transit Assignment Model (ITAM)</u>

The Interactive Transit Assignment Model (ITAM) is a procedure for assigning or loading a transit origin-destination trip table onto a network. ITAM should be considered when the planner has access to a cathode-ray tube (CRT) terminal and sufficient information with which to estimate a trip table.

For each assignment, the user specifies a set of transit routes, frequencies, and vehicle types. The model presents the results of the assignment, passenger loadings and summary, and detailed operating statistics directly to the planner on a CRT. The planner can then quickly and easily revise the transit routes, frequencies, or vehicle types in an attempt to "improve" the system's performance by reducing any or all of the following statistics for the entire system or in a specific area: passenger travel times, passenger-miles, vehicle-miles, and operating costs. An obvious advantage of this system is that the planner receives output directly on a CRT terminal and can revise and resubmit an assignment immediately. A large number and wide range of transit alternatives can therefore be processed with immediate feedback. Although generally only the transit routes, frequencies, and vehicle types are truly "interactive," the user can modify the transit demand trip table to reflect the expected impact on modal split of the different networks.

The planner uses ITAM by developing and inputting via the CRT terminals an areawide base network, a transit trip table, and transit vehicle characteristics. The network is multi-modal to accommodate walk, bus, and rapid transit modes. Any link may therefore have three speeds. Riders enter the system at nodes which may or may not be served by a transit route. The trip table is a node-to-node origin-destination matrix of those trips which are to be assigned onto the network. It represents the transit trip table output of a modal split or, more properly, a non-auto trip table, since the assignment procedure may find that the best path for a particular set of trips consists entirely of walk links. Vehicle characteristics include capacities and per-mile and per-hour operating costs. These are basically considered fixed inputs, but any of the three sets of inputs can easily be modified to reflect changes in conditions. The interactive input for each ITAM assignment is the set of transit routes or ordered sequence of stops, vehicle frequencies or headways, and vehicle types.

The assignment procedure is the probabilistic, multipath assignment algorithm developed by Dr. Robert B. Dial.[1] The basis for the algorithm is that while most trips will generally traverse the shortest time path from origin to destination, a portion of the trips will use other paths so long as each path does not backtrack, i.e., moves progressively closer to the destination than the origin at each node. The longer the path, the fewer the trips that will be assigned to it.

---

[1] Robert B. Dial, "A Multipath Traffic Assignment Model," Highway Research Record 369 (1971), pp. 199-210.

ITAM provides extremely useful performance and operating statistics as output for use in the comparative evaluation of transit system alternatives. Individual route and summary statistics are output as shown in the list below:

1. Passenger loadings or each network link and each transit route.

2. Number of transfers at each stop and total for the system.

3. Number of passengers boarding and alighting at each stop listed by transit route.

4. Average waiting time, in-vehicle travel time, transfer and walk times on the entire network.

5. Total travel times for the system.

6. Total passenger-miles for the system.

7. Number and type of vehicles required on each route and total for the system.

8. Route-miles (total length of route) for each route and total for the system.

9. Vehicle-miles for each route and total for the system.

10. Operating costs for each route and total for the system.

11. Capacity and vehicle utilization for each route and total for the system.

12. Average and total travel times from each stop to every other stop in the network.

ITAM, operational on a PDP-10 computer, is distributed by UMTA. Alternatively, the package is being installed in a number of computer service bureaus throughout the United States. The potential user who would like to use ITAM at a service bureau requires a CRT terminal which can be leased. For further information regarding the acquisition and use of ITAM of the location of service bureaus that offer the package, contact UMTA at the following address:

Dr. Robert B. Dial, Director
Office of Planning Methods and Support, UTP-10
Urban Mass Transportation Administration
U. S. Department of Transportation
400 Seventh Street, S.W.
Washington, D. C. 20590

13. Method 11: Interactive Graphic Transit Design System (IGTDS)

The Interactive Graphic Transit Design System (IGTDS) is a self-contained computer package designed for sketch planning of fixed-route, fixed-schedule transit systems that focus on one central area, generally the CBD. The system enables the transit planner to quickly and efficiently devise and evaluate a large number of transit system alternatives, each of which is a user-specified configuration of routes, bus stops, vehicle types, route frequencies, fares, and parking lot locations for park-and-ride facilities. The planner initially inputs a base travel demand comprising of trips having one trip end in the CBD, together with characteristics of the street network. Transit system configurations are input parametrically. The system performs modal split between automobile, transit accessed by walking, and transit accessed by automobile (park-and-ride); it then performs network assignment. The system outputs modal split results, transit system costs and revenue (including parking lots), system utilization, and accessibility characteristics for each mode. The output enables the planner to evaluate the results relative to established planning objectives. The transit system configuration can then be modified in an attempt to improve the system.

The modal split model incorporated into IGTDS is a logit model that estimates modal split for each of the three modes as a function of travel time in the vehicle, waiting plus walking time, and out-of-pocket cost for each mode. A set of default coefficients for each of other impedance elements is included in the IGTDS modal split model, but the user may revise these if calibrated model coefficients are available. Trips are assigned to the respective modal networks along the paths of least impedance, subject to capacity constraints on transit routes and parking lots.

IGTDS is ideally suited to a transit system design application in a small urban area. Such fixed-route, fixed-schedule systems are generally focused on the CBD. Other large major generators, if they exist, can be analyzed separately using the same network and simply redesignating the destination mode. Performance measures from each separate analysis are added together to form composite system totals.

IGTDS was initially developed in the Urban Transportation Program of the University of Washington's Departments of Urban Planning and Civil Engineering under a research grant sponsored by UMTA. It has been further developed and modified by Peat, Marwick, Mitchell & Co. for UMTA.

IGTDS, like ITAM, is operational on a PDP-10 computer. The package is distributed by UMTA and is also maintained at several computer service bureaus throughout the United States. The potential user who would like to use IGTDS at a service bureau requires a CRT terminal which can be leased. For further information regarding acquisition and use of IGTDS or the location of service bureaus that offer the package contact UMTA at the address shown in the previous section.

D. Financial Evaluation Methods

1. Introduction

This section of the manual presents a variety of methods for evaluating the financial implications of alternative transit proposals. The role of financial evaluation in the transit planning process is described, procedures for estimating the financial implications of alternative transit proposals are presented, the availability of federal and state financial assistance is summarized, and a framework for evaluating local financing alternatives is presented.

2. Role of Financial Evaluation in the Transit Planning Process

The feasibility of transit alternatives and the success of specific transit services often depend on the financial implications of transit investment and operation. This is true whether the transit operation is run for profit or is subsidized by federal, state, or local government. It is particularly true in smaller urban communities, which generally have very limited financial resources for promoting, sponsoring, or providing transit services. It is therefore essential that the financial implications of each alternative transit proposal be considered carefully when planning for transit in a small urban community.

Financial evaluation in the planning process involves both determination of the local financial implications of transit investment and operation and identification and evaluation of mechanisms for providing local financial support for transit services.

3. Measuring the Financial Implications of Transit Investment and Operation

Three results of transit investment and operation require a financial evaluation of transit proposals: capital cost implications, operating expense implications, and operating revenue implications.

a. Capital Cost Implications

Two types of situations are encountered in the measurement of the capital cost implications of transit proposals. The first is a single acquisition of the capital assets required for either the initiation of service or the expansion or modification of existing service. The second situation is a planned investment in capital assets, typically over a 5-year period.

(1) Single Acquisition of Capital Assets

In the single acquisition of capital assets, the capital cost implications of a transit proposal can be estimated in a straightforward manner by determining the current price of assets and using these prices to measure the acquisition costs associated with the transit proposal.

The supply of transit services generally requires, as a minimum, vehicles, vehicle storage facilities, and vehicle maintenance facilities and equipment. The type of equipment and facilities used to provide transit services to the public varies widely from community to community or even within a single community. So, too, do the costs of acquiring these assets or the lease agreements for securing the use of these assets.

Typical values of vehicle costs, for example, are illustrated in Table V-10. As indicated in this table, there is substantial variation in the price of transit vehicles. Part of this variation is explained by the size of the vehicle, but there is still significant variation in the cost of specific vehicle types. Options, including such features as air conditioning, carpeting, special seating, and interior and exterior trim, all add to the cost of a transit vehicle. Special pollution control standards, such as those imposed in California, also add greatly to the capital cost of transit vehicle acquisition.

The variation in transit vehicle costs is indicative of the variation in the costs of other capital assets required to provide transit services. For example, Table V-11 gives estimates of some recent transit facility construction costs. Although the specific determi-

TABLE V-10

CURRENT TRANSIT VEHICLE PRICES (APRIL 1976)

Vehicle Type	Vehicle Price	Price per Seat
Van	$10,000 to $15,000	— —
20-Passenger Bus	$30,000 to $35,000	$1,500 to $1,750
25-Passenger Bus	$45,000 to $50,000	$1,800 to $2,000
45-Passenger Bus	$59,000 to $79,000	$1,311 to $1,755
53-Passenger Bus	$62,000 to $79,000	$1,170 to $1,490

SOURCE: Office of Capital Assistance, Urban Mass Transportation Administration.

TABLE V-11

RECENT TRANSIT FACILITY COSTS (MARCH 1975)

Facility Type	Unit Cost per Square Foot	Unit Cost per Vehicle
Bus Storage Facilities	$16 – $28	$ 5,250 – $15,000
Inspection Garages	$23 – $33	$13,050 – $27,800
Main Maintenance Facilities	$32 – $48	$ 5,400 – $ 8,500

SOURCE: Bus Maintenance Facilities: A Transit Management Handbook, Report No. UMTA-VA-06-004-75-5, prepared for the U.S. Department of Transportation, Urban Mass Transportation Administration, Office of Transit Management, by The Mitre Corporation November 1975.

nation of facility costs requires special skills, experience, and information, data like those presented in Tables V-10 and V-11 are useful for developing capital cost estimates of transit proposals for planning purposes.[1] When preparing estimates of the capital cost implications of a transit proposal, however, it is best to obtain local estimates. Local or regional costs of transit vehicle acquisition can be obtained directly from manufacturers, and facility construction costs can be estimated by local contractors. Recent vehicle equipment and facility costs can also be obtained from one of the following sources:

- the state department of transportation;
- other urban areas in the state (or nearby states) that have recently purchased transit capital assets; or
- the Office of Capital Assistance, Urban Mass Transportation Administration.

(2) Planned Investment in Transit Capital Assets

To measure the capital cost implications of a planned investment in transit assets, it is necessary to estimate the cost of these assets in the near future. This can be done in a straightforward manner by (1) determining the current price of assets as discussed above, (2) estimating the price of assets in the plan year, and (3) using these price estimates to measure the acquisition costs of the transit proposal.

Estimating the price of capital assets in the plan year is the key to measuring planned investment costs. Although precise measurement is not always possible, high and low estimates may be determined for use in the planning and evaluation of transit proposals.

As demonstrated in the past, capital costs may be subject to rapid change. Between 1970 and 1974, for example, there was a continuing and increasing escalation in capital costs, due in part to the strong inflationary trend in the economy.

---

[1] For a more detailed discussion of the design variations in transit facilities and the implication these variations have for construction costs, see Bus Maintenance Facilities: A Transit Management Handbook, Report No. UMTA-VA-06-004-75-5, prepared for the U.S. Department of Transportation, Urban Mass Transportation Administration, Office of Transit Management, by The Mitre Corporation (Washington, D.C.: November 1975).

Figure V-26 shows the wholesale price index for motor vehicles and equipment for the period 1964 to 1974.[1] As shown in this figure, the wholesale price of vehicles has inflated at varying average annual rates over this period. Between 1973 and 1974, the wholesale price index increased at an average annual rate of slightly over 8 percent. Between December 1973 and December 1974, however, the wholesale price index increased by over 13 percent. This information is used in Figure V-11 to develop a set of cost multipliers for use in determining the future cost of planned investments in transit vehicles and equipment. Three different annual rates of increase for the wholesale price index are plotted, showing the impact of inflation on plan year cost estimates.

The use of Figure V-27 can best be explained with a simplified numerical example. Assume that a current estimate for a 25-passenger bus is $45,000 and that the transit proposal includes the purchase of five such vehicles 3 years in the future. High and low estimates of the capital cost implications of this proposal are determined by performing the following calculations:

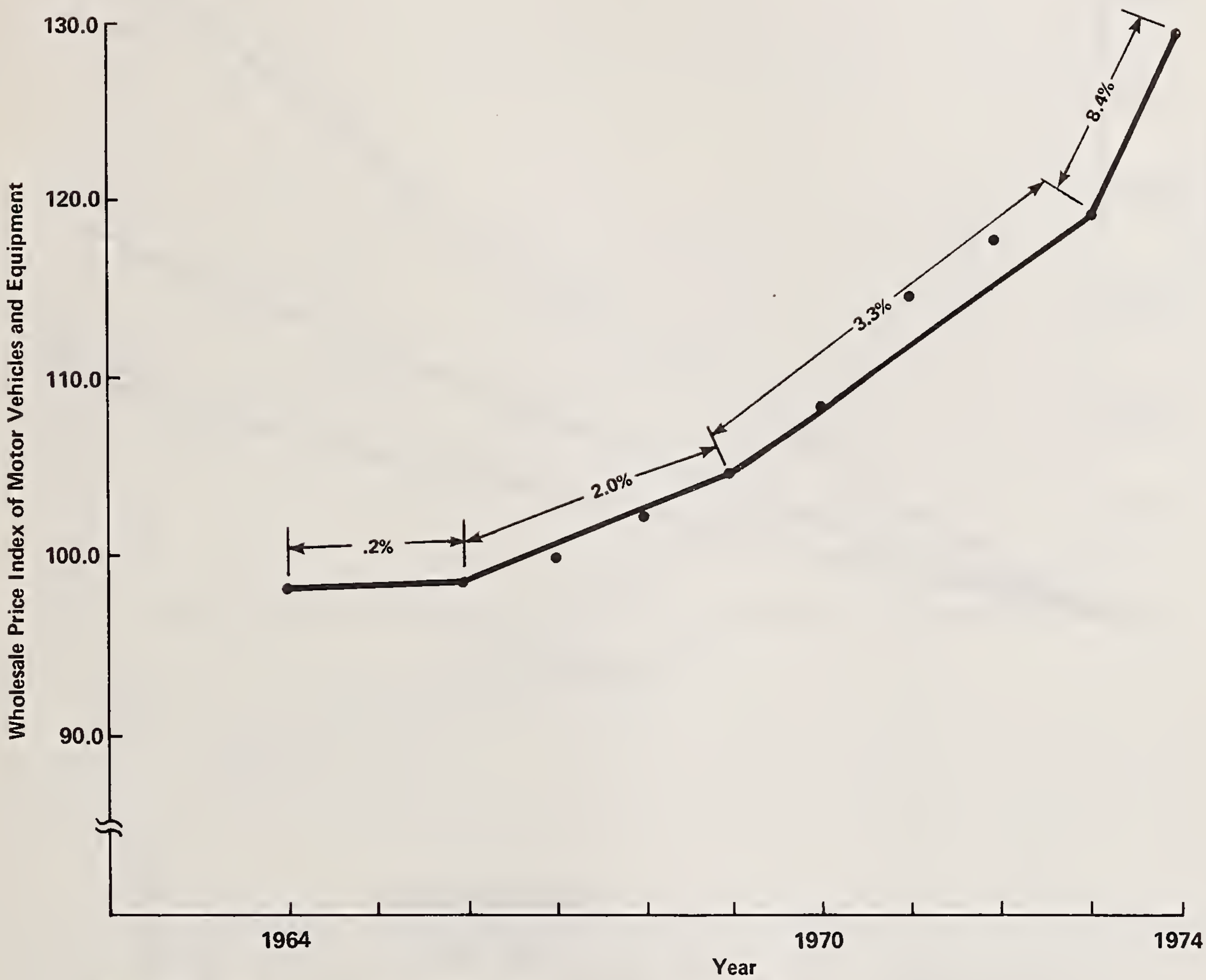
	(Current Price)	x	(Cost Multiplier)	x	(Number of Vehicles)	=	Cost Estimate
High Estimate:	$45,000	x	1.443 (13%)	x	5	=	$324,675
Low Estimate:	$45,000	x	1.158 (5%)	x	5	=	$260,550

The cost implication of planned investment in transit facilities can be determined in a similar manner. Figure V-28 illustrates the Department of Commerce composite construction cost index for the period 1964 to 1975.[2] From this figure, the following set of cost multipliers for use in determining the future cost of planned investments in transit facilities is derived.

---

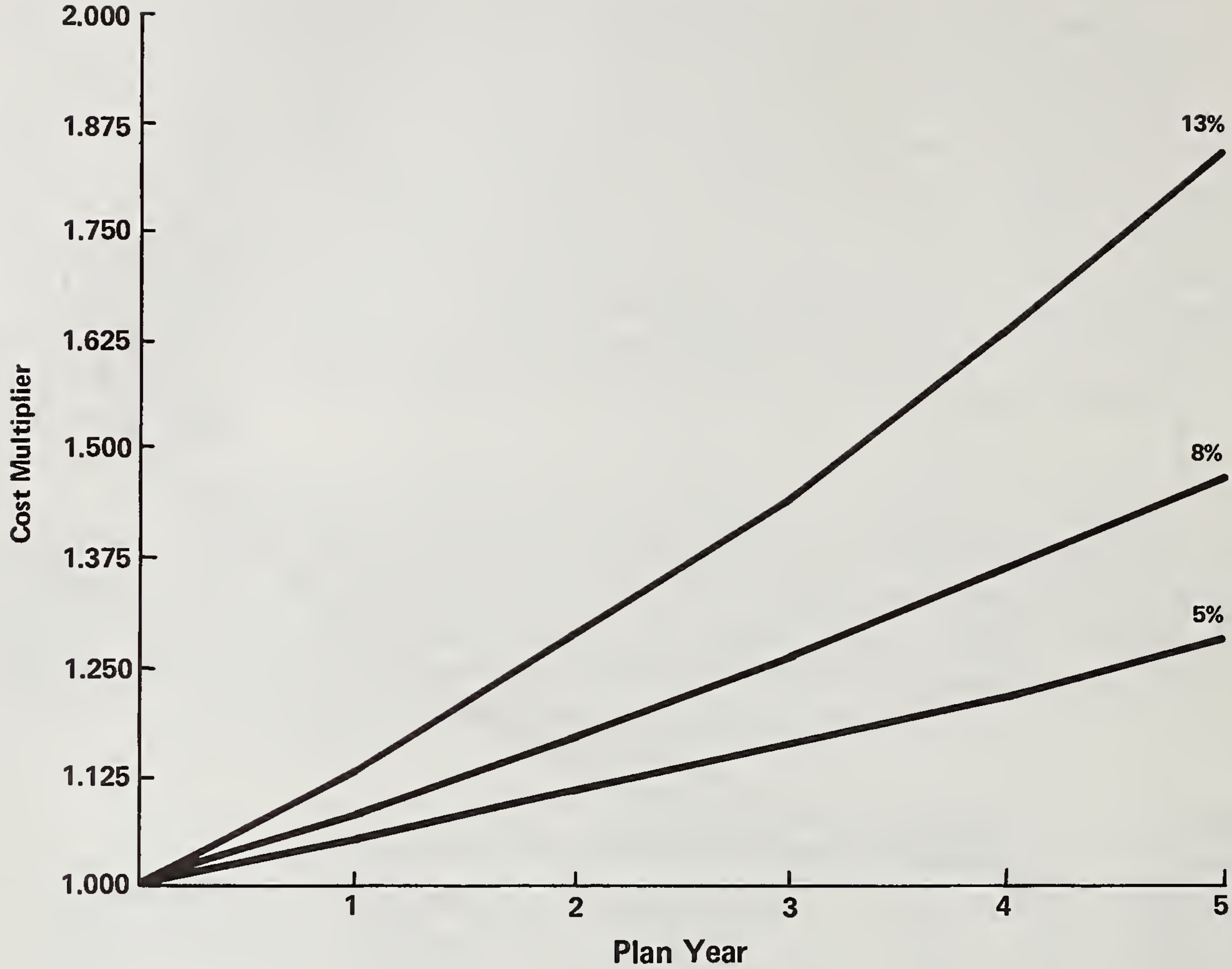
[1] Handbook of Labor Statistics 1975 - Reference Edition, U.S. Department of Labor, Bureau of Labor Statistics (Washington, D.C.).

[2] 1973 Business Statistics: The 19th Biennial Supplement to the Survey of Current Business, U.S. Department of Commerce, Social and Economics Statistics Administration, Bureau of Economic Analysis (Washington, D.C.) and Survey of Current Business, U.S. Department of Commerce, Bureau of Economic Analysis, Volume 56, Number 2 (Washington, D.C.: February 1976).



SOURCE: Handbook of Labor Statistics 1975 – Reference Edition, U.S. Department of Labor, Bureau of Labor Statistics (Washington, D.C.).

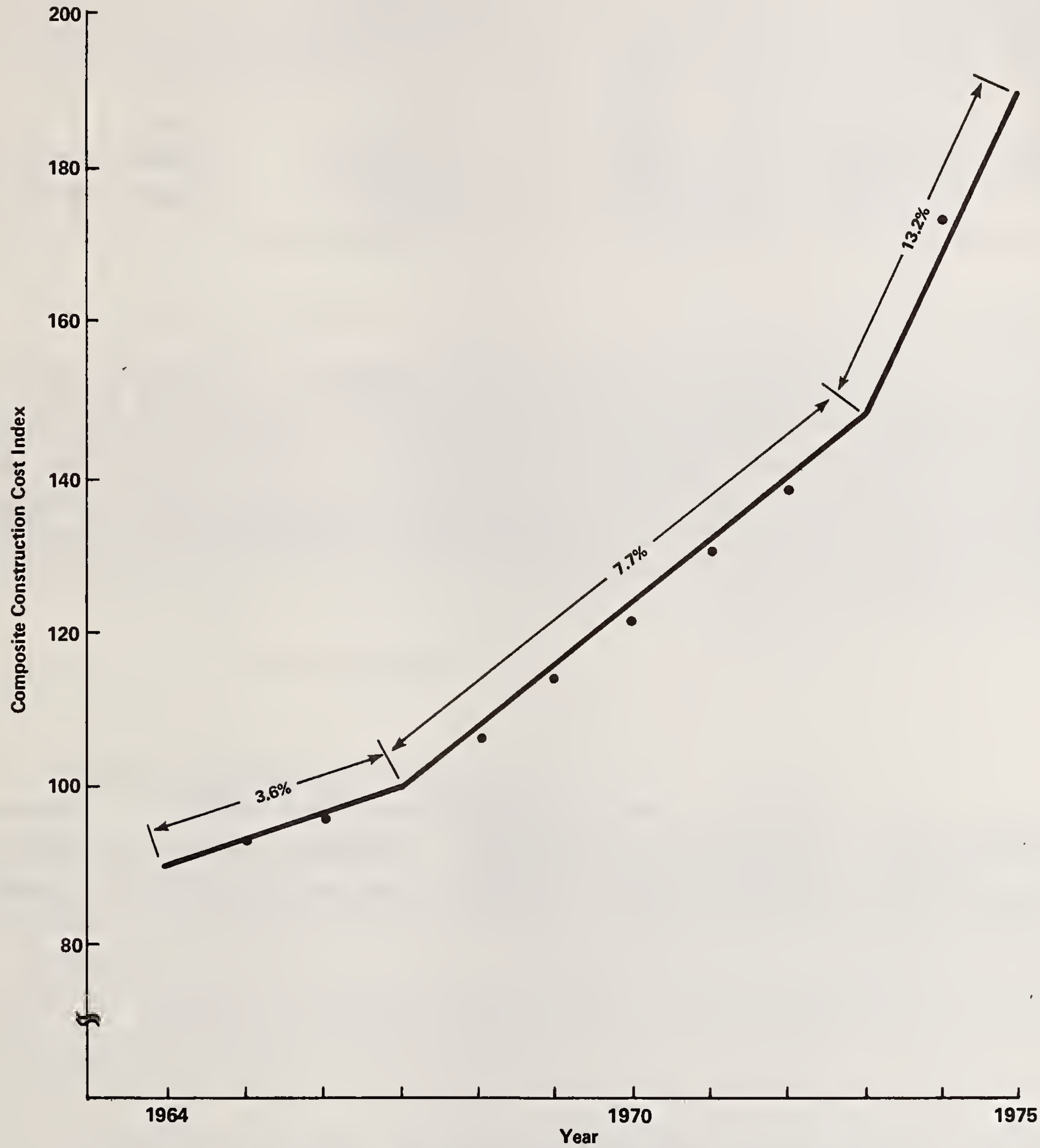
FIGURE V-26: WHOLESALE PRICE INDEX OF MOTOR VEHICLES AND EQUIPMENT – 1964-1974
(1967 = 100)



Cost Multiplier

Rate of Inflation	Plan Year 1	2	3	4	5
13%	1.130	1.277	1.443	1.630	1.842
8%	1.080	1.166	1.260	1.360	1.469
5%	1.050	1.103	1.158	1.216	1.276

FIGURE V-27: COST MULTIPLIERS FOR PLANNED INVESTMENT IN TRANSIT VEHICLES AND EQUIPMENT



SOURCE: 1973 Business Statistics: The 19th Biennial Supplement to the Survey of Currant Business, U.S. Department of Commerce, Social and Economics Statistics Administration, Bureau of Economic Analysis (Washington, D.C.) and Survey of Current Business, U.S. Department of Commerce, Buraau of Economic Analysis, Volume 56, Number 2 (Washington, D.C.: February 1976).

FIGURE V-28: DEPARTMENT OF COMMERCE COMPOSITE CONSTRUCTION COST INDEX–1964-1975 (1967=100)

Rate of Inflation %	Cost Multipliers				
	1	2	3	4	5
13	1.130	1.277	1.443	1.630	1.842
8	1.080	1.166	1.260	1.360	1.469
5	1.050	1.103	1.158	1.216	1.276

Again, the use of the cost multipliers can best be explained with a simplified numerical example. Assume that the current estimate for a vehicle storage facility is $10,000 per vehicle and that the transit proposal includes the construction of a 25-vehicle storage facility 3 years in the future. High and low estimates of the capital cost implications of this proposal are determined by performing the following calculations:

	(Unit Price)		(Units)		Current Price	(Current Price)	(Cost Multiplier)		Cost Estimate
High Estimate:	($10,000)	x	(25)	=	$250,000;	($250,000)	(1.443)	=	$360,750
Low Estimate:	($10,000)	x	(25)	=	$250,000;	($250,000)	(1.158)	=	$289,500

(3) Annualization of Capital Costs

Once the capital cost implications of a transit proposal have been estimated, it is necessary to determine the degree of local financing commitment required to implement the investment program. Local financing requirements are related to the level of the investment proposal (total capital cost) and the level of federal and state financial assistance in support of the proposal. The level of the investment proposal is determined as described above, and federal and state financial assistance opportunities are summarized in Subsection V.D.4 of this manual.

After the total local capital financing requirement has been estimated, the attendant annual costs are calculated. These annual costs are related to the cost of capital investment funds (interest rates) and the economic life of the capital assets. The local annual cost is calculated as follows (assuming fleet replacement and a constant cost of capital):

$$\left[\begin{pmatrix}\text{Total Cost of}\\ \text{Capital Asset}\end{pmatrix} - \begin{pmatrix}\text{Estimated Federal}\\ \text{and State Financial}\\ \text{Assistance}\end{pmatrix}\right]\begin{pmatrix}\text{Capital}^{1/}\\ \text{Recovery}\\ \text{Factor}\end{pmatrix} = \left[\begin{matrix}\text{Annual Local}\\ \text{Cost}\end{matrix}\right]$$

The use of this formula is best illustrated with a simplified numerical example. Assume that the transit proposal includes the acquisition of three vehicles at a total cost of $150, 000, that the federal share of this cost is 80 percent, and that the state finances one-half of the nonfederal share. Assume further that the cost of capital investment funds is 8 percent and that the vehicles have a useful economic life of 12 years (no salvage value). Local annual costs to finance this level of investment would be:

$$(\$150,000-\$135,000)(.1327) = \$1,990$$

b. <u>Operating Expense Implications</u>

Two general categories of operating expense analysis are of interest to planners and decisionmakers. The first, <u>expense analysis of system plans</u>, involves the estimation of system level operating expenses for a transit proposal (either a new system or a major modification to an existing system). The second, <u>expense analysis for detailed evaluation and diagnostic review</u>, involves the development of operating expense estimates by mode, time of day, or individual line or service area.

Expense analyses of system plans are typically conducted using either simplified direct factor methods or statistical regression techniques. Expense analyses for detailed evaluation and diagnostic review are typically conducted by (1) determining the "causative factor" associated with specific

---

1/ Capital Recovery Factor = $\frac{(i)(1+i)^n}{(1+i)^n - 1}$, where i = cost of capital investment funds and n = economic life of capital assets elements of operating expense, (2) developing expense rates per unit of causative factor, and (3) using these rates to estimate transit operating expenses. Each of these methods is described below in sufficient detail for a small urban community planner or decisionmaker to use them directly.

(1) Expense Analysis of System Plans: Simplified Direct Factor Methods

Simplified direct factor methods use the average (unit) cost of transit operation to estimate transit operating expenses for a given level of transit service supply. Factors describing the supply of transit service (vehicle-miles and vehicle-hours operated) or the output of transit service (transit passengers) are related to total operating expenses to determine unit costs experienced by transit operations in other urban areas. These unit costs can then be used to estimate the level of total operating expense for new transit proposals.

However, unit costs determined in this manner must be used with caution. The expense of transit operation varies not only with the level and type of operation, but also with the structure and quality of transit management and the nature of transit ownership (public or private).

Unit costs are presented below for use in applying the simplified direct factor method; they are presented for estimating the operating expenses of two types of transit service: conventional bus transit and dial-a-ride transit.

(a) Conventional Bus Transit Unit Operating Expense

Using 1974 data from the American Public Transit Association,[1] the unit rates of conventional bus transit operating expenses (excluding depreciation and taxes)[2] have been determined with respect to six factors: vehicle-miles operated, vehicle-hours operated, vehicles in the peak service schedule, vehicle operators, transit passengers, and the product of vehicle-hours operated multiplied by the top operator's wage rate.

---

[1] Data for 27 conventional bus transit operations reported in Transit Operating Report for Calendar/Fiscal Year 1974, American Public Transit Association (Washington, D.C.).

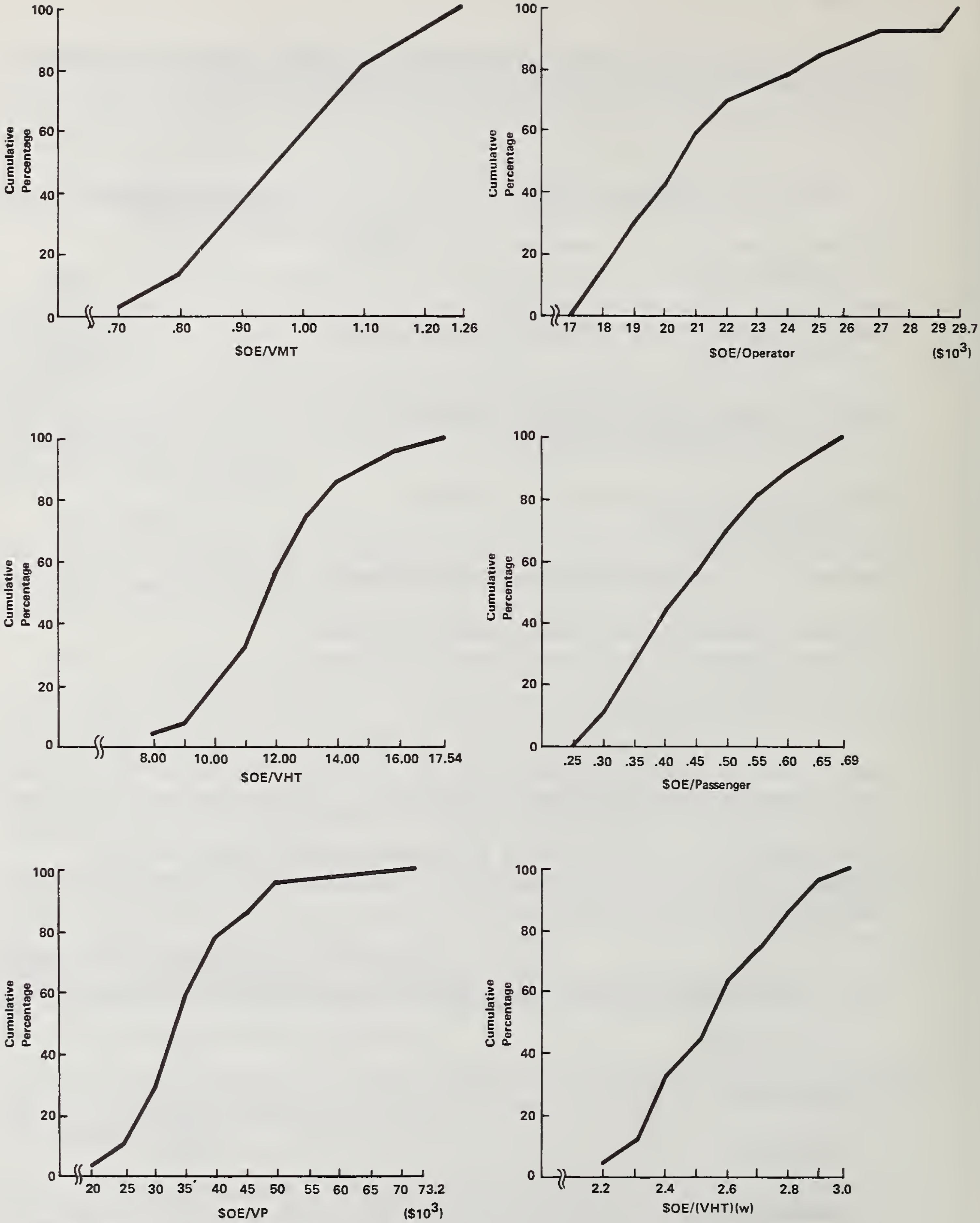
[2] Because depreciation expenses and taxes vary significantly from community to community and because they are related in different ways, to measures of transit supply, they are not included in the determination of unit costs for the direct factor method.

The average value for each of these rates is presented below, with the distribution of values illustrated in Figure V-29.

UNIT EXPENSE FACTOR	(1974) AVERAGE VALUE
Operating expense per vehicle-mile operated ($OE/VMT)	$ .96
Operating expense per vehicle-hour operated ($OE/VHT)	11.97
Operating expense per vehicle in the peak service schedule ($OE/Vp)	35,860.00
Operating expense per vehicle operator ($OE/Operator)	21,370.00
Operating expense per passenger ($OE/Psgr.)	.45
Operating expense per [(vehicle-hour operated) (top operator's wage rate)] [$OE/(VHT)(w)]	2.54

The selection of one of these rates to use in estimating transit operating expenses depends largely on the availability of the corresponding supply (or demand) statistics. The best rate to use, however, is that rate which varies least over the range of transit operators. As indicated below, the rate for [(Operating Expense)] divided by [(Vehicle-Hours Operated) (Operator's Wage Rate)] is most appropriate based on this criterion alone.

UNIT EXPENSE FACTOR	PERCENT DIFFERENCE BETWEEN MAXIMUM VALUE PERCENT AND MINIMUM VALUE
$OE/VMT	80
$OE/VHT	151
$OE/Vp	284
$OE/Operator	74
$OE/Psgr.	176
$OE/(VHT)(w)	40



Source: Based on data from 27 conventional bus transit operations reported in Transit Operating Report for Calendar Year 1974, American Public Transit Association (Washington, D.C.).

FIGURE V-29: CUMULATIVE FREQUENCY DISTRIBUTION OF SELECTED CONVENTIONAL TRANSIT UNIT OPERATING EXPENSES

The use of this rate is best explained by a simplified numerical example. Assume the transit proposal is characterized by 100,000 annual vehicle-hours operated and a top operator's wage rate[1] of $5.00 per hour. Total annual operating expense for this service is calculated as follows:

Range for 80% Conventional Transit Operators		
	High Estimate =	(2.80)*(100,000) (5) + (depreciation and taxes) = $1,400,000 + (depreciation and taxes)
	Average Estimate =	(2.54)*(100,000) (5) + (depreciation and taxes) = $1,270,000 + (depreciation and taxes)
	Low Estimate =	(2.20)*(100,000) (5) + (depreciation and taxes) = $1,100,000 + (depreciation and taxes)

To determine the future expense of conventional transit operations using the simplified direct factor method, it is necessary to estimate the expected value of transit operator wage rates. Figure V-30 illustrates the index of local transit wage rates between 1960 and 1973.[2] Between 1960 and 1966 local transit operator wage rates increased at an average annual rate of 4.1 percent. Between 1966 and 1973 the average annual increase was 7.5 percent. The maximum single year increase occurred between 1969 and 1970 with wages rising 8.9 percent. From Figure V-30 the following set of cost multipliers for use in determining the future expense of transit operation is derived.

Rate of Inflation %	Cost Multipliers				
	Plan Year				
	1	2	3	4	5
8.9	1.084	1.186	1.291	1.406	1.532
7.5	1.075	1.156	1.242	1.335	1.436
4.1	1.041	1.084	1.128	1.174	1.223

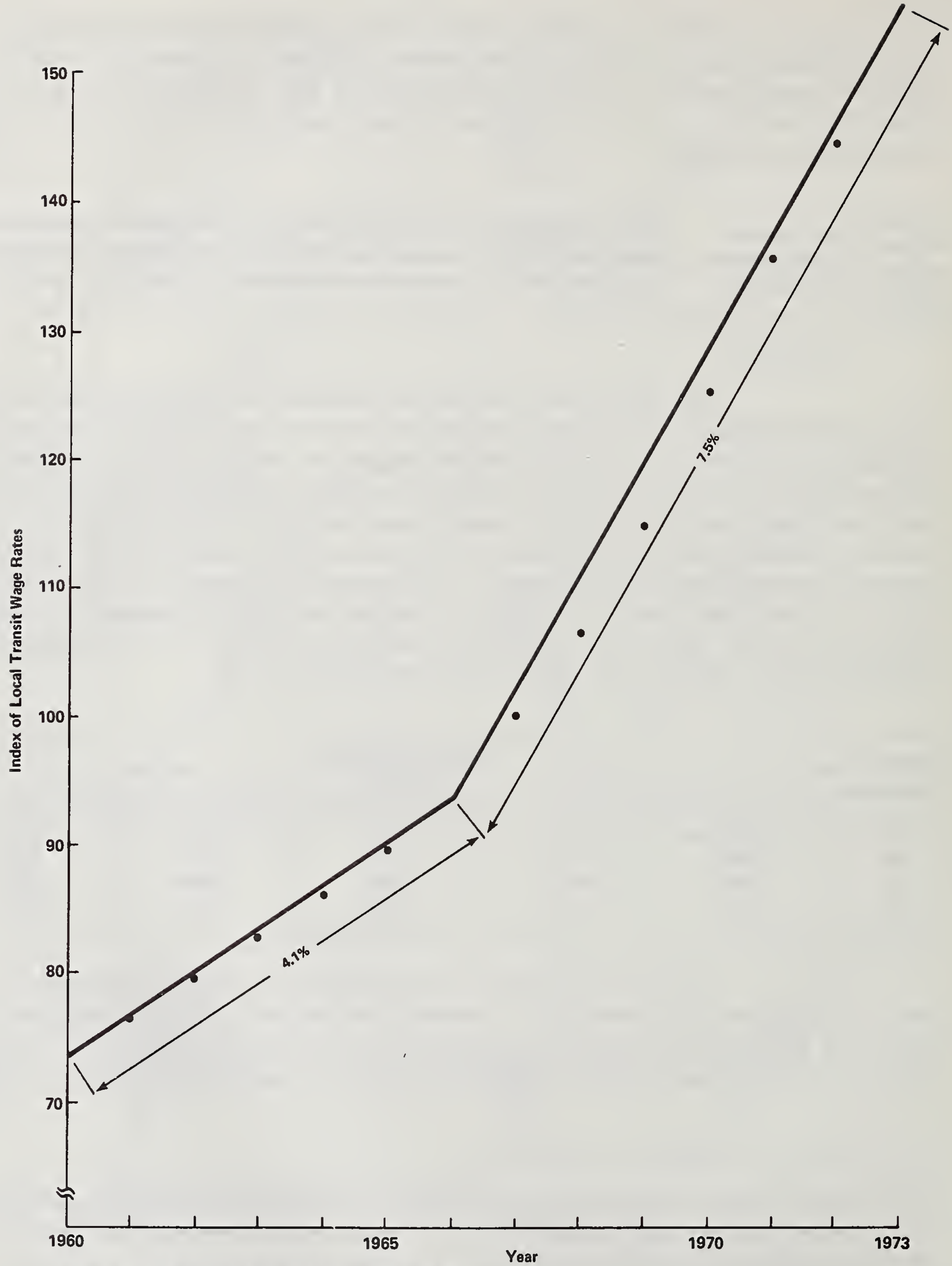
The use of these cost multipliers is illustrated by the following numerical example. Assume the transit proposal suggested above is planned to remain in operation as initially implemented. Estimates of the future expense of operations are calculated, based on an

---

[1] For those urban communities initiating new service, the top operator's wage rate can be approximated by the wage rate on other municipal drivers (refuse collectors, for example).

*From Figure V-29.

[2] Handbook of Labor Statistics 1975 - Reference Edition, U.S. Department of Labor Statistics, Bulletin 1865 (Washington, D.C.).



SOURCE: Handbook of Labor Statistics 1975 — Reference Edition, U.S. Department of Labor Statistics, Bulletin 1865 (Washington, D.C.).

FIGURE V-30: INDEX OF LOCAL TRANSIT WAGE RATES—1960-1973 (1967=100) assumed 8 percent annual rate of inflation for operators' wages, as follows:

Estimate	Current Year*	Plan Year 1*	Plan Year 2*
High	$1,400,000	($1,400,000) (1.075) = $1,505,000	($1,400,000) (1.156) = $1,618,400
Average	$1,270,000	($1,270,000) (1.075) = $1,365,250	($1,270,000) (1.156) = $1,468,120
Low	$1,100,000	($1,100,000) (1.075) = $1,182,500	($1,100,000) (1.156) = $1,271,600

*Excludes depreciation expenses and taxes.

(b) Dial-a-Ride Transit Unit Operating Expenses

Using 1975 data from 27 many-to-many dial-a-ride transit (DRT) systems,[1] the unit rates of DRT operating expense have been determined with respect to three factors: vehicle-hours operated, vehicle-miles operated, and transit passengers. The average value for each of these unit rates is presented below, and the distribution of values for the set of 27 DRT operators is illustrated in Figure V-31.

UNIT EXPENSE FACTOR	AVERAGE VALUE
Operating expense per vehicle-mile operated ($OE/VMT)	$ .69
Operating expense per vehicle-hour operated ($OE/VHT)	$8.41
Operating expense per passenger ($OE/Psgr.)	$1.53

The selection of one of these rates to use when estimating DRT operating expenses depends largely on the availability of the corresponding supply (or demand) statistics. The best rate to use, however, is that rate which varies least over the range of transit operators. As indicated in Figure V-31, each of these statistics varies substantially. Operating expense per vehicle-mile traveled varies from a high of $1.11 to a low of $.35, operating expense per vehicle-hour operated ranges from $3.86 to $12.49, and operating expense per passenger ranges from $.66 to $4.69. However, nearly 80 percent of the DRT operators report values of ($OE/VHT) of between $6.00 and $10.00 (a range of 67 percent), as compared with values of ($OE/VMT) of between $.40 and $1.00 (a range of 150 percent) or ($OE/Psgr.) of between $.80 and $2.00 (a range of 150 percent). Therefore, $OE/VHT is the best of these three rates for estimating DRT operating expenses.

[1] Dial-a-Ride Transportation, Bureau of Urban and Public Transportation, Michigan Department of State Highways and Transportation (Revised February 1976).

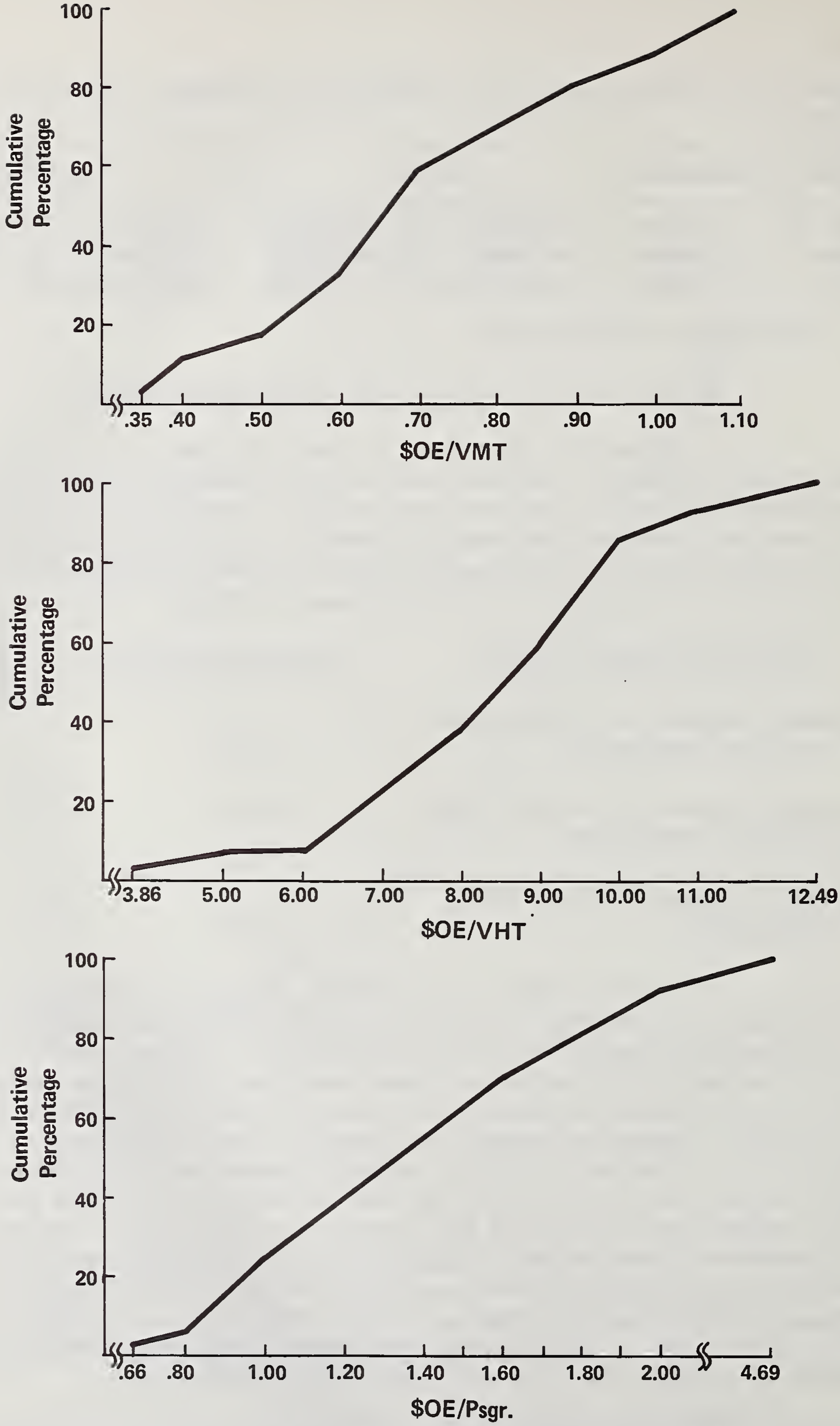


FIGURE V-31: CUMULATIVE FREQUENCY DISTRIBUTION OF SELECTED DRT UNIT OPERATING EXPENSES

The use of this rate is best illustrated by a simplified numerical example. Assume the DRT proposal is characterized by 100,000 annual vehicle-hours operated. Total annual operating expense for this service is calculated as follows:

Range for 80% of DRT Operations	High Estimate:	($10.00) (100,000) = $1,000,000 + (depreciation and taxes)
	Average Estimate:	($8.41) (100,000) = $841,000 + (depreciation and taxes)
	Low Estimate:	($6.00) (100,000) = $600,000 + (depreciation and taxes)

To determine the future expense of DRT operations using the simplified direct factor method, the set of cost multipliers developed for conventional transit operating expense may be used (it is reasonable to use these cost multipliers because 60 percent of DRT operating expense if labor-related).[1] Using these cost multipliers, Table V-12 presents a summary of DRT operating expense rates for use in applying the simplified direct factor method when estimating future DRT operating expenses.

(2) Expense Analysis of System Plans: Statistical Regression Techniques

Statistical regression techniques are used to determine the relation between transit operating characteristics and transit service characteristics at an aggregate (systemwide) level of detail. Familiarity with the transit industry results in an appreciation that transit operators experience similar physical, financial, and operating characteristics. Variations in the financial experience of transit properties can normally be explained by investigating the relation between financial data and selected statistics that describe the transit operation and the environment in which it operates. Several equations expressing these relations can be used in estimating systemwide operating expenses for conventional bus transit and dial-a-ride transit services.

---

[1]Dial-a-Ride Transportation, Bureau of Urban and Public Transportation, Michigan Department of State Highways and Transportation (Revised February 1976).

TABLE V-12

ESTIMATED FUTURE DRT OPERATING EXPENSE *
PER VEHICLE-HOUR OPERATED

RATE OF INFLATION / YEAR	4.1%			7.5%			8.9%		
	Low Estimate	Average Estimate	High Estimate	Low Estimate	Average Estimate	High Estimate	Low Estimate	Average Estimate	High Estimate
1975	$ 6.00	$ 8.41	$10.00	$ 6.00	$ 8.41	$10.00	$ 6.00	$ 8.41	$10.00
1976	6.25	8.76	10.40	6.45	9.04	10.75	6.53	9.16	10.89
1977	6.50	9.11	10.84	6.93	9.72	11.56	7.12	9.97	11.86
1978	6.77	9.49	11.28	7.45	10.45	12.42	7.75	10.86	12.91
1979	7.05	9.88	11.74	8.01	11.23	13.35	8.44	11.83	14.06
1980	7.34	10.28	12.23	8.61	12.07	14.36	9.19	12.88	15.32
1981	7.64	10.70	12.73	9.26	12.98	15.43	10.01	14.03	16.68
1982	7.95	11.14	13.25	9.95	13.95	16.59	10.90	15.28	18.16
1983	8.28	11.60	13.79	10.70	15.00	17.83	11.87	16.64	19.78
1984	8.61	12.07	14.36	11.50	16.12	19.17	12.92	18.12	21.54
1985	8.97	12.57	14.95	12.37	17.33	20.61	14.07	19.73	23.46
1986	9.34	13.08	15.56	13.29	18.63	22.16	15.33	21.48	25.55
1987	9.72	13.62	16.20	14.29	20.03	23.82	16.69	23.40	27.82
1988	10.12	14.17	16.86	15.36	21.53	25.60	18.18	25.48	30.29
1989	10.53	14.76	17.55	16.52	23.15	27.52	19.79	27.75	32.99
1990	10.96	15.37	18.27	17.75	24.88	29.59	21.56	30.21	35.93

*Excludes depreciation and taxes.

(a) Conventional Bus Transit Operating Expense Relations

Equations expressing the relation between the annual operating expense of conventional transit service and the operating characteristics of these services have been developed using data from 33 small to medium-sized transit operations.[1] These equations are presented as multidimensional plots in Figures V-32 and V-33 to permit them to be used with ease and to show the relative effect that each variable has on conventional bus transit operating expense.

(b) Dial-a-Ride Transit Operating Expense Relations

Equations expressing the relation between the operating expense of DRT services and the operating characteristics of these services have been developed for three typical DRT alternatives:

- areawide many-to-many DRT service or shared ride taxi service with no other local competing transit service available;
- areawide or subarea many-to-many DRT service or shared ride taxi service with competing local transit service available; and
- zone and feeder DRT service coordinated with other local or regional transit service.

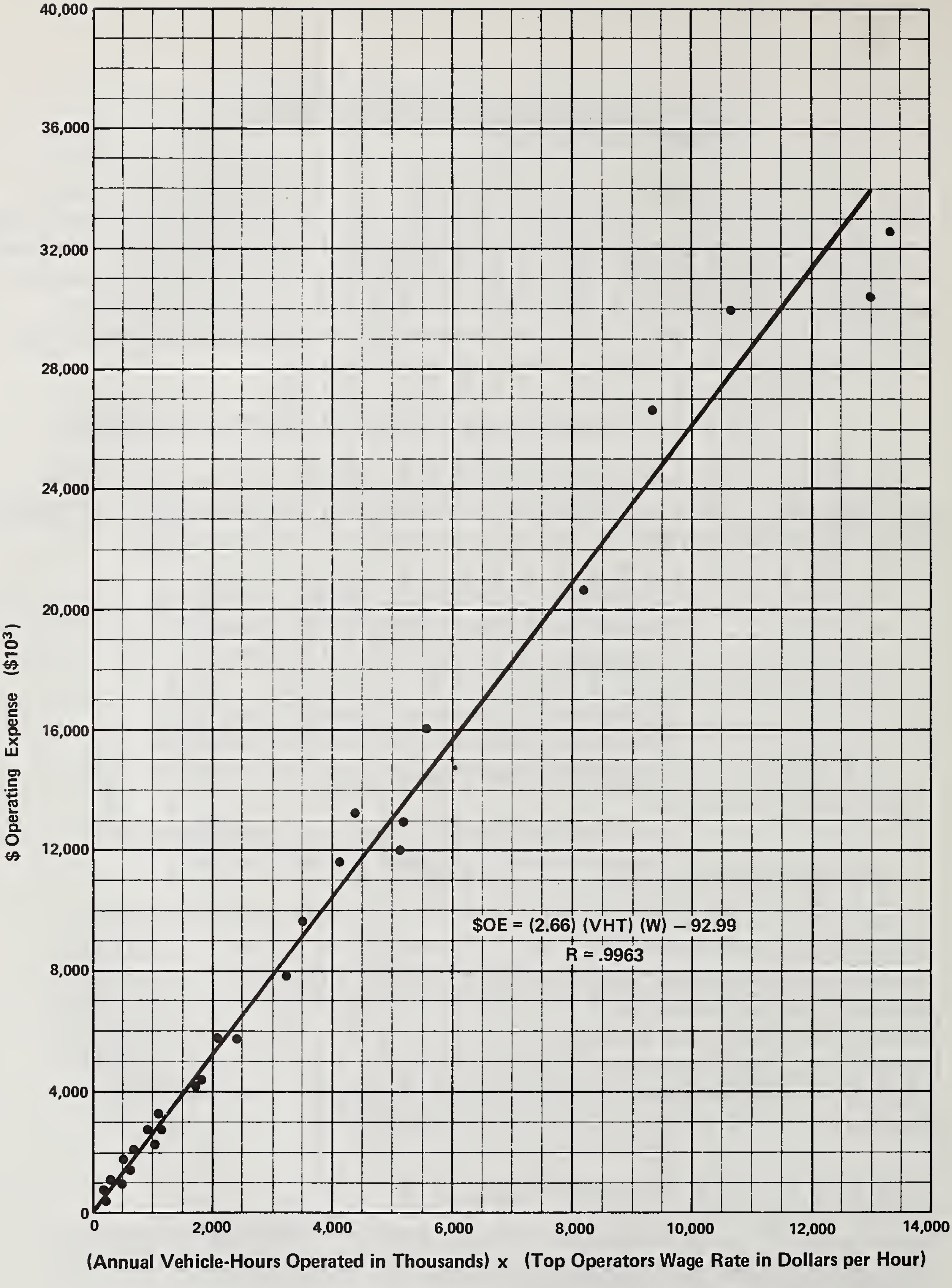
These three DRT scenarios are identical to three of the four DRT scenarios introduced in Section V. C, and the data used to prepare these estimates are from the same sources. One DRT scenario, service for the elderly and handicapped, provided insufficient data to develop Operating Expense Relations. These equations are presented as mutlidimensional plots in Figures V-34 through V-38 to permit them to be used with ease and to show the relative effect that each variable has on DRT operating expense.

---

[1] Data from 33 conventional bus transit systems reported in Transit Operating Report for Calendar/Fiscal Year 1974, American Public Transit Association (Washington, D. C.).

Six sources of data were used to develop these relations as follows:

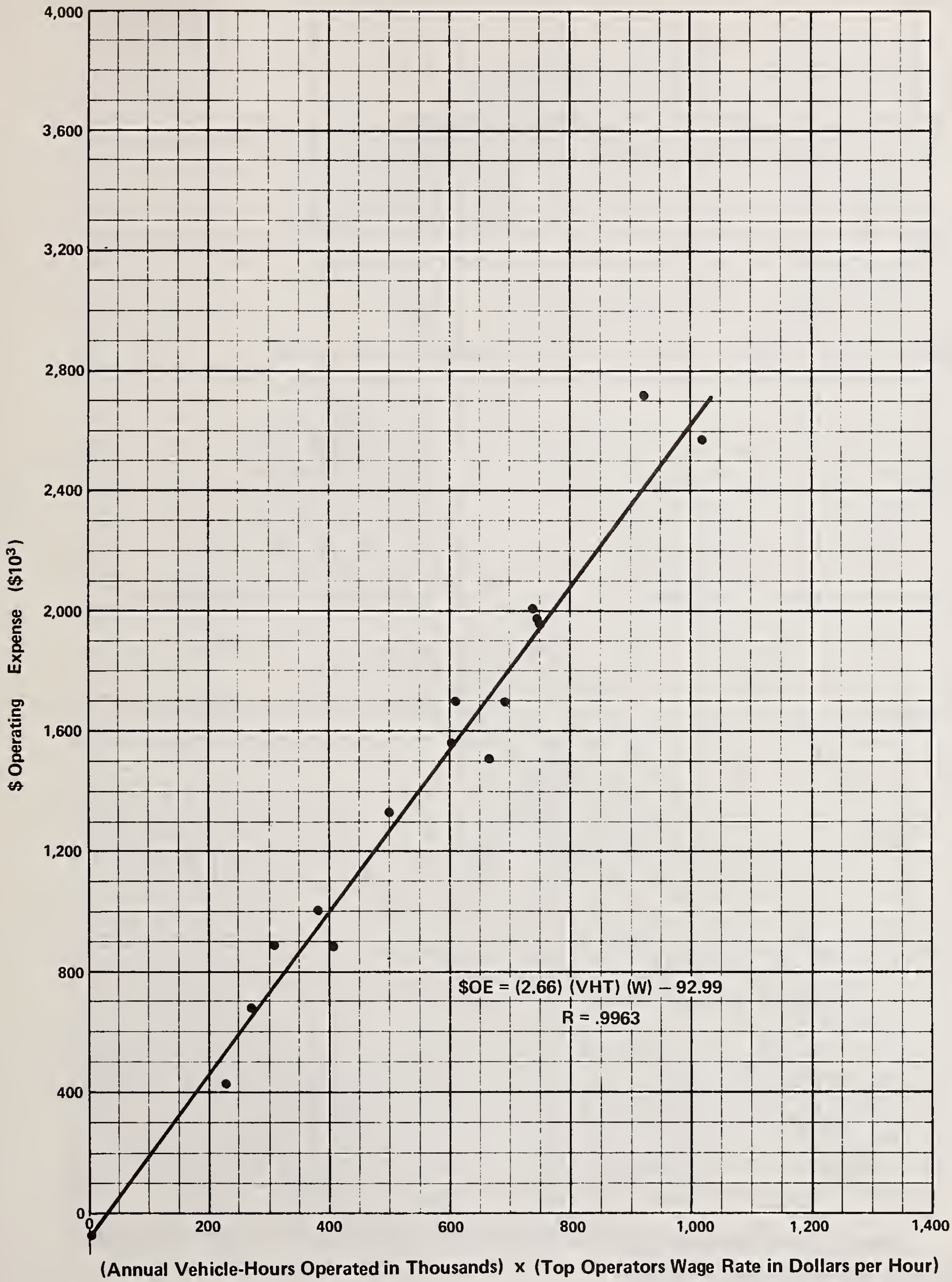
(1) Lea Transit Compendium: Para-transit. Vol. 1, No. 8. Huntsville, Alabama: N.D. Lea Transportation Research Corporation, 1974.



[1]Excludes depreciation and taxes.

Source: Data from 33 conventional bus transit systems reported in Transit Operating Report for Calendar/Fiscal Year 1974, American Public Transit Association (Washington, D.C.).

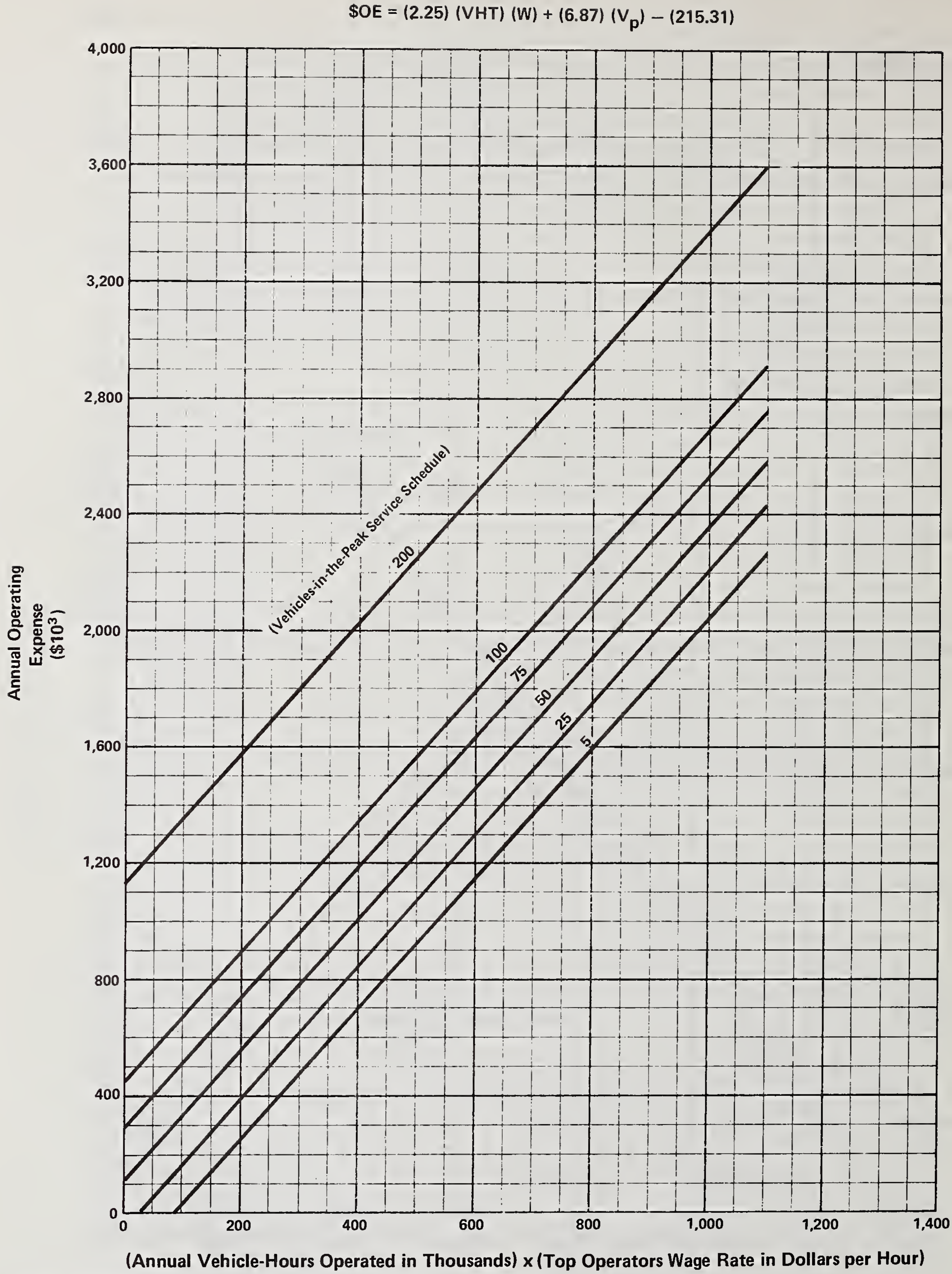
FIGURE V-32: CONVENTIONAL TRANSIT ANNUAL OPERATING EXPENSE[1] VERSUS VEHICLE-HOURS OPERATED (TOP OPERATOR'S WAGE RATE)



Note: This figure presents a focus of the southwest corner of the figure on the previous page.

Source: Data from 33 conventional bus transit systems reported in Transit Operating Report for Calendar/Fiscal Year 1974, American Public Transit Association (Washington, D.C.).

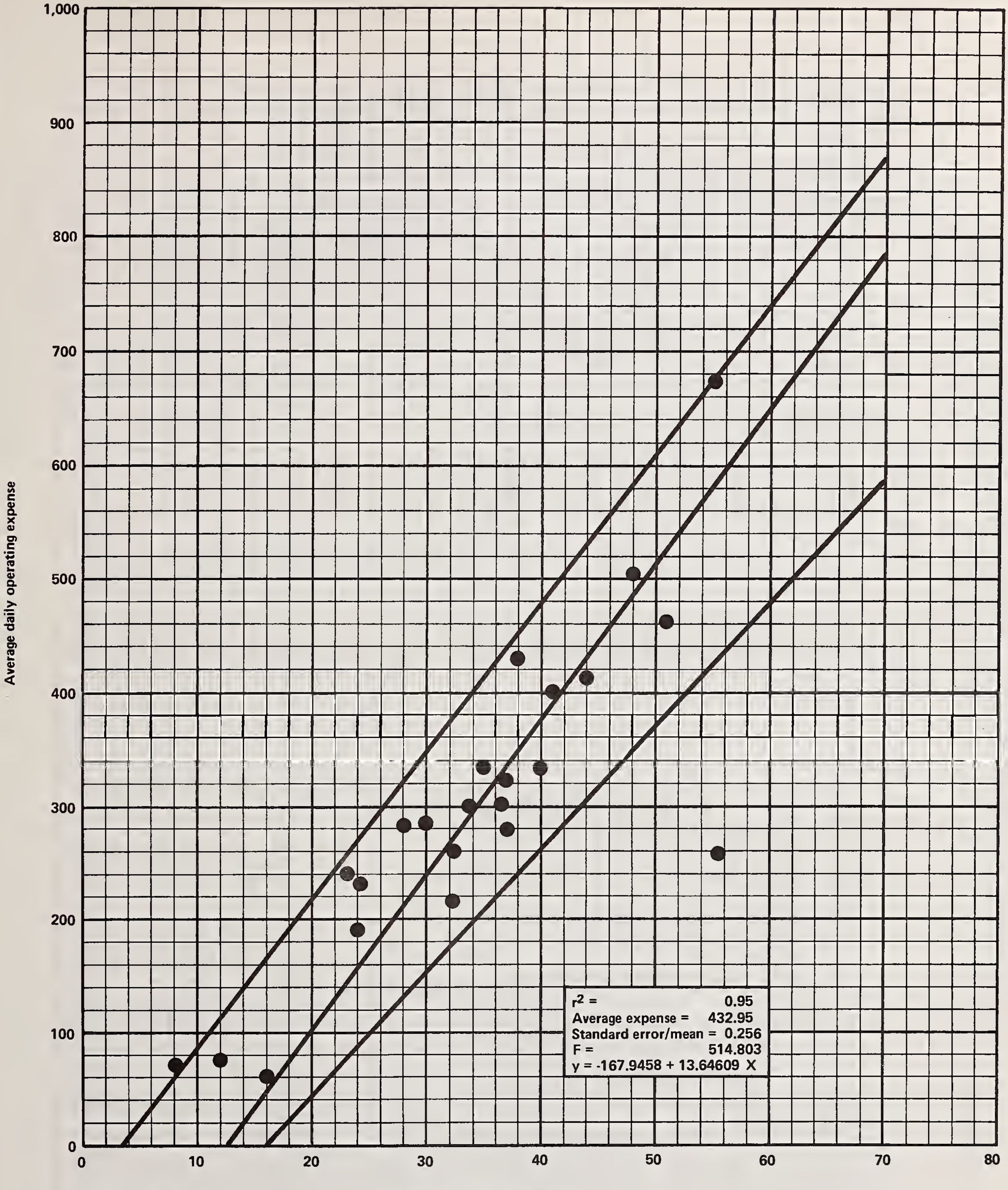
FIGURE V-32 (Continued)



Source: Data from 33 conventional bus transit systems reported in Transit Operating Report for Calendar/Fiscal Year 1974, American Public Transit Association (Washington, D.C.).

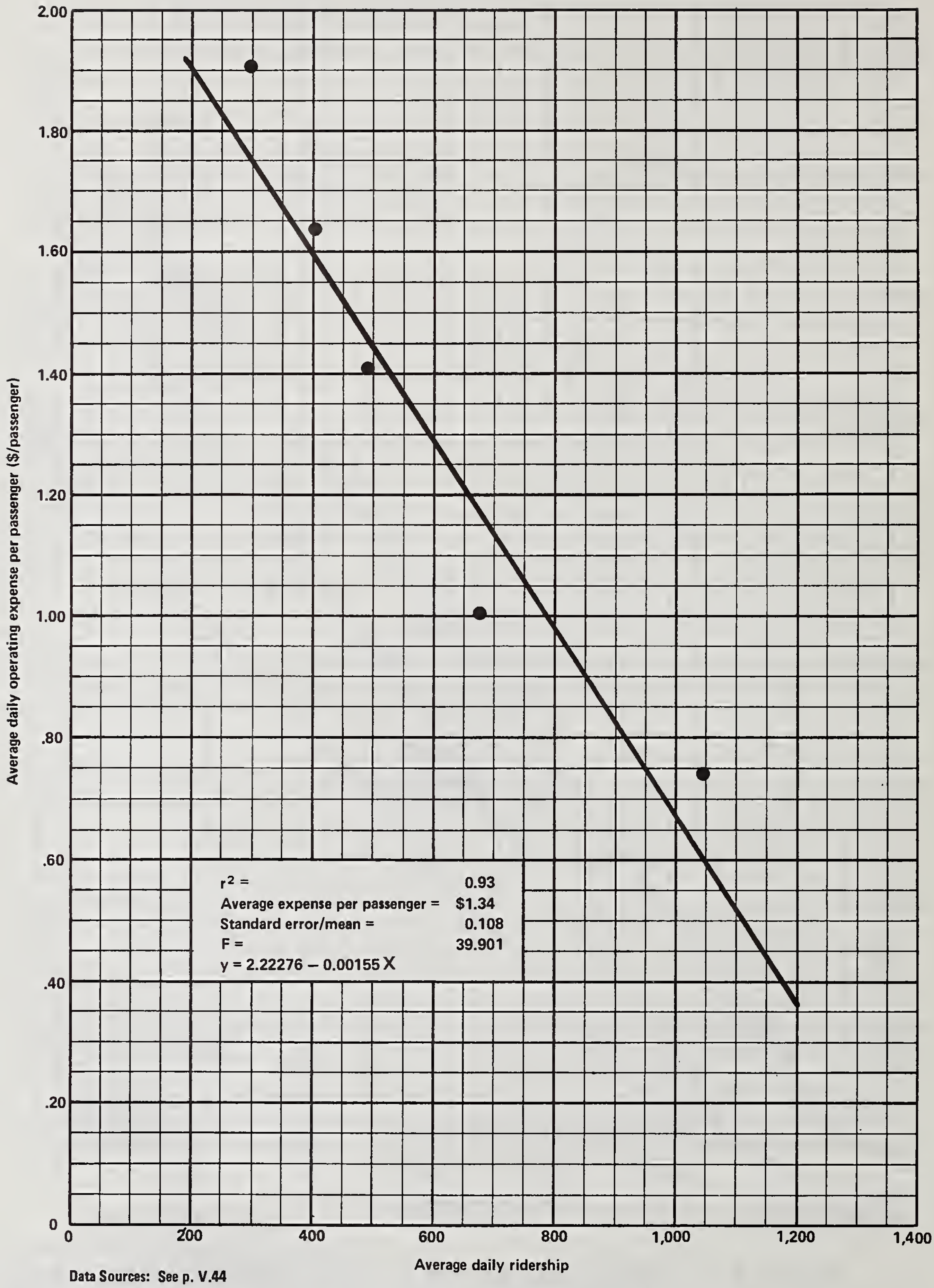
[1]Excludes depreciation and taxes.

FIGURE V-33: CONVENTIONAL TRANSIT ANNUAL OPERATING EXPENSE[1] VERSUS (VEHICLE-HOURS OPERATED) (TOP OPERATOR'S WAGE RATE) AND (VEHICLES-IN-THE-PEAK SERVICE SCHEDULE)



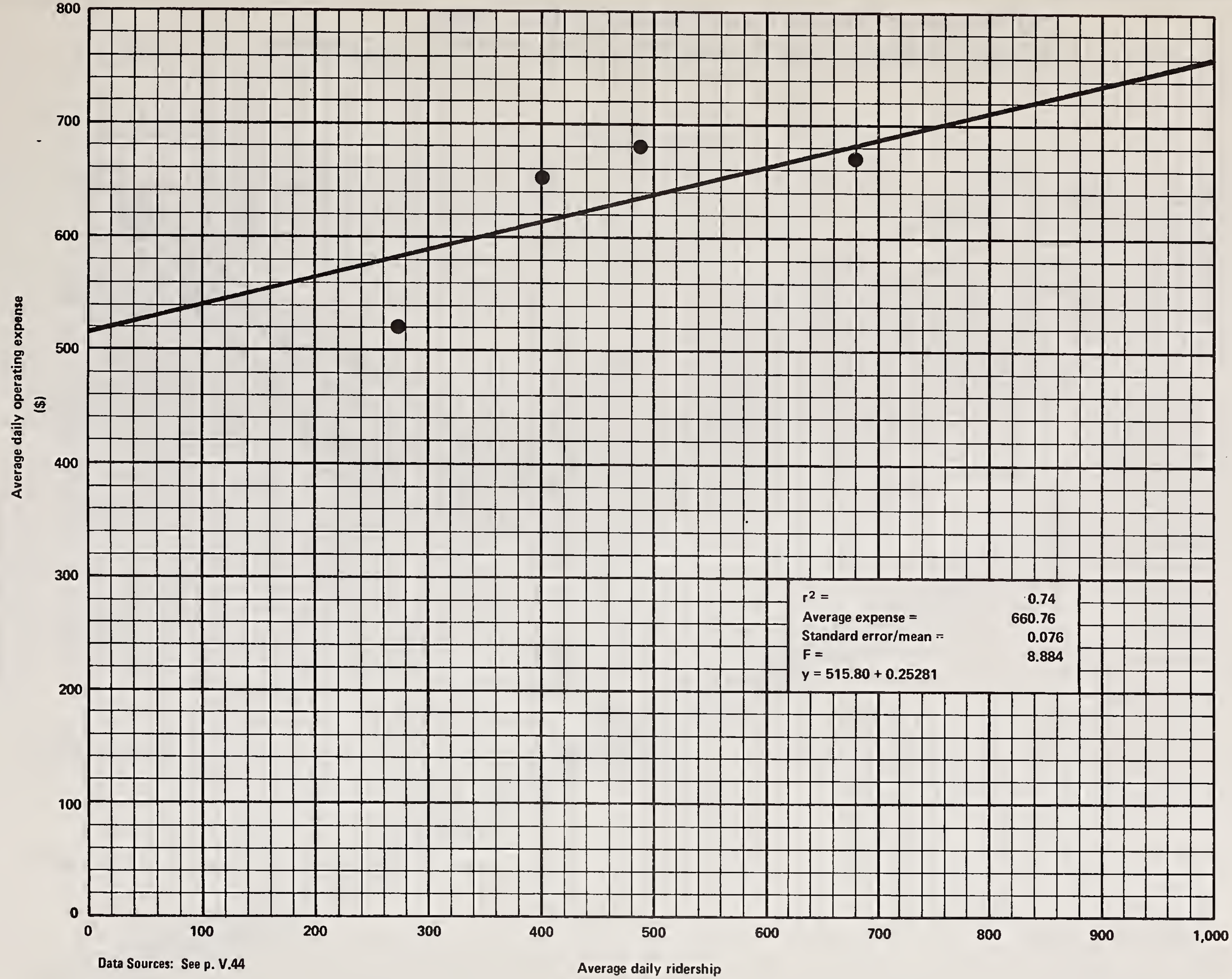
Data Sources: See p. V.44

FIGURE V-34: AVERAGE DAILY OPERATING EXPENSE VERSUS AVERAGE DAILY VEHICLE-HOURS OPERATED IN AREAWIDE MANY-TO-MANY DRT (OR SHARED-RIDE TAXI SERVICE) WITH NO OTHER LOCAL COMPETING TRANSIT SERVICE AVAILABLE



Data Sources: See p. V.44

FIGURE V-35: AVERAGE DAILY OPERATING COST PER PASSENGER VERSUS AVERAGE DAILY RIDERSHIP ON MANY-TO-MANY DRT AND SHARED RIDE TAXI SERVICE (CITYWIDE OR SUBAREA OF CITY) WITH COMPETING LOCAL TRANSIT SERVICE AVAILABLE



Data Sources: See p. V.44

FIGURE V-36: AVERAGE DAILY OPERATING EXPENSE VERSUS AVERAGE DAILY RIDERSHIP IN MANY-TO-MANY DRT AND SHARED RIDE TAXI (CITYWIDE OR SUBAREA OF CITY) COMPETING LOCAL PUBLIC TRANSIT SERVICE AVAILABLE

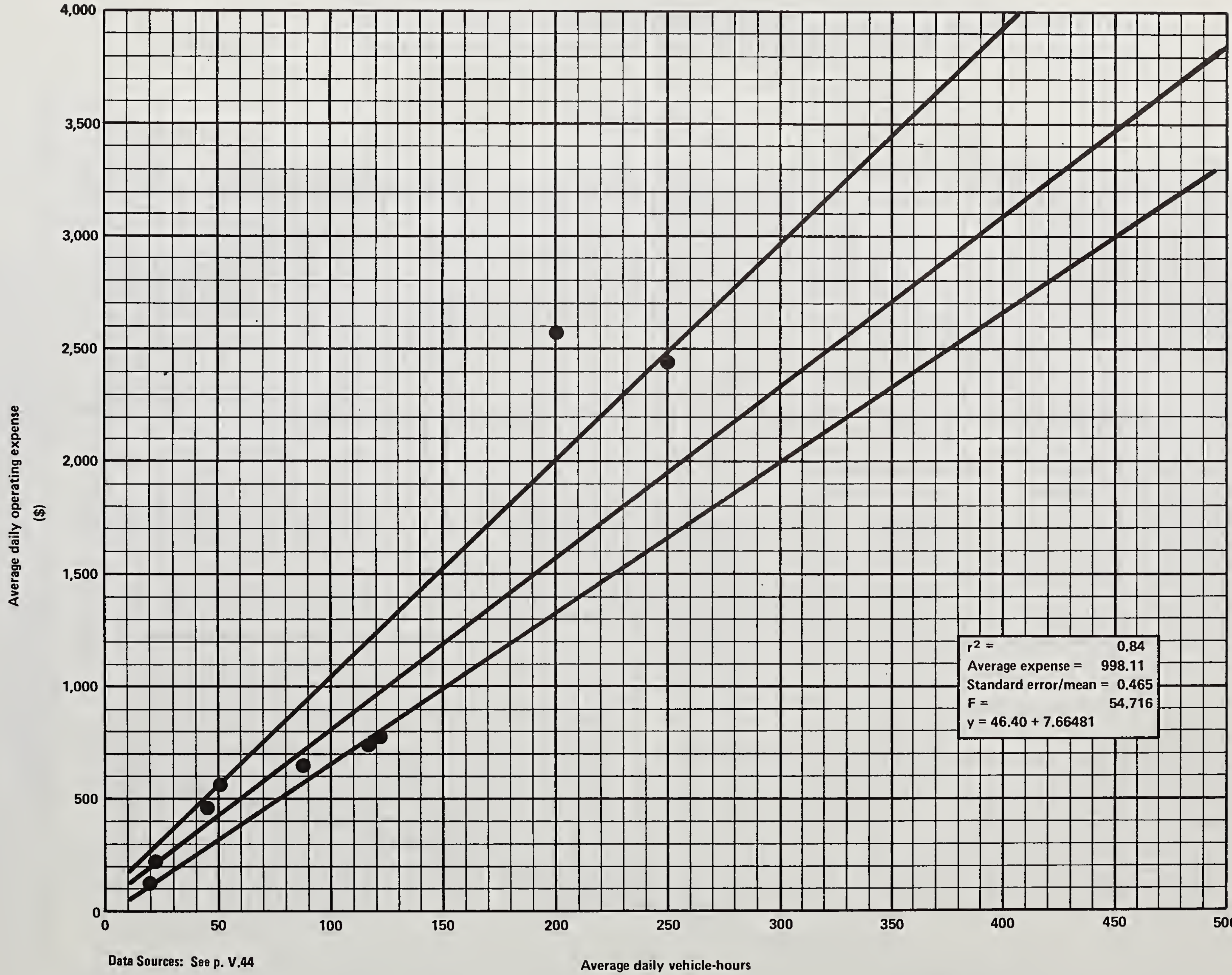
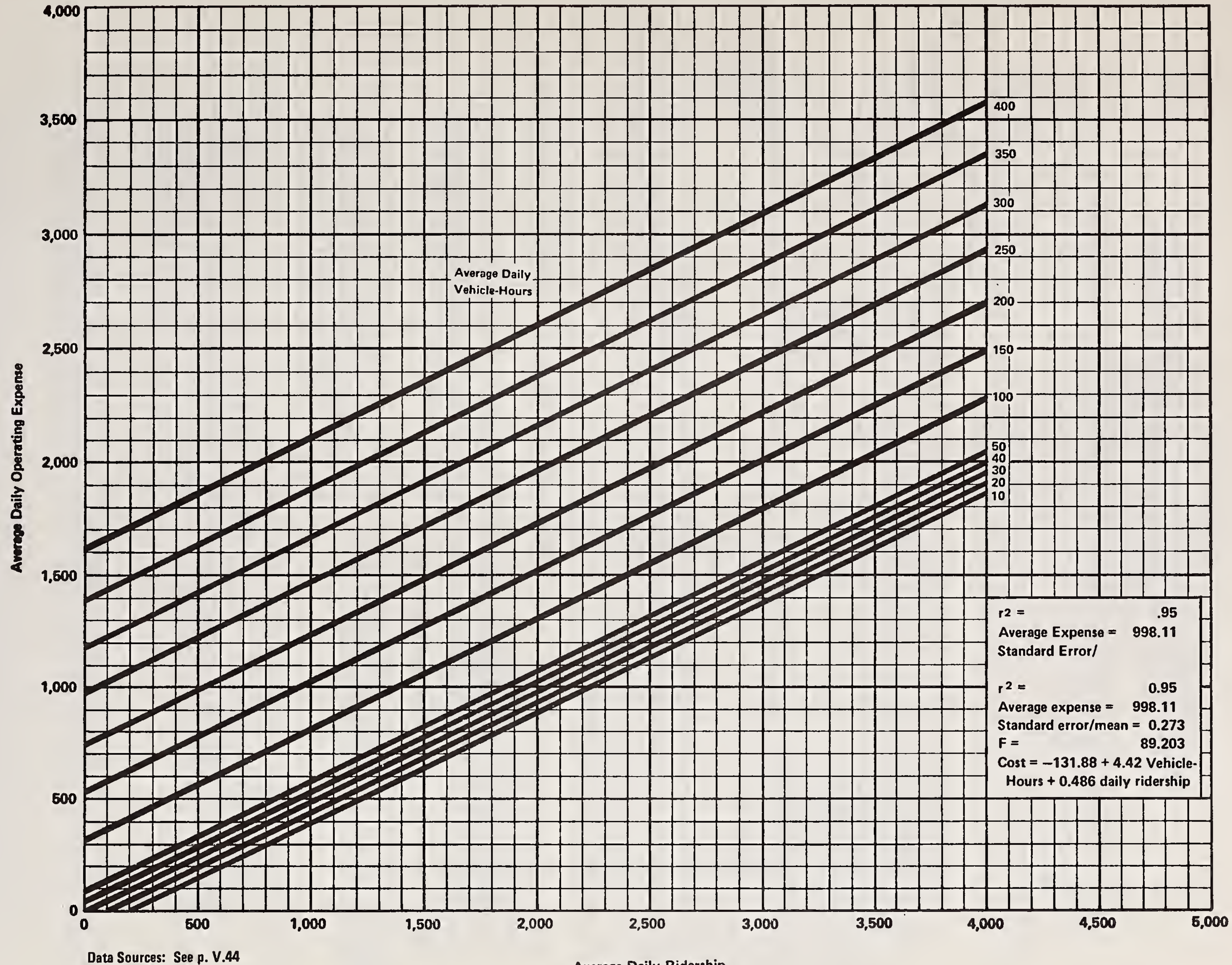


FIGURE V-37: AVERAGE DAILY OPERATING EXPENSE VERSUS AVERAGE DAILY VEHICLE-HOURS (ZONE AND FEEDER DRT SYSTEMS)



Data Sources: See p. V.44

FIGURE V-38: DRT OPERATING EXPENSE ESTIMATION

Zone and Feeder DRT Systems

(Coordination with Other Local and Regional Transit Services)

TABLE V-13

ALLOCATION OF TRANSIT OPERATING EXPENSES
TO TWO CAUSAL FACTORS:
VEHICLE-MILES OPERATED AND VEHICLE-HOURS OPERATED

Expense Category	Annual Expense	Causative Factor	
		Vehicle-Miles Operated	Vehicle-Hours Operated
Fuel for revenue vehicles	$ 1,000.00	$1,000.00	
Tires for revenue vehicles	100.00	100.00	
Repair of revenue vehicles	6,000.00	6,000.00	
Servicing of revenue vehicles	2,000.00	2,000.00	
Operator's wages	10,000.00		$10,000.00
Operator's fringe benefits	2,000.00		2,000.00
Scheduling costs	400.00		400.00
Total	$21,500.00	$9,100.00	$12,400.00

ANNUAL OPERATIONAL DATA:

Vehicle-miles operated:	21,500
Vehicle-hours operated:	2,150
Average system speed:	10 MPH
Mileage-based costs:	$0.42 per vehicle-mile
Hourly based costs:	$5.80 per vehicle-hour

(3) Expense Analysis for Detailed Evaluation and Diagnostic Review: Causative Factor Method

Expense estimating relations determined by the causative factor method are useful for estimating operating expenses by transit mode, time of day, or individual line or service area. They may be used to obtain estimates of the operating expense implications of either conventional transit or paratransit services.

The causative factor method is based on the notion that transit operating expenses are related to vehicle-miles operated, vehicle-hours operated, or other factors that define the transit service and its output. The use of vehicle-miles operated and vehicle-hours operated as causative factors in cost determination is obvious. Fuel, tires, and certain other inputs are required in direct relation to the number of vehicle-miles operated. Similarly, transit vehicle operators' salaries are directly related to vehicle-hours operated.

A simplified example of the causative factor method using these two operating factors to allocate transit operating expenses is presented in Table V-13. In this hypothetical example, fuel and tire expenses and repair and servicing expenses are allocated to vehicle-

---

(footnote continued from preceding page)

(2) Bert Arrillaga and George E. Mouchahoir, Demand-Responsive Transportation System Planning Guidelines (McLean, Virginia: the MITRE Corporation, 1974).

(3) Transportation Systems Center, Demand-Responsive Transportation: State-of-the-Art Overview (Cambridge, Massachusetts: U.S. Department of Transportation, 1975).

(4) Frank W. Davis, Jr., Kenneth W. Heathington, Richard T. Symons, Stephen C. Griese, Roger W. Alford, and David P. Middendorf, Economic Characteristics of Privately Owned Shared-Ride Taxi Systems (Knoxville, Tennessee: Transportation Center, the University of Tennessee, 1974).

(5) David R. Shilling and G. J. Fielding, "LaHabra Dial-a-Ride Project," New Transportation Systems, Transportation Research Record #522.

(6) Michigan Department of State Highways and Transportation, Dial-a-Ride Transportation: Michigan DART Program Status Report (Lansing, Michigan: Michigan Department of State Highways and Transportation, Bureau of Urban and Public Transportation, 1976).

miles operated (resulting in a mileage-based cost of $.42 per vehicle-mile). Operators' wages, fringe benefits, and scheduling costs are allocated to vehicle-hours operated (resulting in an hourly based cost of $5.80 per vehicle-hour).

The transit system represented by this example is assumed to operate two lines.[1] Line A operates in the central city and provides 10,750 annual vehicle-miles and 1,300 annual vehicle-hours of service (the average line speed = 8.27 MPH). Line B operates outside the central city and also provides 10,750 annual vehicle-miles of service but only 850 vehicle-hours of service (the average line speed = 12.65 MPH). The following computation illustrates the application of the causative factor method to these individual lines.

LINE A	(10,750 vehicle-miles operated)($.42) per vehicle-mile)	= $ 4,515
	(1,300 vehicle-hours operated)($5.80 per vehicle-hour)	= 7,540
	Total Cost of Operation	$12,055
LINE B	(10,750 vehicle-miles operated) ($.42 per vehicle-mile)	= $ 4,515
	(850 vehicle-hours operated) ($5.80 per vehicle-hour)	= 4,930
	Total Cost of Operation	$ 9,445

This simple example shows a significant difference in the operating expenses of these two lines. Both provide the same number of vehicle-miles operated, but the line that has the higher average operating speed (and consequently the lower number of vehicle-hours operated) experiences significantly lower annual operating expenses.

In this simple example, however, two operating expense categories, servicing of revenue vehicles and operators' fringe benefits, could be more appropriately allocated to factors other than vehicle-miles or vehicle-hours operated. Because transit vehicles are normally

[1]Two paratransit service areas could have just as easily been assumed.

serviced once a day or once every other day regardless of the number of vehicle-miles operated, expenses in this category are incurred just because the vehicle is being operated and should therefore be allocated to the number of vehicles in service. In addition, because vehicle operators are typically guaranteed fringe benefits once they are on the payroll (with little relation to the number of hours worked), this element of operating expense should be allocated to the number of vehicle operators rather than to vehicle-hours operated.

The effect of these two additional causative factors is now included in the operating expense analysis of the original example, which is reconstructed in Table V-14. Making the same assumptions about the two lines as before, the following details on schedules are added to the example:

Line A — operates two buses from 6:00 a.m. to 10:00 p.m. (two buses and 4 operators are required); and

Line B — operates four buses in each peak period, approximately 3 hours each in the morning peak and 3.5 hours each in the afternoon peak (four buses and four operators are required).

The following computation illustrates the application of this refined causative factor method to these individual lines.

Line A	(10,750 vehicle-miles operated) ($.33 per mile)	=	$3,550.00
	(1300 vehicle-hours operated)($4.65 per hour)	=	6,046.00
	(2 Vehicles)($366.67 per vehicle)	=	733.00
	(4 Operators)($275.00 per operator)		1,100.00
	Total Operating Expense		$11,429.00
Line B	(10,750 vehicle-miles operated)($.33 per mile)	=	$3,550.00
	(850 vehicle-hours operated)($4.65 per hour)	=	3,954.00
	(4 vehicles)($366.67 per vehicle)	=	1,467.00
	(4 operators)($275.00 per operator)	=	1,100.00
	Total Operating Expense		$10,071.00

TABLE V-14

ALLOCATION OF TRANSIT OPERATING EXPENSES TO FOUR CAUSAL FACTORS: VEHICLE MILES OPERATED, VEHICLE HOURS OPERATED, NUMBER VEHICLES IN SERVICE, AND NUMBER OF VEHICLE OPERATORS

EXPENSE CATEGORY	Annual Expense	Causative Factor			
		Vehicle-Miles Operated	Vehicle-Hours Operated	Vehicles In Service	Vehicle Operators
Fuel for revenue vehicles	$ 1,000.00	$1,000.00			
Tires for revenue vehicles	100.00	100.00			
Repair of revenue vehicles	6,000.00	6,000.00			
Servicing of revenue vehicles	2,000.00			$2,000.00	
Operator's wages	10,000.00		$10,000.00		
Operator's fringe benefits	2,000.00				$2,000.00
Scheduling*	400.00			200.00	200.00
Total	$21,500.00	$7,100.00	$10,000.00	$2,200.00	$2,200.00

*Scheduling costs are split between vehicles and operators in this example on the assumption that half the time of the scheduling personnel is spent in scheduling the vehicle and half in scheduling the vehicle operator.

ANNUAL OPERATIONAL DATA:

Vehicle-miles operated:	21,500
Vehicle-hours operated:	2,150
Vehicles required:	6
Vehicle operators required:	8
Average system speed:	10 MPH
Mileage-based costs:	$ 0.33 per vehicle-mile
Hourly based costs:	$ 4.65 per vehicle-hour
Vehicle-based costs:	$366.67 per vehicle
Operator-based costs:	$275.00 per vehicle operator

Because of the higher expense involved in providing peak period service on Line B, the difference in operating expense between the two lines illustrated in the original example is no longer as apparent. The savings realized by operating vehicles at higher speeds are offset by the vehicle and operator requirements for providing peak period transit services.

To simplify the discussion, many normal elements of transit operating expense have been left out of these examples. Elements of operating expense resulting from fare collection, public liability, and public information programs, for example, have not been included. It is not reasonable to assume that any of these expense elements are totally related to the four factors discussed previously, yet they must be considered. To account for these additional elements of operating expense, the transit passenger is included as the final factor influencing transit operating expense.

Together with vehicle-miles operated, vehicle-hours operated, vehicles, and vehicle operators, this last causative factor forms the basis for a technique to allocate transit operating expenses fully.

The use of the causative factor method by a small community planner or decisionmaker depends on two factors:

- the existence of a record of local transit financial and operating data based on transit service in the small urban community; and
- the form in which financial data are currently (or are proposed to be) accounted for (chart of accounts).

If transit service is currently operating in the community and a record of financial and operating data is available, the planner or decisionmaker in the small community must simply allocate individual elements of operating expense to one of the five factors and determine specific values for the component unit expenses of transit service operation.[1] The allocation procedure need not be more complicated than

---

[1] This process works well with few exceptions. In certain circumstances, an element of expense is caused by two or more factors and should therefore be distributed between these factors. Also, there are certain elements of expense that should be allocated directly to a particular element of service rather than to the system as a whole. It is advisable, therefore, that the causative factor method be executed by, or in consultation with, an individual who is very familiar with the financial and operating data accounting format of the transit organization.

that represented by the examples discussed above. Once the component unit expenses of transit service operation are determined, these rates can be used to conduct the following types of analyses:

- comparison of the operating expense of one part of the transit system with another part;
- projection of operating expenses for new transit services;
- comparison of the operating expense of transit service during different times of the day or different days of the week; or
- comparison of the operating expenses of different types of transit services (e.g., conventional bus transit and dial-a-ride transit).

c. Operating Revenue Implications

The revenue generated by transit service operation depends on two factors: the number of transit passengers and the fare charged for use of transit services. The simplest and most prevalent type of fare is the flat fare - a single price for every ride.[1] Fares based on distance travelled, time of day or day of the week, origins and destinations served, level of service, or characteristics of the rider, however, are also common.

To precisely determine the revenue implications of transit operation, the rate charged for each type of transit trip and the number of each type of transit trip made must be known. However, it is possible to estimate the revenue implications of transit operation using a value for the average fare per passenger and the total number of transit trips made.

The average fare per passenger can be determined in one of two ways. If transit service is currently provided in the community and

---

[1]Approximately one-half of the North American transit firms reporting fare data to the American Public Transit Association are currently using flat fares. Public Transportation Fare Policy, Unpublished working paper prepared for the Office of the Secretary, U.S. Department of Transportation, by Peat, Marwick, Mitchell & Co. (August 1975).

a historical record of revenue and ridership data is available, the average fare per passenger can be approximated by calculating the ratio of annual operating revenue to annual revenue passengers. If transit service is not provided or a historical record of revenue and ridership data is not available, the average fare per passenger can be approximated by weighting the different rates charged for transit trips by the estimated proportion of trips made at each rate. For example, if the basic adult cash fare is $. 50 per trip, students are permitted to ride at half fare, the proportion of total trips made by full fare passengers is estimated at 75 percent and the proportion on total trips made by half fare passengers is estimated at 25 percent, the average fare is calculated as follows:

$$(.50)(.75) + (.25)(.25) = \$.44$$

Once the revenue from regular passenger service is estimated, revenue from charter service operations should be included to determine total operating revenue (assuming charter service is planned as part of the operation).

4. Federal and State Financial Assistance Opportunities

Over the past three decades, the transit industry has experienced a general financial decline, having moved from an industry-wide net income in 1945 of $313 million to an industry-wide deficit in 1975 of $1,663 million.[1] This decline has been attributed to a set of related causes that include:

- the emergence of the automobile, which caused initial patronage and revenue losses;
- an industry reaction of fare increases and service reductions, which led to greater losses in patronage and revenue; and
- the recent and rapid increase of transit operating expenses.

Accompanying this general decline has been an accelerating trend toward public ownership of transit systems and an increasing involvement in direct financial assistance of transit operations by local, state, and federal governments. By 1972, local assistance to transit amounted to $545 million (approximately 60 percent for operating subsidies), state assistance reached $177 million (also 60 percent for operating subsidies), and federal assistance totaled $470 million (all for

[1] American Public Transit Association, 1975-76 Transit Fact Book, 1975 preliminary estimate (March 1976), p. 26.

capital improvements).[1] In addition, with the passage of the National Mass Transportation Assistance Act of 1974, the first federal commitment to assist transit systems with direct operating subsidies was enacted.

Small urban communities sponsoring, promoting, providing, or simply considering transit services should be aware of the range of federal and state financial assistance opportunities. The eligibility requirements, grant funding limitations, and matching fund requirements associated with federal and state financial aid programs are described below.

a. Federal Financial Assistance Opportunities

Within the administrative structure of the U.S. Department of Transportation, there are four items of legislation that affect federal policy toward urban mass transportation financing.[2] Table V-15 summarizes the legislative basis for this support. On an annual basis, UMTA undertakes a review of local transit operations and planning efforts to determine eligibility for the receipt of these federal funds. This evaluation is based on, but not limited to, planning requirements for urbanized or nonurbanized areas, whichever is applicable. These planning requirements are summarized in Table V-16.

Guidelines for qualifying and applying for financial assistance through an UMTA program are specified in the UMTA External Operating Manual.[3] This manual provides information about UMTA, its programs, and how each program is administered. In particular, it provides potential applicants with the following detailed information for each program:

- specific criteria for eligibility;
- how to prepare an application;
- UMTA criteria for evaluating proposals; and
- specific policies and procedures for administering contracts.

---

[1] American Transit Association, A Summary of Financial Assistance for Transit Systems in 1972 (June 1973).

[2] For the details of this and related legislation refer to the most recent version of Urban Mass Transportation Act of 1964 and Related Laws, as amended, U.S. Department of Transportation, Washington, D.C.

[3] UMTA External Operating Manual, Urban Mass Transportation Administration, Washington, D.C., August 1972, Revised February 1973, March 1974, and May 1974.

TABLE V-15

SUMMARY OF FEDERAL LEGISLATION IN SUPPORT OF TRANSIT DEVELOPMENT AND OPERATION

Act	Type of Assistance	Eligible Recipients	Minimum Non-Federal Match	Allocation Formula	Funding Level	Notes
Urban Mass Transportation Act of 1964, as amended	Provision of grants and loans primarily for capital improvements. Funds also used for research and training grants.	State and local agencies; also, private and non-profit institutions of higher learning.	1/3	Case by case basis.	Congress funded program annually. Committed $734 million from 1964 to 1970.	Introduced labor protection provision (Section 13c). Predicated receipt of funds on region's having comprehensive, areawide, continuing planning process.
Urban Mass Transportation Assistance Act of 1970	Capital improvements, research, and training.	State and local agencies.	1/3	Case by case basis. Grants to any one state may not exceed 12.5% of aggregate funds; 15% of aggregate funds to be expended at discretion of U.S. Secretary of Transportation.	$3.1 billion obligation; $10 billion commitment over 12-year period.	Introduced concept of long-term funding.
Federal-Aid Highway Act of 1973	Capital improvements.	State and local agencies.	1/5	In accordance with allocation formula of Title 23; essentially population-based.	. Amended UMTA, 1970 by increasing $3.1 billion contract authority to $6.1 billion over same 12-year period. . Beginning FY 75, $200 million of the Highway Trust Fund's designated $800 million for Federal Urban Aid Systems may be used for purchase of buses.	First use of Federal highway funds for urban transit capital improvements.

TABLE V-15 (Continued)

Act	Type of Assistance	Eligible Recipients	Minimum Non-Federal Match	Allocation Formula	Funding Level	Notes
Federal-Aid Highway Act of 1973 (Continued)					. Beginning FY 76, all $800 million may be used for improvement or construction of fixed rail facilities or rail or bus rolling stock. . Except for the above provisions, the following sums may be spent on either highway or public mass transit projects (e.g., exclusive busways): for FY 74, $780 million; FY 75, $800 million; and FY 76, $800 million. . $40 million per fiscal year may be spent for bicycle transportation and pedestrian walkways. . Funds are authorized for use in provision of services for elderly and handicapped. . $30 million authorized for rural Public Transportation Demonstration Projects in FY 75 and FY 76. . The Act permits state and local governments with the concurrence of the U.S. Secretary of Transportation to substitute a public transit improvement for a non-essential Interstate Highway Project or Urban System highway project and to use monies from general revenues not to exceed the Federal share of highway costs.	
National Mass Transportation Assistance Act of 1974	Grants for capital expenditures and for operating expenses.	State and local agencies.	1/5 for capital expenditures; 1/2 for operating costs.	1/2 according to population; 1/2 according to population density.	. $11.854 billion for FY 75-FY 80, including: . $7.8 billion for capital grants (of which $500 million is reserved for rural areas). . Over $4 billion for capital or operating grants (FY 75, $800 million; FY 76, $500 million; FY 77, $650 million; FY 78, $775 million; FY 79, $850 million; FY 80, $900 million). . $40 million for experimental fare-free transit. . Contract authority increased from $6.1 billion to $10.925 billion.	. Alternate use proposal to allow cities to use up to 1/2 of their capital grants to defray operating expenses if they agree to replenish the capital program—using local revenues—by the end of the following fiscal year. . Other Federal grants or farebox revenues cannot be used as local match.

TABLE V-16

OUTLINE OF FEDERAL PLANNING REQUIREMENTS

SOURCE	PLANNING REQUIREMENTS	APPLICABILITY	
		Urbanized Area	Nonurbanized Area
Federal Register, Volume 40, Number 181, September 17, 1975, pp 42976-42978.	The transportation planning process shall, as a minimum, cover the urbanized area and the area likely to be covered by the long-range element of the transportation plan.	X	
	The urban transportation planning process shall include a Transportation Systems Management (TSM) element and a long-range element.	X	
	. The TSM element shall:		
	(1) provide for the short-range transportation needs of the urbanized area by making efficient use of existing transportation resources and providing for the movement of people in an efficient manner; and		
	(2) identify traffic engineering, public transportation, regulatory, pricing, management, operational and other improvements to the existing urban transportation system not including new transportation facilities or major changes in existing facilities.		
	. The long-range element shall:		
	(1) provide for the long-range transportation needs of the urbanized area; and		
	(2) identify new transportation policies and transportation facilities or major changes in existing facilities by location and modes to be implemented.		
	The transportation plans shall be consistent with the area's comprehensive long-range land-use plan, urban development objectives, and overall social, economic, environmental, system performance, and energy conservation goals and objectives.	X	
	. The urban transportation planning process shall:	X	
	(1) provide for the consideration of social, economic, and environmental effects, in support of the requirements of 23 U.S.C. 109(h), and sections 5(h) (2) and 14 of the UMT Act (49 U.S.C. 1604(h) (2) and 1610);		

TABLE V-16 (Continued

SOURCE	PLANNING REQUIREMENTS	APPLICABILITY	
		Urbanized Area	Nonurbanized Area
	(2) be coordinated with air quality planning conducted pursuant to 42 U.S.C. 1857 (Clean Air Act);		
	(3) include provisions to ensure involvement of the public;		
	(4) be consistent with Title VI of the Civil Rights Act of 1964 and the Title VI assurance executed by each State under 23 U.S.C. 324 and 29 U.S.C. 794, which ensure that no person shall on the grounds of race, color, sex, national origin, or physical handicap be excluded from participation in, be denied benefits of, or be otherwise subjected to discrimination under any program receiving Federal assistance from the Department of Transportation;		
	(5) include special efforts to plan public mass transportation facilities and services that can effectively be utilized by elderly and handicapped persons pursuant to section 16 of the UMT Act (49 U.S.C. 1612) and section 165(b) of the Federal-Aid Highway Act of 1973, as amended;		
	(6) provide for the consideration of energy conservation; and		
	(7) include consideration of existing private mass transportation services.		
	The urban transportation planning process shall include the following technical activities to the degree appropriate for the size of the metropolitan area and the complexity of its transportation problems:	X	
	(1) an analysis of existing conditions of travel, transportation facilities, and systems management;		
	(2) an evaluation of alternative transportation systems management improvements to make more efficient use of existing transportation resources and the development of the transportation systems management element of the transportation plan;		
	(3) projections of urban area economic, demographic, and land-use activities consistent with urban development goals and the development of potential transportation demands based on these levels of activity;		

TABLE V-16 (Continued)

SOURCE	PLANNING REQUIREMENTS	APPLICABILITY	
		Urbanized Area	Nonurbanized Area
	(4) analysis of alternative transportation investments to meet areawide needs for new transportation facilities and the development of the long-range element of the transportation plan; (5) refinement of the transportation plan through the conduct of corridor, transit technology, and staging studies; and subarea, feasibility, location, legislative, fiscal, functional classification, and institutional studies; (6) monitoring and reporting of urban development and transportation indicators and a regular program of reappraisal of the transportation plan; and (7) implementation programming which merges the results of plan refinement of the long-range element and the improvements recommended in the transportation systems management element of the transportation plan to produce a transportation improvement program.		
Summary Information About Non-Urbanized Area Transit Assistance Available from the Urban Mass Transportation Administration, Office of Public Affairs, Urban Mass Transportation Administration, U.S. Department of Transportation, Washington, D.C., February 1976.	The transportation planning process for nonurbanized areas shall include the following: (1) identification of existing or expected needs; (2) inventory of existing transit services and identification of proposed additional services to provide for identified needs; (3) estimation of capital and operating costs; (4) identification of existing and proposed sources of local financing; and (5) specification and review of management options.		X

In nonurbanized areas, requests for federal financial assistance must be preceded by the preparation of a Transit Development Program (TDP). The TDP should identify (1) existing or expected needs for transit in the community, (2) existing transit services and proposed additional services to provide for identified needs, (3) capital and operating costs of the proposed services, (4) existing and proposed sources of local financing, and (5) local management options.

In urbanized areas, requests for federal financial assistance must be preceded by the development of a transportation plan and a transportation improvement program, both of which take highway and transit modes into consideration. Both elements are to be reviewed annually and updated as required.

The transportation plan consists of a short-range element, known as the transportation systems management (TSM) element, and a long-range element. The TSM element should attempt to make the most efficient use of existing transportation resources and consider policy, regulatory, and management operational improvements for both highway and public transportation systems.

The transportation improvement program (TIP) must include both (a) a staged multiyear program of transportation improvement projects consistent with the transportation plan and (b) an annual element which is a list and description of projects proposed for implementation during the upcoming year. The TIP is a schedule for both a community's investment in transportation and the requirements for federal financial assistance during the next 3 to 5 years. Because the TIP is a program of spending for a 3- to 5-year period, initiation and approval of projects are based on the estimation of financial resources, by funding source, to be available during this period. Completion of the process of TIP development does not guarantee federal approval and funding of local projects. However, FHWA requires plan development, and UMTA requires planning and programming before projects are considered for approval.

The Transit Development Program (TDP), formerly required by UMTA as the short-range transit planning document for urbanized areas, is no longer formally required. However, the planning elements of the TDP must be incorporated as a part of the TSM element of the transportation plan. The programming elements of the TDP, including priorities and implementation staging, must be incorporated in the TIP.

Whether the proposed project is a part of a TDP (nonurbanized areas) or a TIP (urbanized areas), all project applications must meet the following general requirements:

- Maintenance of Effort--applicant must demonstrate that state and local financial support will be continued through the project's duration;

- Improve or Continue Service--applicant must show that assistance will be used to improve or continue the transportation services provided in the community;

- Elderly and Handicapped Fares--applicant must ensure that fares for elderly and handicapped persons using the federally subsidized transit system during off-peak hours are at most one-half the normal peak fare;

- Social, Environmental, and Economic Impact--applicant must show that all social, environmental, and economic impacts have been reviewed and their adverse impact minimized;

- Public Hearing--applicant must conduct a public hearing on each of the proposed projects;

- Protection of Private Transportation Companies--applicant must provide for the maximum feasible participation of privately-owned transportation companies;

- Charter Bus Operations--applicant must ensure that the transit proposal does not adversely impact upon charter bus operations;

- School Bus Operations--applicant must demonstrate that the transit proposal does not adversely impact upon school bus operations;

- Nondiscrimination of Program Benefits--applicant must not violate Title VI of the Civil Rights Act of 1964;

- Special Service for the Elderly and Handicapped--during the planning and design phases, the applicant must ensure that elderly and handicapped persons will be able to effectively use transit facilities; and

- Review Area Planning--applicant must provide for the proper review and comment procedures contained within Section 204 of the Demonstration Cities and Metropolitan Development Act of 1966, the Intergovernmental Cooperation Act of 1968, and the National Environmental Policy Act of 1969.

Under existing federal policy, only public agencies are eligible for the receipt of capital cost and operating expense subsidies. The agency requesting funds must be legally capable of contracting for the receipt and distribution of federal financial assistance. However, the agency need not be the direct user of the funds nor the actual provider of transit services. Private transportation companies therefore may participate in federally funded projects, through contractual agreements with a public agency that assumes the role of project sponsor.

As provided for under existing legislation, UMTA will share in up to 80 percent of the cost of capital acquisitions, with the remaining amount coming from state and local matching funds.

UMTA has also recently begun to provide operating assistance to eligible projects. The limit for federal participation is 50 percent of the total operating deficit, subject to (1) the availability of Section 5 funds apportioned to the urbanized area in which the transit system operates[1] and (2) the availability of a local share to match federal funds. This "local share" may come from:

- state and local governmental funds;
- non-fare box transit system revenues;
- the cost of contributing services;

---

[1] Section 5 funds are apportioned to urbanized areas according to the following formula:

- one-half of the total funds available multiplied by the ratio which the population of the urbanized area or part thereof, as designated by the Bureau of the Census, bears to the total population of all the urbanized areas in all the states as shown by the latest available federal census; and
- one-half of the total funds available multiplied by a ratio for that urbanized area determined on the basis of population weighted by a factor of density, as determined by the Secretary.

As used in the preceding sentence, the term "density" means the number of inhabitants per square mile.

Urbanized areas with 200,000 or more residents receive their apportionment of Section 5 funds directly. For urbanized areas of under 200,000 population, current UMTA requirements provide for the governor of the particular state to be the grant recipient. The governor is then empowered to determine the amount of funds that should be rendered available to the various cities in the state with this qualifying population. Existing legislation, however, does not require the governor to allocate these exact amounts each year. Nonurbanized areas are not eligible to receive Section 5 funds for transit operating assistance.

- undistributed cash surpluses;
- replacement or depreciation funds or reserves available in cash; and
- new capital.

Funds from other federal programs or from federal general revenue sharing may not be used toward the local contribution.

b. State Financial Assistance Opportunities

Table V-17 and V-18 illustrate the extent and type of state financial assistance for transit investment and operation in small urban communities. As indicated in these tables, 22 states currently provide capital assistance for transit investment in small urban communities and 16 currently provide financial aid to assist in the operation of transit services in these communities. Fourteen states provide both capital and operating assistance.

Of those states providing capital cost subsidies, two provide aid only for projects not receiving federal assistance, 10 provide aid only as matching funds for federally assisted projects, and nine provide aid whether or not federal financial assistance is used to subsidize the project. States offering capital cost subsidies provide between 50 and 100 percent of the nonfederally funded share of project costs; any difference between project costs and federal and state subsidies must be provided from local sources.

Of those states providing operating expense subsidies, two provide aid only as matching funds for federally assisted projects, and 13 provide aid regardless of federal participation. States offering operating expense subsidies provide aid in varying amounts; any difference between operating deficits and federal and state subsidies must be provided from local sources.

A detailed summary of individual state financial and technical assistance programs and an identification of reference sources for further clarification of these individual programs are contained in the following publication: Small City Transit: Summary of State Aid Programs, U.S. Department of Transportation, Urban Mass Transportation Administration, Office of Service and Methods Demonstrations, Report No. UMTA-MA-06-0049-76-15 (Washington, D.C.: March 1976).

5. Evaluating Local Financing Alternatives

The evaluation of local financing alternatives proceeds in three steps. First, the range of alternative financing mechanisms must be specified; second, a set of criteria for evaluating each alternative mechanism must be established;

TABLE V-17

STATE CAPITAL COST SUBSIDY PROGRAMS FOR SMALL URBAN COMMUNITIES

STATE	Capital Assistance Provided			Source of Funds		
	As Federal Match Only	For Non-Federal Projects Only	Whether or Not Federal Assistance is Used to Finance Project	General Revenue	Highway Fund	Other
California			X			X
Connecticut			X			X
Florida			X		X	
Georgia	X			X		
Illinois			X			X
Indiana	X		X			
Maryland	X				X	
Michigan			X		X	X
Minnesota		X		X		
New Jersey			X	X		
New York	X			X		
North Carolina	X			X		
Ohio	X			X		
Oregon	X			X		
Pennsylvania	X			X		
Rhode Island			X	X		
Tennessee	X				X	
Texas			X	X		
Virginia	X				X	
Washington			X	X		
West Virginia			X	X		
Wisconsin		X		X		

SOURCE: Small City Transit: Summary of State Aid Programs, U.S. Department of Transportation, Urban Mass Transportation Administration, Office of Service and Methods Demonstration, Report No. UMTA-MA-06-0049-76-15 (Washington, D.C.: March 1976).

TABLE V-18

STATE OPERATING EXPENSE SUBSIDY PROGRAMS
FOR SMALL URBAN COMMUNITIES

STATE	Operating Assistance Provided		Source of Funds		
	As Federal Match Only	Whether or Not Federal Assistance is Used to Finance Operations	General Revenue	Highway Funds	Other
California		X			X
Connecticut		X	X		
Illinois		X		X	
Indiana	X		X		
Maryland	X			X	
Michigan		X		X	
Minnesota		X	X		
Montana		X		X	
Nebraska		X	X		
New Jersey		X	X		
New York		X	X		
Pennsylvania		X	X		
Rhode Island		X	X		
Washington		X		X	X
West Virginia		X	X		
Wisconsin		X	X		

SOURCE: Small City Transit: Summary of State Aid Programs, U.S. Department of Transportation, Urban Mass Transportation Administration, Office of Service and Methods Demonstration, Report No. UMTA-MA-06-0049-76-15 (Washington, D.C.: March 1976).

and, third, each potential financing mechanism must be evaluated in relation to this set of criteria.

a. Alternative Financing Mechanisms

The range of financing mechanisms available to subsidize the local share of transit investment costs and operating expenses depends on the nature of the administrative entity providing local financial resources for transit and the statutory powers of the administrative entity. In Table V-19 the most widely recognized forms of administrative entities providing local financial support for transit investment and operation are listed, and a summary of their potential sources of funds is presented.

As shown in this table, there are four basic types of administrative entities:

- Corporations - artificial legal entities chartered by the state to perform the purpose stated in its charter. Corporations may have perpetual life, hold property, conduct business, and sue or be sued. They may be private or public organizations.

- Special purpose governments - forms of government organization authorized by specific enabling legislation to perform a single function (in some instances more than one function) outside the structure of the general purpose government. Two common types of special purpose government relevant to the provision of transit service in small urban communities are:

    - special districts; and

    - public authorities.

- General purpose governments - cities, municipalities, counties, etc.

- Intergovernmental public/private partnerships - the association of two or more political subdivisions of the state in partnership with a private organization as co-owners, administrators, or operators of an enterprise.

In any small urban community, the role of these administrative entities in the financing of transit services depends on the type of existing legislation and the nature and role of transit service in the community.

TABLE V-19

ALTERNATIVE FINANCING MECHANISMS OF VARIOUS ADMINISTRATIVE ENTITIES

Source of Funds	ADMINISTRATIVE ENTITY					
	Corporations		Special Purpose Governments		General Purpose Government	Intergovernmental Public/Private Partnership
	Private	Public	Special District	Public Authority		
General Obligation Bonds					X	X (2)
Revenue Bonds		X	X (1)	X (1)	X	X (2)
Corporate Bonds	X					X (3)
Stock	X					X (3)
Dedicated Taxation		X	X (1)	X (1)	X	X
Government Appropriations	X	X	X	X	X	X

(1) If authorized by statute.

(2) Provided one partner is a general purpose government.

(3) Provided one partner is a private corporation.

SOURCE: A Value Capture Policy: Volume IV, Financial Element, Carl P. Sharpe, et. al., Rice Center for Community Design and Research, Rich University, Houston, Texas, November 1974, Report Number DOT-TST-75-85.

In most small urban communities, however, local transit investment costs are generally very small because the federal government provides up to 80 percent of the cost of capital acquisitions, and many states provide the bulk of the nonfederal share of acquiring these assets. As a practical matter, therefore, the role of the small urban community in transit finance is to provide funds to keep transit operating. In most cases, the source of funds for this purpose comes from government taxation in the form of dedicated tax revenues or appropriations from the general fund, which may include nontax revenues such as lottery receipts. In some cases, subsidy funds may come from local merchants or charter revenues. The evaluation of alternative financing mechanisms, however, typically reduces to an evaluation of alternative sources of local tax revenue.

Generally, local financing mechanisms for supporting transit operation and the local share of transit investment costs fill in two categories: transportation-related and nontransportation-related sources. Transportation-related sources include parking taxes, charter revenues, motor fuel taxes, tolls, and motor vehicle taxes. Representative non-transportation-related sources include income tax, sales tax, property tax, payroll tax, commuter tax, merchant subsidies, and lotteries.

In all small urban communities one or more of these taxes forms the basis of the general revenue fund. In some small urban communities one or more (or a portion of one or more) of these taxes may be specifically dedicated for transit support. Table V-20, for example, presents a partial listing of local tax sources specifically authorized for transit support. Of these sources, property taxes currently contribute the largest portion of local revenues used for transit assistance.

b. Criteria for Evaluating Local Financing Mechanisms

Regardless of the administrative entity responsible for financing the local share of transit investment and operation, the following criteria should be considered when assessing the relative merits of alternative financing mechanisms.

- Equity: Tax and Benefit Incident. This criterion refers to the distribution of the economic burden of individual financing mechanisms. In evaluating the burden of any financing proposal, however, the distribution both of the burden and of the subsidy benefits should be considered. A financing mechanism, for example, that relies on a tax that

TABLE V-20

LOCAL TAX SOURCES SPECIFICALLY AUTHORIZED FOR TRANSIT SUPPORT

(Partial List)

Authorizing State	Dedicated Taxes
Arizona	Property tax
California	Motor vehicle tax, tax on gross receipts of parking lots, transaction and use tax, sales tax on gasoline
Colorado	Real property tax
Hawaii	Fuel taxes and county motor vehicle taxes
Illinois	Property tax, county allocation of motor fuel tax
Indiana	Property tax, motor vehicle highway fund allocations, state cigarette tax fund allocation
Iowa	Property tax
Kansas	Tangible property tax
Massachusetts	Property tax (MBTA – Boston area assessment)
Michigan	Property tax
Nebraska	Real and personal property taxes
North Dakota	Real and personal property taxes
Ohio	Property tax
Oregon	Ad valorem tax, business license tax, net income tax, retail sales and use of tangible personal property tax, employers payroll tax
Utah	Property tax
Washington	Property tax, excise tax on value of motor vehicles, business and occupation tax, sales and use tax, public utilities tax on persons served by city owned utility

*William D. Hart, Public Financial Support for Transit, Highway Users Federation, Technical Study Memorandum Number 7 (Washington, D.C.: September 1973).

tends to fall more heavily on middle-income families than on higher-income families would be regressive in itself, unless the proceeds of the tax were used to finance transit services that largely benefitted middle-income families. In principle, the burden of the financing mechanism should fall on the beneficiaries of transit investment and operation, whether these beneficiaries realize personal gain from the direct use of the system or not. The cost of the subsidy should fall, insofar as possible, on those who benefit from the subsidy the taxes are financing. In practice, this is of course subject to local prerogative.

- Adequacy of Yield. Two other criteria for measuring alternative financing mechanisms are (1) their potential for generating revenue yields sufficient to meet the cash flow demands of the transit system and (2) their reliability to provide a stable source of revenue over time. The revenue-generating capabilities of various revenue sources should be examined to determine the dependability and timeliness of specific financial bases to maintain a desired level of yield in order to support transit funding requirements consistently.

- Public Acceptability. This criterion is perhaps the most difficult one to measure. Although no financing program can be implemented if it fails to have at least a minimum degree of public acceptability, it would be shortsighted to reject a good financing mechanism because it was not currently acceptable or to adopt a poor financing mechanism because it was acceptable. Public acceptance of a program is more likely to be developed than discovered. It can best be developed if the financing program is sound, reasonable, and carefully explained. In a small urban community, particular attention should be directed to the following factors to determine public acceptability of specific financing proposals:

- historical precedents;

- degree of support for local transit services; and

- attitudes toward existing taxes.

- Ease of Implementation and Administration. Those financing mechanisms which pose a minimum of legal problems and are simple and economical to administer are preferred. Mechanisms that already have legal authorization or for which legal authorization could easily be obtained should be given particular attention by the small urban community. To simplify and economize the administration of the financing mechanism, complex taxes should be avoided; a rate increase on an existing tax may often be the preferred alternative.

- Economic Effects. Financing mechanisms that tend to cause distortions in the local economy should normally be avoided. As a general proposition, the broader and more general the source of financial assistance, the less likely it is to have adverse effects on the economy or specific components of the economy. A financing mechanism that draws revenue from a general income tax or general sales tax will normally be preferable to one that draws revenue from a narrower tax base. An exception to this rule exists, however, if specific economic effects are desired by the community. To encourage a greater balance between transit and auto use, for example, a financing mechanism may be adopted that in effect penalizes auto use. Such transportation-related mechanisms as fuel taxes and parking taxes are examples of this type of financing mechanism. When considering the economic effects of the financing proposal, two things should be considered:

  - the mechanism's effect on demand; and

  - the mechanism's effect on investment.

☆ U. S. GOVERNMENT PRINTING OFFICE : 1978 O - 271-617

DEPARTMENT OF TRANSPORTATION
URBAN MASS TRANSPORTATION
ADMINISTRATION
Washington, D.C. 20590

Official Business

PENALTY FOR PRIVATE USE, $300

POSTAGE AND FEES PAID
URBAN MASS TRANSPORTATION
ADMINISTRATION
DOT 511

U.S. MAIL

DEPARTMENT OF TRANSPORTATION ★ UNITED STATES OF AMERICA