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16. Abstract

This report is divided into 2 parts. Part I presents a set of generalized planning guidelines to assist transit properties in developing a transit performance monitoring system which can be used to evaluate the effectiveness of the services they provide. Included in the guidelines are sections detailing the following: 1) Potential uses of performance evaluation; 2) Establishment of goals and objectives; 3) A review of transit performance indicators; 4) Data needs 5) Frequency of evaluation; and 6) Implementation of evaluative procedures.

Part II of this report presents the results of a detailed evaluation of the effectiveness of the I-45 North Freeway contraflow lane in Houston, Texas. This evaluation addressed the following areas of concern: 1) Start up and operating costs; 2) Operation of the contraflow; 3) Support facilities; 4) Ridership; 5) Enforcement and accidents; 6) Effect on traffic congestion, fuel consumption and air pollution; 7) Effect on modal split; and 8) User and nonuser attitudes toward priority treatment. In addition, a set of generalized planning guidelines for use in planning and implementing contraflow operations in other urban areas of Texas was developed based on North Freeway contraflow lane experience.

17. Key Words
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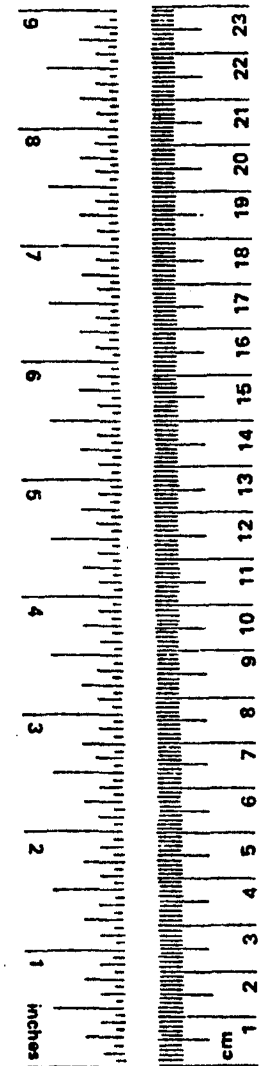
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

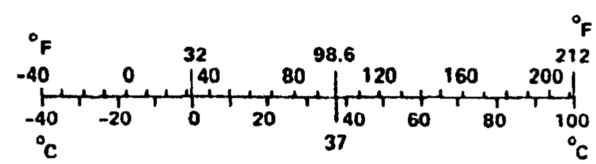
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



EFFECTIVENESS OF TRANSIT OPERATIONS

IN TEXAS CITIES

by

Diane L. Bullard

Technical Report 1077-1F
Study 2-10-84-1077

Sponsored by

State Department of Highways and Public Transportation
in cooperation with
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Urban Mass Transportation Administration

Texas Transportation Institute
The Texas A&M University System
College Station, Texas 77843

August 1984

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ABSTRACT

This report is divided into 2 parts. Part I presents a set of generalized planning guidelines to assist transit properties in developing a transit performance monitoring system which can be used to evaluate the effectiveness of the services they provide. Included in the guidelines are sections detailing the following: 1) Potential uses of performance evaluation; 2) Establishment of goals and objectives; 3) A review of transit performance indicators; 4) Data needs; 5) Frequency of evaluation; and 6) Implementation of evaluative procedures.

Part II of this report presents the results of a detailed evaluation of the effectiveness of the I-45 North Freeway contraflow lane in Houston, Texas. This evaluation addressed the following areas of concern: 1) Start up and operating costs; 2) Operation of the contraflow; 3) Support facilities; 4) Ridership; 5) Enforcement and accidents; 6) Effect on traffic congestion, fuel consumption and air pollution; 7) Effect on modal split; and 8) User and nonuser attitudes toward priority treatment. In addition, a set of generalized planning guidelines for use in planning and implementing contraflow operations in other urban areas of Texas was developed based on North Freeway contraflow lane experience.

Key Words: Public transportation, transit, performance measures, park-and-ride, contraflow lane, concurrent flow lane, priority treatment

SUMMARY

Over the past few years, considerable attention has been focused on the need to develop a system for measuring the efficiency and effectiveness of public transportation services. Since the transit systems in Texas differ substantially with respect to size, operating environment, organizational structure and operating procedures, it is obvious that no single measurement system will be applicable to all the systems in the state. Instead, each transit property must design a transit performance measurement system tailored to their specific needs and characteristics. In the process of developing and implementing a transit performance measurement system, the following steps are suggested.

- Delineation of the intended uses of the performance measurement and monitoring system.
- Establishment of transit system goals and objectives.
- Selection of specific indicators of performance.
- Development of a plan for collecting the data necessary for computation of the performance indicators to include:
  - An assessment of available data;
  - The establishment of a transit operating profile; and
  - A plan for periodic re-evaluation of transit system performance in some or all of the selected categories.
- Development of a methodology by which the computed values for the transit performance measures are compared against some predetermined standards or mean values or are used in combination with other indicators to form composite scores for a route.

In addition to measuring the effectiveness of transit operations, it is also desirable to increase the effectiveness to the fullest extent possible. The implementation of the North Freeway contraflow lane (CFL) along with support facilities, such as park-and-ride and ramp metering, has proven

to be a highly effective means of increasing transit ridership by offering commuters an attractive alternative to driving in heavy traffic congestion and paying the high gasoline, vehicle maintenance and parking costs associated with commuting. In addition, the contraflow lane offers a travel time savings to commuters and what time is spent traveling on board a bus (or van) can be used constructively.

Other benefits derived from CFL operation include reductions in fuel consumption and air pollutants. Reductions in traffic congestion are also realized, but these reductions have been offset by traffic growth in the corridor. Furthermore, the CFL has maintained a good safety record. Finally, surveys show that the contraflow operation has been widely accepted by both users of park-and-ride and the general public.

The extent to which contraflow can operate equally as effective on other freeways in Texas cities depends on a number of factors including:

- The design characteristics of the freeway;
- The availability of excess capacity in the off-peak direction;
- The severity of peak direction congestion;
- The length of contraflow lane;
- The hours of operation;
- The types of vehicles authorized to use the lane;
- Support facilities implemented along with the contraflow lane;
- The travel time savings realized by using the lane;
- The improvements to transit service;
- Rate of population growth along the freeway corridor;
- Capital and operating costs; and
- Other considerations.

IMPLEMENTATION STATEMENT

In order to provide the best transportation service possible, transit planners must continuously monitor and evaluate the effectiveness of transit system operations. The planning guidelines outlined in the first part of this report will be of immediate use to transit planners in designing comprehensive transit performance monitoring procedures for their systems.

In addition to measuring the effectiveness of transit operations, it is also desirable to increase the effectiveness (i.e., modal split) to the fullest extent possible. The type of quantitative information and the resulting planning guidelines presented in the second part of this report will be of immediate use to those larger urban areas of the state which are now considering implementing priority bus service (e.g., a contraflow lane) to increase the effectiveness of transit operations.

DISCLAIMER

This report was prepared by the Texas Transportation Institute for the Texas State Department of Highways and Public Transportation in cooperation with the U.S. Department of Transportation, Urban Mass Transportation Administration.

The contents of this report reflect the views of the author who is responsible for the opinions, findings and conclusions presented herein. The contents do not necessarily reflect the official views or policies of the sponsors. This report does not constitute a standard, specification or regulation.

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INTRODUCTION

In recent years, rising costs and limited budgets have encouraged transit systems to evaluate the effectiveness of the services they provide. Recent Urban Mass Transportation Administration (UMTA) Section 15 reporting requirements have further encouraged properties to collect the data necessary to assess transit services.

Transit performance indicators have been suggested as a potentially useful means of measuring and comparing the effectiveness of transit operations. Although a significant number of transit systems across the country have begun to conduct formal performance evaluations on a regular basis, no generally accepted set of standards or evaluative criteria have been developed which can be applied to the transit systems of Texas. It is clear that no single set of criteria for measuring the effectiveness of transit operations would probably be appropriate for all systems due to differences in size and operation. Instead, each transit property must devise a system of evaluation tailored to their specific needs (1)*.

Part I of this report presents a set of generalized planning guidelines to assist Texas transit properties in devising such a system of performance evaluation. Included in the guidelines are sections detailing the following:

- Potential uses of performance evaluation;
- Establishment of goals and objectives;
- A review of various criteria frequently used to assess the effectiveness of transit operations;
- Data needs;
- Frequency of evaluation; and
- Implementation of evaluative procedures.

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*Numbers in parentheses refer to references listed at the end of the report.

In addition to the need for developing a methodology to measure the effectiveness of transit operations, there also exists a desire to increase the effectiveness of public transit. One alternative which offers promise of increasing the effectiveness on a very large scale is the implementation of priority treatment for buses along heavily traveled freeway corridors. Studies have shown, for example, that a lane of buses has a people moving capacity of 40,000 to 50,000 persons per hour (assuming 50 passengers per bus) while a lane of auto traffic historically can carry 2,600 persons per hour (assuming 1.3 persons per vehicle).

In Texas, the Metropolitan Transit Authority of Harris County (METRO) and the State Department of Highways and Public Transportation (SDPHT) have recently implemented preferential treatment for buses and vanpools along a 9.6 mile section of the I-45 North Freeway in Houston which includes a contraflow lane (CFL), freeway ramp metering/closures and park-and-ride service. The program, which has been in operation approximately 5 years, has been met with much success and public support. A detailed evaluation of the transit operations and improvements along this corridor was performed; the results of this evaluation are presented in Part II of this report. Included in the evaluation of the North Freeway CFL are the following:

- Start-up and operating costs;
- Operation of the CFL;
- Support facilities (park-and-ride service);
- Ridership;
- Enforcement;
- Accidents;
- Effect on traffic congestion;
- Impact of priority treatment measures on modal split; and
- User and nonuser attitudes toward priority treatment.

In addition, a set of generalized planning guidelines for implementing contraflow projects in other urban areas of Texas were developed based on the experience of the North Freeway contraflow lane.

PART I

GUIDELINES FOR DESIGNING A TRANSIT PERFORMANCE MEASUREMENT SYSTEM

BACKGROUND

In years past, relatively little attention was given to measuring the performance of urban public transportation systems. Prior to the 1960's public transit systems were predominately privately owned business enterprises which were measured in terms of their profitability. As long as these systems remained economically viable, there was little concern expressed for further performance evaluation. During the decades that followed, however, the majority of the nation's transit systems became unprofitable business enterprises. Public ownership became the rule and the provision of urban public transportation was considered to be an essential public service (2). By 1980, there were a total of 576 publicly owned transit systems in operation. These publicly owned systems, which accounted for about 55% of all systems, operated 93% of the industry's total vehicle miles and carried 94% of the industry's total passengers (Table 1).

Table 1: Publicly Owned Transit as a Portion of the Transit Industry

Statistic	Caldendar Year		
	1960	1970	1980
Number of Transit Systems	58	159	576
Percent of Industry Total	5%	15%	55%
Total Transit Vehicles Owned and Leased	23,738	40,778	64,128
Percent of Industry Total	36%	66%	90%
Vehicle Miles Operated (Millions)	*	1,280	1,939
Percent of Industry Total	*	68%	93%
Linked Passenger Trips (Millions)	*	4,567	5,945
Percent of Industry Total	*	77%	94%

*Data not available.

Source: Reference 3.

With the shift from private business to public service, came a commitment through the Urban Mass Transportation Act (UMTA) of 1964 and subsequent amendments of federal, state, and local funding for financial and technical assistance to aid the declining transit industry. At the same time, public transit (particularly the bus industry) has been under increasing pressure to provide service to a much wider and more varied market, often at considerable cost. An example of this expansionary pressure is the Section 504 of the Rehabilitation Act of 1973 requirement that all federally funded facilities be accessible to all handicapped persons. Furthermore, although significant studies have been made in improving urban public transportation, there has not been a corresponding increase in ridership. For example, over 9.3 billion total passengers were carried by public transit in 1960, but only 8.2 billion total passengers were carried in 1980 - a decrease of 13.4% (1, 2, 3).

During this same time period, transit revenue increased from $1.40 billion in 1960 to $2.56 billion in 1980, but operating expenses had increased from $1.37 billion in 1960 to $6.51 billion in 1980. This was a change from a $30 million profit in 1960 to a $39.5 billion deficit in 1980 - a deficit which was offset by public resources (3). Today, the resources available to support public transportation are constrained by the limited funds available for all public services. As a result, assurances are now needed that scarce resources are being expended efficiently and effectively. This, in turn, has led to an increasing interest in the evaluation of transit performance.

Transit performance has been the subject of numerous studies, technical reports, journal articles and dissertations over the last 25 years. While there appears to be a general agreement concerning the need for performance evaluation, there is considerable debate over:

- How many indicators should be used;
- Which indicators provide the "best" measurement of performance;
- The definition of some of the indicators;
- Whether efficiency measures or effectiveness measures (or both) should be used;
- Whether national standards of transit performance should be established;
- Whether funding allocations to individual transit properties should be based on their attainment of some minimal level of performance; and
- Whether performance indicators can (or should) be used as a means of comparing one system's performance to another's.

In spite of the disagreement regarding the specifics of performance evaluation, there does appear to be a general consensus concerning the need for transit management to be able to quantitatively assess the effectiveness of the services it provides. The following sections of Part I are intended to assist transit officials in developing a system by which the effectiveness of transit operations can be measured.

POTENTIAL USES FOR A SYSTEM OF TRANSIT PERFORMANCE MEASUREMENT

The potential uses of developing and implementing a system of transit performance measurement and evaluation are many. These uses generally fall into one of 2 areas: (1) funding and (2) planning, management and policy functions.

From a funding point of view, transit performance measurement can provide a means by which transit is able to justify its financial needs when competing against other public services for scarce resources. Documented performance measures also allow transit system management to make more rational decisions concerning internal resource allocation and provide a means of communicating the service policies to elected officials and the general public (4). The potential for formal application of performance measures in the allocation of resources across transit systems appears to be more limited, however. In fact, the American Public Transit Association has stated that "the emphasis of performance evaluation must be upon the use of the resulting information internally for improved transit system management, not for determining funding agency allocations" (5). This view is based on the premise that "too much depends on independent variables at the local level over which transit operators and funding agencies have no control" (5).

It, therefore, appears that the most immediately beneficial applications of transit performance measurement lie in the area of short-term planning, management and policy.

Policy - Consistent, current and comprehensive information concerning the performance of urban public transportation systems can be an important policy tool (2). Information from performance data monitoring can be helpful in assessing the effectiveness of alternative program and policy options.

For example, in a public organization such as transit, the overall philosophy of the organization, the service policies, and the operational guidelines are usually established by a political decision-making body. The political body would be responsible for establishing organization-level goals. Many goals may be outlined for transit, yet not all of the goals may be pursued simultaneously. Performance measurement provides a means of evaluating the trade-offs between various goals in terms of services provided, the quality of those services and the cost of providing services (6).

The development of service standards is yet another important policy issue which can be facilitated by performance measurement. Transit systems may find it extremely beneficial to specify minimum levels of service, comfort and amenities by which to measure each route in the system (2).

Management - The information provided by performance measurement can facilitate the assessment of service, effectiveness and management in finding ways to reduce costs and help community leaders and other local decision-makers determine the level and types of transit services their community can afford. In addition, such information can provide management with the knowledge of which services or service aspects are performing better than others (2).

As mentioned previously, performance measurement can also be helpful to management in the area of allocating resources within the transit system. If a transit manager is to realize optimal improvement from the resources available, then the allocation of those resources must be made to those services which are most efficient and effective in achieving the stated objectives. In other words, a priority of funding within a transit system can be established in order that the public will receive the maximum benefits (2).

Planning - Planning on a continuing basis is essential to the success of a transit system. However, in the planning process very often certain goals and objectives for the provision of transit service may be conflicting. As such, there is a need to evaluate the extent to which a particular transit improvement relates to each of the goals and objectives set forth in the areawide transportation plan. One way this can be accomplished is by a trade-off analysis that uses relevant transit performance measures related to the specific goals and objectives under consideration (2).

In conclusion, improving urban public transportation services has been a nationwide concern in recent years. The increasing reliance on local, state and federal funding sources to provide the financial support necessary to implement various transit improvements has led to the need for evaluating these potential improvements in terms of their effect on transit efficiency and effectiveness measures. When collected over a period of time, performance measurements would enable evaluation of particular investment programs and policies in terms of changes in system performance. Furthermore, the information provided by various performance measures can be useful for the planning of new or additional service as well as for influencing decisions to modify or continue existing service (2).

THE DEVELOPMENT OF TRANSIT PERFORMANCE MEASURES

Relationship to System Goals and Objectives

Transit performance measures should ideally be based on the goals and objectives of the transit system. In general, goals represent the basic ends which a transit agency wishes to achieve; they set the framework for action. Objectives establish directives to carry out a program of action; they facilitate the definition of indicators by which the achievement of goals can be evaluated. Objectives are specific, observable and attainable. Performance indicators are the quantitative measures of objectives which enable managers and policy-makers to determine the current position of any agency and outline strategies to improve performance (7).

The task of relating specific performance measures to goals and objectives may be complicated, however, by poorly articulated and possibly conflicting goals and objectives which are not equally amenable to quantitative assessment. Therefore, a major consideration in the development of a performance monitoring system is the establishment of straight forward goals and objectives which can then lead to the selection of the appropriate indicators (Figure 1). Once the indicators are selected, desired levels of performance on each indicator (i.e., service standards) may be established (1, 7, 8).

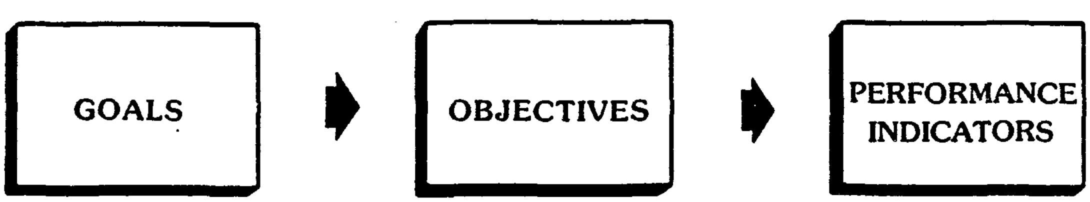


Figure 1: Relationship of Transit Performance Measures to System Goals and Objectives

The development of an evaluative framework in this manner is generally viewed to facilitate public understanding of the philosophy guiding the provision of transit services. It provides an opportunity for the capabilities, limitations and costs of transit to be presented to the public and to policymakers. Finally, it minimizes the possibility of implementing conflicting or inappropriate performance indicators (7).

An example of the goals-objectives-performance indicators relationship is presented in the following paragraphs (7):

> One highly desirable goal of any transit system is to ensure that its services are geographically accessible to the area's residents. The goal of ensuring accessibility to services, as such, is not very clear or measurable and requires additional clarification through objectives. If there is to be special emphasis on accessibility of services to a particular target group (youth, elderly, handicapped, or transit dependent individuals) then the objectives clarifying the goal of accessible special transit must explicitly mention these groups. For instance, special emphasis on service to the elderly might bring about an objective such as: "Transit services will be accessible to 85% of the area's elderly residents during the off-peak hours of service." Two points must be noted in this sample objective:
>
> 1. Objectives must be realistically attainable by the system - thus the objective is for transit service to be accessible to 85% of the elderly rather than 100%; and
>
> 2. Objectives should balance other considerations in the system's management; in this case the desire is to focus elderly service at other than peak periods.
>
> Instead of defining accessibility in terms of residents, it may also be defined in terms of locations: public services, shopping facilities, and employment or educational opportunities. A

possible objective under the goal of accessibility in this regard might be: "Transit will serve all major public facilities within the service area." If accessibility to employment is considered especially important for its potential economic and social benefits, then another objective might be: "Transit will serve 80% of all employment opportunities within the service area." Again, objectives must be realistically attainable.

Once objectives are specified, performance indicators may be developed to evaluate the system's satisfaction of those objectives or progress toward them. Many desirable measures are simply infeasible given currently available operating and financial data.

Continuing the example of accessibility, the specified objective that "Transit services will be accessible during the off-peak hours of service" may be evaluated through an indicator such as the percent of elderly served during the off-peak hours. This measure, and other indicators focusing on special population groups, will require detailed analysis of census data and transit routes. The use of such an indicator must recognize the manpower and monetary cost entailed.

The Concepts of Efficiency and Effectiveness

It is generally agreed that public transit should perform both efficiently and effectively. Therefore, measures of transit performance are usually classified as either efficiency indicators or effectiveness indicators (2, 5, 6, 9, 10, 11, 12, 13, 14, 15, 16). Briefly stated, efficiency indicators are most commonly used to evaluate the process by which transit services are produced; that is, the relationship of inputs to outputs, or the concept of "doing things right." Measures of effectiveness are concerned with the extent to which the service provided -- in terms of quantity, location and character -- corresponds to the goals and objectives established for it and the needs of the community. Effectiveness then, is the comparison of produced output to intended output, or the concept of "doing the right things" (6, 9, 11, 12, 13, 14).

Table 2 presents a listing of potentially useful indicators of efficiency and effectiveness which have been proposed by various professionals in the transportation industry.

Table 2: Potential Transit Performance Indicators

Effectiveness Measures

Accessibility and Reliability

- Percent of population within 1/4 mile of a route
- Percent of transit dependent within 1/4 mile of a route
- Revenue passengers/service area population
- Percent of employment served by transit
- Percent of population more than 1 hour from key destinations
- Time required to travel between major origin and destination points
- Headways
- Number of buses taking x minutes longer than schedule
- Percent of buses 1 minute early to 4 minutes late
- Percent missed trips
- Average waiting time of passengers
- Excess waiting time of passengers
- Seat hours/capita

Utilization of Service

- Revenue passengers/service area population
- Revenue passengers/vehicle mile
- Revenue passengers/vehicle hour
- Total passengers/vehicle
- Total passengers/vehicle mile
- Total passengers/vehicle hour
- Passenger miles/vehicle mile
- Revenue passengers/capacity hour
- Revenue passengers/capacity mile
- Revenue passenger miles/capacity hour
- Revenue passenger miles/capacity mile
- Average length of passenger journey
- Number of annual passengers/annual seat miles

Convenience

- Hours of service
- Bus travel time/auto travel time

- Transfer opportunities/route mile
- Number of transfers/number of passengers
- Average operating speed
- Bus stop spacing
- Vehicle step height
- Information services

Comfort

- Maximum number of passengers/total available seats (averaged over each route at maximum load point)
- Peak hour floor area/passenger (averaged over each route at the maximum load point)
- Ventilation
- Vehicle jerk
- Average bus age
- Vehicle cleanliness

Labor/Usage Relationship

- Passengers/employee hour
- Passenger miles/employee hour

Safety

- Number of accidents/vehicle mile
- Number of crimes/vehicle mile
- Vehicle miles/number of road calls

Efficiency Measures

Costs, Revenues, Deficit

- Operating cost/total passengers
- Operating cost/revenue passenger
- Operating cost/passenger mile
- Operating cost/vehicle mile
- Operating cost/vehicle hour
- Operating cost/capacity mile
- Operating cost/capacity hour
- Operating cost/operating revenue
- Maintenance cost/vehicle mile
- Maintenance cost/vehicle hour
- User cost/trip
- Revenue/vehicle hour
- Total revenue/operating costs
- Operating revenue/vehicle mile
- Operating revenue/passenger mile
- Operating revenue/passenger
- Operating revenue/$ of direct cost for providing service
- Operating revenue/vehicle
- Net deficit/total operating cost
- Net deficit/hours of service
- Net deficit/total revenue passengers
- Net deficit/total passenger revenues
- Net deficit/passenger mile
- Net deficit/vehicle mile

Vehicle Utilization

- Revenue vehicle miles/revenue vehicle hours
- Peak vehicles required/off-peak vehicles required

- Spare vehicles/required fleet size
- Revenue vehicle hours/total vehicle hours
- Daily vehicle miles/scheduled number of vehicles
- Vehicle seat capacity/total transit seats
- Percent lost mileage
- Annual vehicle hours of service/revenue vehicle
- Annual vehicle miles of service/vehicle
- Revenue vehicle hours/vehicle
- Revenue vehicle miles/vehicle

Labor Productivity
- Revenue vehicle hours/employees
- Revenue vehicle miles/employees
- Total vehicle miles/employee
- Total vehicle hours/total employee hours
- Capacity hours of revenue service/employee hour
- Capacity miles of revenue service/employee hour
- Total vehicle miles/bus operators
- Annual vehicle hours/annual employee hours
- Passengers/employee hour
- Passengers/employee
- Operators/vehicle
- Operator pay hours/vehicle hour
- Annual vehicle miles/operator
- Annual vehicle hours/operator
- Annual passengers/operator
- Absenteeism (operators and maintenance)
- Total labor input/vehicle miles operated
- Total labor input/passenger mile
- Total labor input/passenger

Maintenance
- Average fleet age
- Vehicles/mechanic
- Annual vehicle hours/mechanic
- Annual vehicle miles/mechanic
- Vehicle miles/quart of oil consumed
- Vehicle miles/gallon of fuel consumed
- Vehicle miles/maintenance related road call
- Facility age

Source: References 6, 8, 10, 16, 17, 18, 19, 20, 21, 22, and 23.

While the listing in Table 2 is extensive it is by no means complete. There are considerable differences of opinion within the transit industry and among the governmental agencies as to which criteria provide the best measurement of transit performance (24). There is also some disagreement concerning whether or not the use of ratios is valid in measuring and evaluating system performance; it is argued that ratios are not really measures of efficiency and effectiveness at all, unless the objective is to optimize the ratio itself. It should also be noted that although the indicators in Table 2 have been classified as either measures of efficiency or effectiveness, it is entirely possible for the same indicator to measure either efficiency or effectiveness, depending on the objective being sought. Consider the following example (25):

> System A carried 1,500 passengers at a cost of $20,000 and System B carried 1,000 passengers at a cost of $10,000. If the goal is to carry the maximum number of riders, then System A is the most effective. However, if the goal is to carry each rider as inexpensively as possible, then System B is the most efficient. In other words, if the goal is to maximize ridership, then operating expense per passenger represents an effectiveness measure of "doing the right things." If, on the other hand, the goal is transporting each rider as economically as possible, then operating expense per passenger becomes an efficiency measure of "doing things right."

Although there may be a fine line between efficiency and effectiveness in some cases, it is generally agreed that effectiveness measures are usually "cost-free," and usually do not include ratios involving the use of resources. Indicators of effectiveness should measure the degrees to which the goals of the system are accomplished, whereas efficiency measures should involve input/output relationships in attaining the goals (25).

Selecting the Appropriate Performance Indicators

The selection of how many and which measures to use as performance indicators is highly dependent on the individual system involved. Each performance indicator, by virtue of component data elements, focuses on different aspects of transit performance (25). It remains, then, to consider how the choices regarding performance measurement vary according to their intended uses. External uses such as annual reports can probably be accommodated by fewer measures of a more aggregate nature than the evaluative, planning and decision-making uses which are internal to the system. With regard to internal uses, there is a need for further differentiation in number, type and level of detail of performance measures on the basis of functional application and organizational characteristics. For example, monitoring the performcance of an operations department would require a distinctly different set of measures than would monitoring performance of an individual transit route or a particular type of service (such as park-and-ride). The former application is likely to be oriented toward efficiency measures which relate output to input (e.g., the cost of performing specific maintenance or scheduling functions, etc.), while the latter application would concentrate more on effectiveness measures which describe the quality of output (e.g., schedule adherence) and the degree to which output is consumed (e.g., passengers per vehicle hour) (1).

Upon determining the intended uses of the performance evaluation, several criteria should be applied in the selection of specific indicators. In general, performance indicators chosen should be:

- Related to a stated system objective;
- Easily understandable and definable;
- Measurable from available data; and

• Acceptable to the parties involved.

Finally, each indicator chosen should be analyzed in terms of inherent weaknesses, biases and drawbacks (4, 12, 23, 25).

Available Level of Resources and Expertise

An important consideration in the selection of transit performance measures (and in the overall design of the performance monitoring program) is the level of financial resources and staff expertise available for data collection and data processing. Complying with the recent UMTA reporting requirements has undoubtedly resulted in significant changes in accounting procedures and expansion of the data collection, processing and reporting efforts by many transit systems in the state. While UMTA is underwriting a significant portion of the costs of complying with these requirements, there nevertheless may be a shortage of funds, expertise and staff enthusiasm to design and implement a transit performance measurement system which will involve a substantially expanded data base with detailed levels of stratification (1). For example, at one point in time, the San Mateo County Transit District in California was collecting data for use in 141 different performance indicators. All of the indicators were felt to have stated something interesting about the system's performance and all possibly would serve some useful purpose someday. However, data collection and analysis is costly and a significant portion of it can be meaningless and wasteful. Therefore, the district finally settled on 5 measurable factors (24).

DATA NEEDS

A system of transit performance monitoring not only involves the selection of the appropriate number and types of indicators, but also the availability and accuracy of the necessary data. The UMTA Section 15 reporting system prescribes a rather comprehensive battery of detailed financial and operating statistics, from which it is possible to derive the following performance measures (27):

Total revenue vehicles
- per thousand line miles

Total revenue vehicles (p.m. peak)
- per thousand line miles

Total revenue vehicles (base period)
- per thousand line miles

Total annual vehicle miles
- per vehicle (p.m. peak)
- per operator
- per vehicle hour (m.p.h.)
- per line mile

Total annual vehicle hours
- per vehicle (p.m. peak)
- per operator

Total annual vehicle revenue miles
- per vehicle (p.m. peak)
- per operator
- per vehicle revenue hour (m.p.h.)
- per line mile

Total annual vehicle revenue hours
- per vehicle (p.m. peak)
- per operator

Fuel consumption (gallons)
- per hundred vehicle miles
- per hundred passenger miles
- per hundred capacity miles

Total operating expenses ($)
- per vehicle (p.m. peak)
- per vehicle mile
- per hundred capacity miles
- per vehicle hour
- per vehicle revenue hour
- per hundred passengers
- per passenger mile
- per employee
- per operator hour

Total annual passenger miles
- per line mile (thousands)
- per vehicle (thousands)
- per capacity mile
- per vehicle revenue hour

Total annual passengers
- per line mile
- per vehicle mile
- per employee (thousands)
- per vehicle revenue hour

Total employees
- per vehicle (total)
- per vehicle (p.m. peak)

Total administrative employees
- per ten vehicles
- per ten vehicles (p.m. peak)

Total annual vehicle miles
- per dollar vehicle maintenance expense
- per road call

Total revenue vehicles
- per maintenance employee

Number of collision accidents
- per million vehicle miles
- per million passenger miles

Total number of noncollision accidents
- per million vehicle miles
- per million passenger miles

Tables 3 through 15 summarize transit performance indicator values for the transit properties in Texas for fiscal years 1979, 1980 and 1981. Unfortunately, some data items (such as passenger miles and vehicle hours) which are necessary for the computation of a number of the transit performance ratios have not been routinely collected by many transit systems. This situation is expected to improve in subsequent years, however, as these systems begin to collect the necessary data. This will then pave the way to a monitoring of the historical trends of the system's performance.

Since the UMTA Section 15 requirements are for systemwide measures only, the individual transit operator still has the option, in designing its performance measurement system, of maintaining particular data items at a more disaggregate level (1). This is a particularly important consideration if the performance measurement system is to serve as an effective management, planning and policy tool.

There is reason to believe that a greater emphasis on the collection of accurate and detailed service quality data on a route-by-route basis would

Table 3: Transit Performance Indicators - Section 15 Reports

Transit System	Total Revenue Vehicles											
	Total Revenue Vehicles			Operated Peak Period (p.m.)			Operated Base Period			Per line Mile		
	1979	1980	1981	1979	1980	1981	1979	1980	1981	1979	1980	1981
Abilene	----	----	12	----	----	6	----	----	6	----	----	0.16
Amarillo	47	32	47	18	17	17	13	13	13	0.18	0.33	0.48
Austin	71	71	71	59	59	59	38	38	38	0.33	0.39	0.39
Beaumont	25	----	25	13	----	13	11	----	11	0.14	----	0.27
Brownsville	----	18	24	----	0	0	----	0	0	----	0.26	0.25
Corpus Christi	46	----	52	26	----	31	19	----	73	0.15	----	0.19
Dallas	456	456	520	385.0	385	390	135	135	134	0.38	0.45	0.51
El Paso	----	----	93	----	----	75	----	----	62	----	----	0.14
Ft. Worth	----	106	106	----	92	91	----	43	43	----	0.31	0.31
Galveston	15	15	15	11	11	10	10	10	9	0.20	0.27	0.32
Houston	----	631	837	----	349	356	----	175	176	----	0.67	0.61
Laredo	19	26	25	16	20	20	15	16	16	0.08	0.18	0.23
Lubbock	40	40	42	26	26	26	23	21	21	0.19	0.28	0.29
Port Arthur	----	----	6	----	----	0	----	----	0	----	----	0.11
San Angelo	9	9	9	5	0	0	5	0	0	0.09	0.17	0.18
San Antonio	----	403	530	----	329	338	----	177	151	----	0.61	0.36
Waco	16	21	21	14	12	13	9	8	10	0.14	0.21	0.23
Wichita Falls	10	10	10	0	0	0	0	0	0	0	0.12	0.12

Source: References 27, 28, and 29.

Table 4: Transit Performance Indicators - Section 15 Reports

Transit System	Total Annual Vehicle Miles											
	Per Vehicle (p.m. peak)			Per Operator			Per Vehicle Hour (mph)			Per Line Mile		
	1979	1980	1981	1979	1980	1981	1979	1980	1981	1979	1980	1981
Abilene	------	------	65,229	------	------	35,580	----	----	17.1	------	------	5,083
Amarillo	43,811	48,481	58,095	27,193	28,518	39,505	14.3	15.3	15.2	8,072	8,436	10,109
Austin	44,224	44,224	44,224	22,263	0	21,671	12.3	12.3	12.3	14,496	14,496	14,496
Beaumont	43,092	------	42,754	22,408	------	17,369	12.5	----	12.4	6,102	------	6,055
Brownsville	------	0	0	------	10,269	13,464	----	8.2	12.6	------	5,275	5,449
Corpus Christi	54,698	------	42,167	19,562	------	26,140	13.9	----	14.2	8,127	------	4,832
Dallas	34,864	35,050	35,680	23,673	23,633	22,408	14.0	14.2	14.4	13,302	13,373	13,638
El Paso	------	------	54,880	------	------	24,795	----	----	14.4	------	------	6,018
Ft. Worth	------	30,612	32,953	------	21,017	20,399	----	12.4	11.9	------	8,283	8,820
Galveston	46,282	47,250	43,384	24,455	25,987	21,692	0	12.2	10.4	9,107	9,298	9,330
Houston	------	50,201	45,858	------	21,314	19,693	----	13.5	13.6	------	18,542	11,835
Laredo	0	43,766	47,250	0	21,349	18,173	0	7.9	10.2	0	6,079	8,591
Lubbock	39,709	41,866	41,100	23,046	24,297	24,397	12.9	13.9	13.7	7,705	7,570	7,431
Port Arthur	------	------	0	------	------	19,847	----	----	13.9	------	------	3,570
San Angelo	0	0	0	0	29,403	25,020	0	14.5	13.2	0	5,047	5,054
San Antonio	------	44,386	44,554	------	24,920	25,140	----	14.0	14.1	------	21,979	10,312
Waco	33,457	36,097	32,667	21,291	19,689	20,223	15.3	12.6	13.0	4,638	4,345	4,708
Wichita Falls	0	0	0	25,488	26,690	26,196	14.1	14.1	14.1	3,446	3,446	3,446

Source: References 27, 28, and 29.

Table 5: Transit Performance Indicators - Section 15 Reports

Transit System	Total Annual Vehicle Hours						Total Annual Vehicle Revenue Hours					
	Per Vehicle (p.m. peak)			Per Operator			Per Vehicle (p.m. peak)			Per Operator		
	1979	1980	1981	1979	1980	1981	1979	1980	1981	1979	1980	1981
Abilene	-----	-----	3,825	-----	-----	2,086	-----	-----	3,825	-----	-----	2,086
Amarillo	3,074	3,174	3,829	1.908	1,867	2,604	3,026	3,090	3,537	1,878	1,818	2,405
Austin	3,595	3,595	3,595	1,810	0	1,762	3,517	3,517	3,509	1,771	0	1,719
Beaumont	3,460	-----	3,460	1,799	-----	1,406	3,671	-----	3,460	1,694	-----	1,406
Brownsville	-----	0	0	-----	1,251	1,069	-----	0	0	-----	1,094	1,069
Corpus Christi	3,936	-----	2,970	1,408	-----	1,842	2,976	-----	2,970	1,064	-----	1,842
Dallas	2,483	7,246	2,473	1,686	1,669	1,553	2,183	2,177	2,172	1,482	1,468	1,364
El Paso	-----	-----	3,824	-----	-----	1,728	-----	-----	3,797	-----	-----	1,715
Ft. Worth	-----	2,475	2,781	-----	1,700	1,721	-----	2,255	2,213	-----	1,548	1,370
Galveston	0	3,880	4,152	0	2,134	2,076	0	3,628	4,152	0	1,996	2,076
Houston	-----	3,716	3,383	-----	1,578	1,453	-----	3,637	2,942	-----	1,544	1,264
Laredo	0	5,508	4,623	0	2,687	1,778	0	4,568	4,568	0	2,228	1,757
Lubbock	3,073	3,004	2,992	1,783	1,744	1,776	3,022	2,951	2,942	1,754	1,713	1,746
Port Arthur	-----	-----	0	-----	-----	1,426	-----	-----	0	-----	-----	1,426
San Angelo	0	0	0	0	2,029	1,890	0	-----	0	0	-----	1,800
San Antonio	-----	3,164	3,163	-----	1,777	1,785	-----	2,737	2,989	-----	1,537	1,687
Waco	2,186	2,874	2,510	1,391	1,568	1,554	2,186	2,874	2,482	1,391	1,568	1,537
Wichita Falls	0	0	0	1,811	1,896	1,861	0	0	0	1,760	1,843	1,794

Source: References 27, 28, and 29.

Table 6: Transit Performance Indicators - Section 15 Reports

Transit System	Total Annual Vehicle Revenue Miles											
	Per Vehicle (p.m. peak)			Per Operator			Per Vehicle Revenue			Per Line Mile		
	1979	1980	1981	1979	1980	1981	1979	1980	1981	1979	1980	1981
Abilene	------	------	65,025	------	------	35,468	----	----	17.0	------	------	5,067
Amarillo	42,180	46,754	46,055	26,181	27,502	31,317	13.9	15.1	13.0	7,771	8,135	8,014
Austin	40,206	40,206	40,206	20,240	0	19,702	11.4	11.4	11.5	13,179	13,179	13,179
Beaumont	38,761	------	42,754	17,890	------	17,369	10.6	----	12.4	7,787	------	6,055
Brownsville	------	0	0	------	10,269	13,464	----	9.4	12.6	------	5,275	5,449
Corpus Christi	43,327	------	42,162	15,495	------	26,140	14.6	----	14.2	6,437	------	4,832
Dallas	30,667	30,816	31,342	20,823	20,778	19,684	14.1	14.2	14.4	11,700	11,757	11,980
El Paso	------	------	52,771	------	------	23,842	----	----	13.9	------	------	5,786
Ft. Worth	------	27,728	28,032	------	19,037	17,353	----	12.3	12.7	------	7,503	7,503
Galveston	46,282	45,327	43,384	25,455	24,930	21,692	0	12.5	10.4	9,107	8,919	9,330
Houston	------	49,643	39,996	------	21,077	17,176	----	13.6	13.6	------	18,336	10,322
Laredo	9,287	43,730	47,220	3,715	21,332	18,161	0	9.6	10.3	739	6,074	8,585
Lubbock	39,299	41,071	40,896	22,808	23,836	24,276	13.0	13.9	13.9	7,625	7,426	7,394
Port Arthur	------	------	0	------	------	19,847	----	----	13.9	------	------	3,570
San Angelo	11,963	------	0	6,797	------	24,720	0	----	13.7	1,096	------	4,993
San Antonio	------	40,165	42,103	------	22,550	23,758	----	14.7	14.1	------	19,889	9,745
Waco	33,457	36,097	32,601	21,291	19,689	20,182	15.3	12.6	13.1	4,638	4,345	4,699
Wichita Falls	0	0	0	25,096	26,279	25,793	14.3	14.3	14.4	3,393	3,393	3,393

Source: References 27, 28, and 29.

Table 7: Transit Performance Indicators - Section 15 Reports

Transit System	Fuel Consumption (gallons)								
	Per Vehicle Mile			Per Ten Passenger Miles			Per Ten Capacity Miles		
	1979	1980	1981	1979	1980	1981	1979	1980	1981
Abilene	----	----	0.28	----	----	0.69	----	----	0.08
Amarillo	0.18	0.18	0.16	0.81	0.74	0.81	0.04	0.03	0.03
Austin	0.28	0.29	0.30	0.35	0.37	0.33	0.05	0.05	0.05
Beaumont	0.21	----	0.32	0.29	----	0.19	0.04	----	0.06
Brownsville	0	0.27	0.20	0	0	0	0.43	0.10	0.05
Corpus Christi	0.21	----	0.24	0	----	0	0.05	----	0.05
Dallas	0.28	0.29	0.30	0.17	0.14	0.16	0.05	0.05	0.05
El Paso	----	----	0.34	----	----	0.34	----	----	0.05
Ft. Worth	----	0.01	0.30	----	0.01	0.40	----	0	0.06
Galveston	0.20	0.28	0.29	0.90	0.28	0.36	0.04	0.05	0.05
Houston	----	0.28	0.36	----	0.26	0.25	----	0.05	0.07
Laredo	0	0.20	0.24	0	0	0.40	0.21	1.10	0.05
Lubbock	0.20	0.20	0.37	0	0.10	1.11	0.05	0.05	0.08
Port Arthur	----	----	0.15	----	----	0.16	----	----	0.04
San Angelo	0	0.15	0.15	0	0.26	0.19	2.24	0.05	0.05
San Antonio	----	0.28	0.28	----	0.35	0.47	----	0.05	0.05
Waco	0.16	----	0.21	0.44	----	0.32	0.03	----	0.06
Wichita Falls	0.15	0.15	0.15	0	0.29	0.12	0.04	0.04	0.04

Source: References 27, 28, and 29.

Table 8: Transit Performance Indicators - Section 15 Reports

Transit System	Total Operating Expenses								
	Per Vehicle (p.m. peak)			Per Vehicle Mile			Per Capacity Mile		
	1979	1980	1981	1979	1980	1981	1979	1980	1981
Abilene	------	-------	61,060	----	----	.94	----	----	0.03
Amarillo	42,446	48,876	60,997	0.97	1.01	1.05	0.02	0.01	0.02
Austin	54,552	60,496	77,032	1.23	1.37	1.74	0.02	0.02	0.03
Beaumont	50,046	-------	71,601	1.16	----	1.67	0.03	----	0.03
Brownsville	0	0	0	0	2.19	2.12	0.40	0.08	0.05
Corpus Christi	55,306	-------	50,201	1.01	----	1.19	0.02	----	0.02
Dallas	51,147	60,375	73,261	1.47	1.72	2.05	0.03	0.03	0.04
El Paso	------	-------	------	----	----	----	----	----	----
Ft. Worth	------	50,344	63,616	----	1.64	1.93	----	0.03	0.04
Galveston	54,105	65,445	86,276	1.17	1.39	1.99	0.02	0.03	0.03
Houston	------	137,583	169,638	----	2.74	3.70	----	0.05	0.07
Laredo	65,282	63,367	82,225	0	1.45	1.74	0.18	0.80	0.03
Lubbock	37,568	44,614	48,488	0.95	1.07	1.18	0.02	0.02	0.03
Port Arthur	------	-------	0	----	----	1.71	----	----	0.04
San Angelo	37,425	-------	0	0	----	1.28	1.25	----	0.04
San Antonio	------	67,963	70,610	----	1.53	1.58	----	0.02	0.03
Waco	36,784	53,796	54,999	1.10	1.49	1.68	0.02	0.03	0.05
Wichita Falls	0	0	0	1.03	1.01	1.17	0.03	0.02	0.03

Source: References 27, 28, and 29.

Table 9: Transit Performance Indicators - Section 15 Reports

Transit System	Total Operating Expenses								
	Per Vehicle Hour			Per Vehicle Revenue Hour			Per Passenger		
	1979	1980	1981	1979	1980	1981	1979	1980	1981
Abilene	----	----	16.0	----	----	16.0	----	----	0.82
Amarillo	13.8	15.4	15.9	14.0	15.8	17.2	1.18	1.19	1.55
Austin	15.2	16.8	21.4	15.5	17.2	22.0	0.40	0.49	0.69
Beaumont	14.5	----	20.7	14.5	----	20.7	0.46	----	0.99
Brownsville	0	18.0	26.7	0	20.5	26.7	0	0.96	0.62
Corpus Christi	14.1	----	16.9	18.6	----	16.9	0.77	----	0.99
Dallas	20.6	24.4	29.6	23.4	27.7	33.7	0.60	0.61	0.76
El Paso	----	----	----	----	----	----	----	----	----
Ft. Worth	----	20.3	22.9	----	22.3	28.7	----	0.76	0.78
Galveston	0	16.9	20.8	0	18.0	20.8	1.3	0.38	0.70
Houston	----	37.0	50.1	----	37.8	57.7	----	1.27	1.29
Laredo	0	11.5	17.8	0	13.9	18.0	0	0	0.57
Lubbock	12.2	14.9	16.2	12.4	15.1	16.5	0	1.65	1.00
Port Arthur	----	----	23.8	----	----	23.8	----	----	1.22
San Angelo	0	----	16.9	0	----	17.8	0	----	0.73
San Antonio	----	21.5	22.3	----	24.8	23.6	----	0.61	0.74
Waco	16.8	18.7	21.9	16.8	18.7	22.2	0.72	0.49	0.90
Wichita Falls	14.5	14.2	16.5	15.0	14.6	17.1	0	0.94	1.75

Source: References 27, 28, and 29.

Table 10: Transit Performance Indicators - Section 15 Reports

Transit System	Total Operating Expenses								
	Per Passenger Mile			Per Employee			Per Operator Hour		
	1979	1980	1981	1979	1980	1981	1979	1980	1981
Abilene	----	----	0.24	------	------	28,182	----	----	16.0
Amarillo	0.43	0.41	0.54	23,153	25,255	35,757	12.7	13.8	19.9
Austin	0.15	0.17	0.19	19,000	0	25,138	13.2	0	18.1
Beaumont	0.13	----	0.10	18,072	------	20,235	12.5	----	14.0
Brownsville	0	0	0	14,278	12,226	15,796	15.3	10.8	13.7
Corpus Christi	0	----	0	12,537	------	18,750	9.5	----	15.0
Dallas	0.09	0.09	0.11	21,038	24,702	28,430	16.7	19.6	22.1
El Paso	----	----	----	------	------	------	----	----	----
Ft. Worth	----	0.20	0.26	------	22,538	24,222	----	16.6	18.9
Galveston	0.54	0.14	0.25	19,199	23,222	27,831	14.3	17.3	20.7
Houston	----	0.26	0.26	------	29,189	34,908	----	28.1	35.0
Laredo	0	0	0.29	16,847	19,802	21,357	12.6	14.9	15.2
Lubbock	0	0.06	0.36	16,279	18,709	18,844	10.5	12.4	13.8
Port Arthur	----	----	0.17	------	------	19,982	----	----	16.3
San Angelo	0	----	0.17	18,713	------	26,091	10.2	----	15.4
San Antonio	----	0.20	0.26	------	25,095	25,309	----	18.3	19.2
Waco	0.29	0.18	0.26	13,733	20,559	21,601	11.3	14.1	16.4
Wichita Falls	0	0.20	0.09	17,099	17,169	20,186	12.7	12.9	14.7

Source: References 27, 28, and 29.

Table 11: Transit Performance Indicators - Section 15 Reports

Transit System	Total Annual Passenger Miles											
	Per Line Mile (000)			Per Vehicle - p.m. Peak (000)			Per Capacity Mile (000)			Per Vehicle Revenue Hour		
	1979	1980	1981	1979	1980	1981	1979	1980	1981	1979	1980	1981
Abilene	-----	-----	20.2	-----	-----	258.8	----	----	0.12	-----	-----	67.7
Amarillo	18.1	20.5	19.7	98.2	118.0	113.2	0.04	0.03	0.04	32.4	38.2	32.0
Austin	116.4	114.7	130.3	355.1	350.0	397.5	0.14	0.14	0.16	101.0	99.5	113.3
Beaumont	55.7	-----	104.9	393.5	-----	740.5	0.21	----	0.30	113.7	-----	214.0
Brownsville	0	0	0	0	0	0	0	0	0	0	0	0
Corpus Christi	0	-----	0	0	-----	0	0	----	0	0	-----	0
Dallas	217.3	253.9	253.6	569.5	665.6	663.5	0.29	0.34	0.33	260.9	305.8	305.5
El Paso	-----	-----	60.1	-----	-----	548.4	----	----	0.16	-----	-----	144.4
Ft. Worth	-----	66.9	66.1	-----	247.3	246.9	----	0.14	0.14	-----	109.7	111.6
Galveston	19.7	92.7	74.4	100.1	471.2	346.1	0.05	0.18	0.14	0	129.9	83.4
Houston	-----	197.7	170.3	-----	535.4	659.9	----	0.18	0.27	-----	147.2	224.3
Laredo	0	0	51.7	0	0	284.6	0	0	0.12	0	0	62.3
Lubbock	0	145.8	24.7	0	806.3	136.5	0	0.45	0.08	0	273.2	46.4
Port Arthur	-----	-----	34.9	-----	-----	0	----	----	0.24	-----	-----	136.1
San Angelo	0	29	39.1	0	0	0	0	0.20	0.27	0	84.7	107.6
San Antonio	-----	172.3	62.9	-----	348.0	271.8	----	0.13	0.11	-----	127.1	90.9
Waco	17.4	36.8	31.0	125.8	305.5	215.2	0.08	0.18	0.21	57.6	106.3	86.7
Wichita Falls	0	17.5	42.5	0	0	0	0	0.13	0.31	0	73.4	180.2

Source: References 27, 28, and 29.

Table 12: Transit Performance Indicators - Section 15 Reports

Transit System	Total Passengers											
	Per Line Miles (000)			Per Vehicle Miles			Per Employee (000)			Per Vehicle Revenue Hour		
	1979	1980	1981	1979	1980	1981	1979	1980	1981	1979	1980	1981
Abilene	----	----	5.8	----	----	1.1	----	----	34.5	----	----	19.6
Amarillo	6.6	7.2	6.8	0.8	0.8	0.7	19.7	21.3	23.1	11.9	13.3	11.1
Austin	44.2	40.2	36.5	3.0	2.8	2.5	47.0	0	36.3	38.3	34.8	31.7
Beaumont	15.4	----	10.2	2.5	----	1.7	39.3	----	20.4	31.5	----	20.9
Brownsville	0	12.1	18.8	0	2.3	3.4	0	12.8	25.7	0	21.4	43.4
Corpus Christi	10.7	----	5.8	1.3	----	1.2	16.3	----	19.0	24.2	----	17.1
Dallas	32.4	37.7	37.0	2.4	2.8	2.7	34.9	40.5	37.6	38.9	45.4	44.6
El Paso	----	----	13.2	----	----	2.2	----	----	29.8	----	----	31.7
Ft. Worth	----	17.9	21.8	----	2.2	2.5	----	29.6	31.0	----	29.4	36.8
Galveston	9.4	34.2	26.5	1.0	3.7	2.8	17.0	61.7	39.8	0	48.0	29.7
Houston	----	40.1	34.0	----	2.2	2.9	----	23.0	27.1	----	29.9	44.8
Laredo	0	0	26.0	0	0	3.0	0	0	37.2	0	0	31.3
Lubbock	0	4.9	8.7	0	0.6	1.2	0	11.3	18.8	0	9.2	16.4
Port Arthur	----	----	5.0	----	----	1.4	----	----	16.4	----	----	19.5
San Angelo	0	6.1	8.8	0	1.2	1.7	0	29.5	35.5	0	17.7	24.2
San Antonio	----	55.6	22.2	----	2.5	2.2	----	41.4	34.4	----	41.0	32.1
Waco	0	13.3	8.8	0	3.1	1.9	0	42.3	24.1	0	38.5	24.7
Wichita Falls	0	3.7	2.3	0	1.1	0.7	0	18.2	11.6	0	15.5	9.8

Source: References 27, 28, and 29.

Table 13: Transit Performance Indicators - Section 15 Reports

Transit System	Total Employees						Total Administrative Employees					
	Per Vehicle (Total)			Per Vehicle (p.m. peak)			Per Vehicle (Total)			Per Vehicle (p.m. peak)		
	1979	1980	1981	1979	1980	1981	1979	1980	1981	1979	1980	1981
Abilene	---	---	1.1	---	---	2.2	----	----	0	----	----	0
Amarillo	0.7	1.0	0.6	1.8	1.9	1.7	0.05	0.08	0.05	0.14	0.15	0.15
Austin	2.4	0	2.5	2.9	0	3.1	0.11	0	0.12	0.13	0	0.15
Beaumont	1.4	---	1.8	2.8	---	3.5	0.06	----	0.16	0.12	----	0.31
Brownsville	2.6	3.6	3.0	3.3	0	0	0.05	0.17	0.47	0	0	0
Corpus Christi	2.5	---	1.6	4.4	---	2.7	0.20	----	0.15	0.35	----	0.26
Dallas	2.1	2.1	1.9	2.4	2.4	2.6	0.27	0.2	0.18	0.32	0.24	0.24
El Paso	---	---	3.3	---	---	4.0	----	----	0.74	----	----	0.92
Ft. Worth	---	1.9	2.3	---	2.2	2.6	----	0.24	0.26	----	.27	0.31
Galveston	2.1	2.1	2.1	2.8	2.8	3.1	0.05	0.05	0.10	0.07	0.07	0.15
Houston	---	2.6	2.1	---	4.7	4.9	----	0.29	0.27	----	0.52	0.63
Laredo	3.3	2.5	3.1	3.9	3.2	3.8	0.11	9.82	0.20	0.13	0	0.25
Lubbock	1.5	1.5	1.6	2.3	2.4	2.6	0.08	0.08	0.16	0.12	0.12	0.25
Port Arthur	---	---	2.8	---	---	0	----	----	0.42	----	----	0
San Angelo	1.1	1.2	1.4	2.0	0	0	----	----	0.03	----	----	0
San Antonio	---	2.2	1.8	---	2.7	2.8	----	0.12	0.13	----	0.15	0.21
Waco	0.8	1.5	1.6	0	2.6	2.5	0.34	0.16	0.15	0.39	0.28	0.25
Wichita Falls	1.7	1.7	1.6	0	0	0	0	0	0	0	0	0

Source: References 27, 28, and 29.

Table 14: Transit Performance Indicators - Section 15 Reports

Transit System	Total Annual Vehicle Miles						Total Revenue Vehicles		
	Per $ Vehicle Maint. Expense			Per Road Call			Per Maint. Employee		
	1979	1980	1981	1979	1980	1981	1979	1980	1981
Abilene	----	----	4.27	-------	-----	0	----	----	0
Amarillo	4.53	4.15	3.96	1,474	1,662	1,333	0	0	0
Austin	0	4.21	3.44	4,039	2,396	3,889	1.92	0	2.28
Beaumont	5.37	----	3.3	3,335	-----	1,436	1.53	----	2.78
Brownsville	0	3.55	1.61	0	236	300.0	0	1.46	1.56
Corpus Christi	3.71	----	2.82	4,678	-----	1,541	0.90	----	2.6
Dallas	4.18	3.25	2.73	3,154	2,439	2,176	2.35	2.58	2.68
El Paso	----	----	0	-------	-----	2,474	----	----	1.5
Ft. Worth	----	3.6	3.44	-------	1,925	2,367	----	3.26	2.12
Galveston	4.55	3.07	1.84	3,611	950.2	1,538	1.41	1.92	1.88
Houston	----	1.03	.83	-------	467.6	648.9	----	1.21	1.68
Laredo	0	1.72	1.34	0	874	1,985	0.94	1.53	1.47
Lubbock	5.91	5.34	4.97	2,458	2,066	6,037	2.71	3.45	3.02
Port Arthur	----	----	3.53	-------	-----	628.1	----	----	1.5
San Angelo	----	----	2.94	-------	-----	1,905	----	----	45
San Antonio	----	3.76	3.16	-------	4,881	5,442	----	2.05	2.54
Waco	0	3.16	3.57	1,829.7	1,227	1,672	1.56	4.20	2.66
Wichita Falls	6.46	4.41	4.07	1,617	1,725	1,230	0	3.33	3.85

Source: References 27, 28, and 29.

Table 15: Transit Performance Indicators - Section 15 Reports

Transit System	Total Number of Collison Accidents						Total Number of Non-Collision Accidents					
	Per Million Vehicle Miles			Per Million Passenger Miles			Per Million Vehicle Miles			Per Million Passenger Miles		
	1979	1980	1981	1979	1980	1981	1979	1980	1981	1979	1980	1981
Abilene	----	----	17.9	----	----	4.5	----	----	0	---	----	0
Amarillo	52.0	41.3	34.4	23.2	16.9	17.7	2.5	3.6	3.0	1.1	1.5	1.6
Austin	55.2	53.7	41.4	6.9	6.8	4.6	27.6	11.1	5.4	3.4	1.4	0.6
Beaumont	60.7	----	77.4	6.6	----	4.5	35.7	----	72.0	3.9	----	4.2
Brownsville	0	16.4	54.5	0	0	0	0	0	0	0	0	0
Corpus Christi	45	----	86.5	0	----	0	30.9	----	19.9	0	----	0
Dallas	70.2	87.6	78.5	4.3	4.6	4.2	34.0	42.6	39.1	2.1	2.2	2.1
El Paso	----	----	29.4	----	----	2.9	----	----	4.9	---	----	0.5
Ft. Worth	----	36.2	40.4	----	4.5	5.4	----	40.5	6.7	---	5.0	0.9
Galveston	29.5	46.2	69.2	13.6	4.6	8.7	17.7	13.5	16.1	8.2	1.4	2.0
Houston	----	81.1	91.5	----	7.6	6.4	----	98.7	104.1	---	9.3	7.2
Laredo	0	18.3	42.3	0	0	7.0	0	98.2	107.9	0	0	17.9
Lubbock	32.0	0	29.9	0	0	9.0	12.6	0	15.0	0	0	4.5
Port Arthur	----	----	25.2	----	----	2.6	----	----	5.0	----	----	0.5
San Angelo	----	----	23.5	----	----	3.0	----	----	3.9	----	----	0.5
San Antonio	----	41.3	40.8	----	5.3	6.7	----	21.2	19.1	----	2.7	3.1
Waco	27.8	27.7	70.6	7.4	3.3	10.7	17.1	13.9	61.2	4.5	1.6	9.3
Wichita Falls	24.7	14.1	21.2	0	2.8	1.2	0	0	0	0	0	0

Source: References 27, 28, and 29.

have a substantial effect in terms of reduced transit operating costs, improved service levels, and increased passenger demand (1, 24). However, it is not clear that these potential benefits warrant the incorporation of such measures in a formalized performance measurement system wherein large quantities of data are generated on a routine basis for every route. A more feasible and cost-effective scheme would involve the spot-checking of a limited number of measures to identify particular aspects of performance or particular locations within the system which are substandard and in need of more detailed investigation and remedial actions (1, 30).

A Proposed Approach to Data Collection

A detailed methodology for the design of a comprehensive, statistically based data system performance evaluation was developed by Attanucci et al. (31, 32) under contract to the Urban Mass Transportation Administration. By using this methodology, the authors claim that most transit systems will be able to develop and maintain comprehensive profiles on all their bus routes at a reasonable cost. Although the proposed approach focuses primarily on route-level data collection, it also provides for systemwide data (such as UMTA required Section 15 data) through the aggregation of individual route data (21).

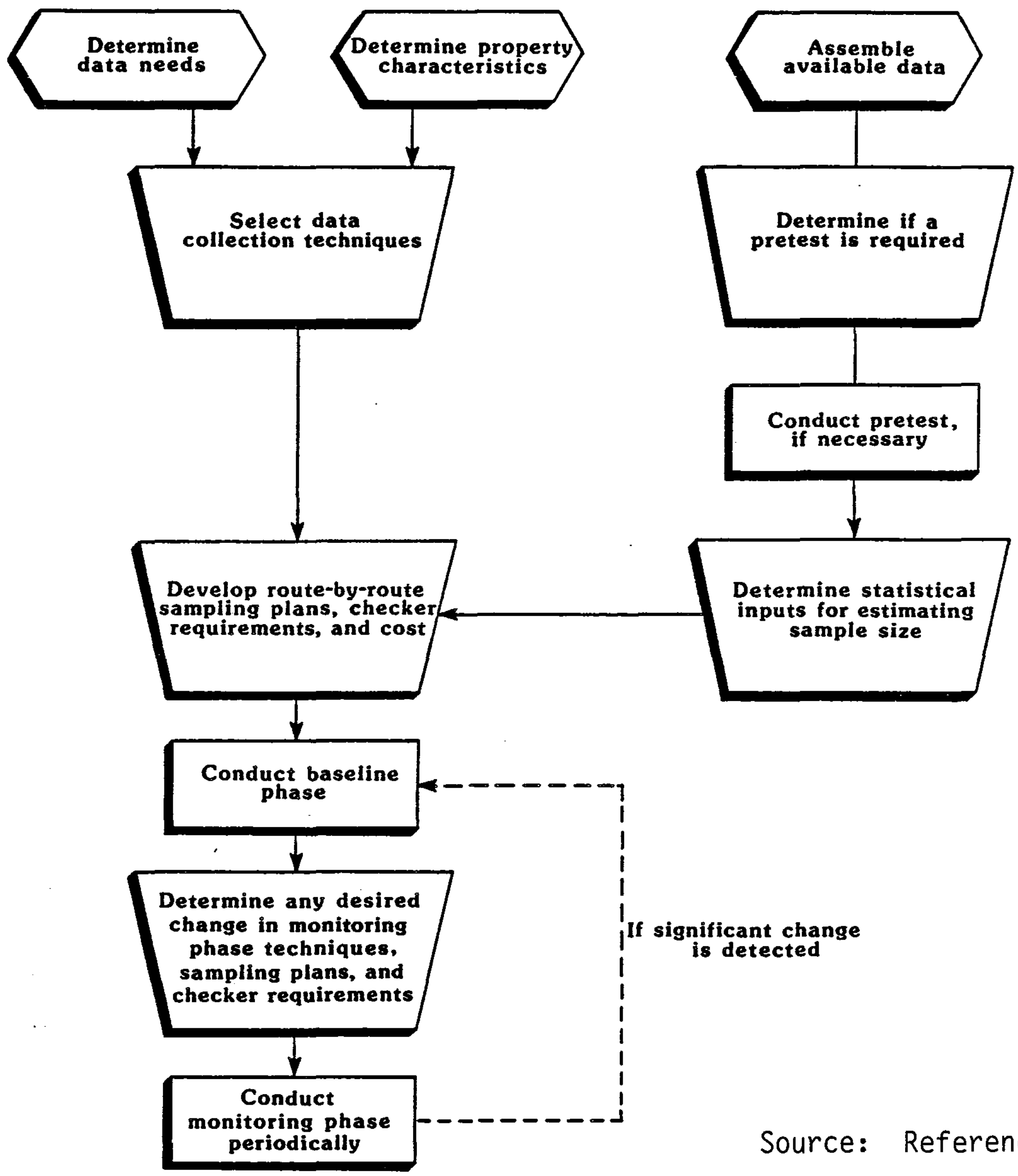
To summarize briefly, the proposed methodology is composed of 2 distinct data collection phases. In Phase I, the base line data collection phase, the base conditions are defined by time of day for each bus route in the system. The base conditions include all the data required for effective operations management and planning including total boardings, passenger loads at key locations on the route, running times, revenues, origin-destination data and passenger characteristics. The base line phase presents a clear picture of route performance at one point in time. Complete route profiles are developed from these data, which enable comparisons among routes in specific subareas, function types, or the system as a whole. Because the base line phase necessarily involves the collection of all data items needed for service planning and evaluation, it also provides an excellent opportunity to analyze the potential for route improvements and reallocation of equipment (21).

In phase II, the monitoring phase of data collection, each route is checked periodically to verify that the base conditions (i.e., route profile) for the route are still valid. Only 3 data items are collected in this phase -- bus arrival time, peak-point load and passenger utilization. It is assumed that if peak-point load and passenger utilization have not changed significantly, the other data collected during Phase I have not also changed significantly (21).

Although the base line and monitoring data collection phases differ in the number of items collected, the 2 phases are designed in the same manner. In this regard, 4 important inputs are required:

- A list of data required by the system based on the performance indicators selected for use. (Note: These data will vary among transit systems depending on size and type of system operated, the specific management objectives and the requirements for the external reporting.);
- An estimate of the required accuracy for each data item;
- Key system and route characteristics; and
- Existing data available or data obtained in a special pretest from which sample sizes can be determined (21).

In the design of the data collection phases both the desired accuracy and the inherent variability of the data items are considered. To reduce the overall cost of the data collection effort, consideration is given to the use of simple linear relationships between data items. Step-by-step procedures for the 2 phases of the data collection program are included in the publications Bus Transit Monitoring Manual: Volume I -- Data Collection Design and Volume II -- Sample Size Tables. The methodology discussed in this manual has been approved as meeting the Section 15 reporting requirements for passenger-related data. Figure 2 illustrates the data collection program design and implementation developed by Attanucci et al. (21).



Source: Reference 21

Figure 2: Data Collection Program Design and Implementation

Regardless of the specific transit performance measures selected, the principles of defining the base conditions for each transit route and periodically reexamining some (or all) of the data elements for comparison purposes remain sound. This is particularly important in those situations where no formal data collection efforts are employed or where there is a lack of key historical data available.

APPLICATION OF PERFORMANCE INDICATORS

Once the appropriate data has been collected and values have been computed for each performance indicator on a route by route basis, there are several approaches available for the application of the indicators to aid in transit management and planning. One approach consists of establishing minimum standards for each indicator (based on transit system goals and objectives) and then determining the extent to which each transit route satisfies the minimum level of performance for that particular category. Those routes which do not measure up in a specific area would then be subjected to a more in-depth analysis to determine where the problems exist and what can be done to remedy the situation.

Another approach involves calculating a mean value for each performance indicator and then determining where each individual route's performance value falls in relation to the mean. Those routes whose performance falls below the mean in a particular category would then warrant further investigation.

A third approach in the application of performance measures is to:

- Rank each transit route - from highest to lowest - in each performance measurement category;
- Assign a relative importance to each performance measure;
- Calculate a composite score for each transit route; and
- Add the scores for each route over all performance measures and rank each route by this composite score.

Priorities would include investigating those routes which exhibit the lowest overall level of performance. Proponents of this third approach cite that no single performance indicator or standard is appropriate in assessing whether a route should be expanded, modified or eliminated. Therefore, a methodology which takes into account all aspects of the route's performance is often preferred over a system which concentrates in one area only (8, 13, 24, 33, 34). Furthermore, the improvement of a route's composite score can become the standard (or base condition) for measurement of progress. That is not to say, however, that the other two approaches discussed do not have merit - especially in pinpointing specific problem areas in a particular performance category and in determining if specific transit system objectives have been realized.

Implementation and Frequency of Evaluation

Implementation of the transit performance evaluation and monitoring system should begin with the establishment of a transit operating profile which details the base conditions. The frequency and detail of subsequent evaluations should to a large extent depend on the individual transit system's need and the staff and financial resources available. Generally speaking, once an operating profile has been established, a rather detailed performance evaluation focusing on each route individually, as well as the system as a whole, should be conducted on an annual basis. However, it may be desirable to evaluate specific routes more often. It may also be advisable to single out one or two indicators to conduct a route-by-route or system-wide evaluation on a monthly, weekly or even daily basis (staff and financial resources permitting). This is a particularly important consideration if several transit routes or the system as a whole has been experiencing problems in one or two specific areas, such as schedule adherence. (Note: In years to come, the frequency and detail of performance evaluation may increase as transit systems across the state acquire or gain access to computers.)

Documenting the Results of the Performance Evaluation

Upon completion of the transit system's initial performance evaluation, the results should be documented in a formal report. The first report should discuss current transit performance, relate that performance to the goals and objectives of the system and identify opportunities for improvements where necessary. The evaluation report should serve as a useful management tool for the transit system and, therefore, should include the following:

- A brief description of transit system;
- A listing of all performance indicators (and their definitions) selected for use in the evaluation;
- The findings of the performance evaluation and how they were derived; and
- Opportunities for improvements.

Additional reports (which should be prepared at the conclusion of subsequent evaluations) should also include:

- Documentation of historical trends; and
- An assessment of the progress that has been made toward improving the efficiency and effectiveness of transit system operations since the last evaluation.

CONCLUSIONS

The process of developing and implementing a transit performance measurement and monitoring system will be rather difficult and time-consuming. To summarize, the process should consist of the following steps:

- Delineation of the intended uses of the performance measurement and monitoring system.
- Establishment of transit system goals and objectives.
- Selection of specific indicators of performance.
- Development of a plan for collecting the data necessary for computation of the performance indicators to include:
  - An assessment of available data;
  - The establishment of a transit operating profile; and
  - A plan for periodic re-evaluation of transit system performance in some or all of the selected categories.
- Development of a methodology by which the compared values for the transit performance measures are compared against some predetermined standards or mean values or are used in combination with other indicators to form composite scores for a route.

The previous sections of Part I are intended to serve as general guidelines for the development of a transit performance measurement system. As such, each section briefly highlights some of the more important areas of concern in designing a performance monitoring system geared to local operating conditions and financial and manpower constraints. An annotated bibliography with more than 130 entries is included at the end of this report in Appendix A. This bibliography was compiled to provide transit managers and planners with additional sources of information pertinent to the issue of transit performance measurement.

Although the performance measurement systems to be developed by the transit properties in Texas will necessarily vary considerably from one property to the next, each should prove to be a valuable management tool in improving the efficiency and effectiveness of transit system operations.

PART II

EVALUATION OF THE
I-45 NORTH FREEWAY CONTRAFLOW LANE

BACKGROUND

During the 1950's and 1960's, the need for increased vehicular capacity along heavily traveled corridors was generally met by constructing new roadway facilities. By the 1970's, however, the construction of new facilities had been curtailed due to a variety of factors including:

- Cost considerations;
- Land availability;
- Environmental concerns; and
- Energy conservation.

As a result, considerable effort is now being concentrated in the area of increasing the person movement capacity of the existing transportation systems.

Reserving lanes for the exclusive use by high occupancy vehicles (HOVs) represents an implementable, relatively low cost alternative means of increasing the person movement capacity of the existing transportation systems without major new construction. Implementation of HOV lanes, by offering its users a travel time savings, encourages mode shifts from low occupancy vehicles (autos) to high occupancy vehicles (buses and vans) which are authorized to use the lane. This in turn results in higher average vehicle occupancies and a more effective use of existing freeway facilities.

Techniques for providing priority treatment for high occupancy vehicles on existing urban freeways include:

- Exclusive lanes;
- Concurrent flow lanes; and
- Contraflow lanes.

Briefly defined, an exclusive lane facility is one that is physically separated from the normal freeway lanes. Access is limited to special ramps, so that opportunities for unauthorized vehicles to enter are limited. Possible locations for exclusive lanes are the median, adjacent to normal lanes within the right-of-way or an exclusive right-of-way.

The concurrent flow reserved lane concept is merely the assignment of a normal flow lane (using signs and markings) for use by designated high occupancy vehicles. In concurrent flow operations, the lane adjacent to the median is generally used for HOV traffic in order to reduce conflicts with the ramp traffic.

The contraflow lane concept is a technique whereby an off-peak direction lane is borrowed for use by peak direction HOV traffic. The basic reasons for considering contraflow lanes on freeways are to better utilize available capacity and to provide priority treatment to high occupancy vehicles.

The selection of which type of HOV facility is most desirable in a particular situation depends on a number of variables, such as existing traffic conditions, freeway design and cost considerations. Generally speaking, exclusive lanes are viewed as long-term solutions to congestion problems. Because exclusive lanes are the most capital intensive type of HOV facility, a high level of potential demand should exist before this type of facility should be considered. The implementation of an exclusive lane facility would best be considered as part of a freeway construction or reconstruction, because available right-of-way is generally lacking and costs are very high.

Concurrent flow lanes are the least costly HOV facility to implement and warrant consideration when a short-term solution is required for congestion bypasses. The main disadvantage of concurrent flow projects is that they can have a significant adverse effect on traffic congestion if they are implemented on freeway segments which are operating at or near capacity. Enforcement can also be a major problem.

Contraflow operations, which do not adversely affect peak direction traffic congestion or require major capital investment, may in a limited number of situations in Texas represent the optimal method for implementing an HOV facility. The feasibility of contraflow operation depends primarily on the directional split, the total traffic volumes and the freeway cross section. Contraflow lanes offer potential when the off-peak direction has relatively light volumes and the removal of a lane would not cause a drop below Level-of-Service C. Minimum peak/off-peak directional splits should generally fall into the range of 64/36 for 6 lanes, 62/38 for 8 lanes and 60/40 for 10 lanes (36). The minimum freeway cross section where contrafow is applicable is a 6-lane facility which allows 2 lanes in the off-peak direction during contraflow operation. Without 2 lanes in the off-peak direction, freeway operation would unduly be constrained by slow moving vehicles and accidents.

The contraflow concept is not new; excess off-peak direction capacity has been utilized for peak direction travel on bridges and other facilities for some time as a means of increasing peak direction capacity without major new construction. As an HOV lane, however, contraflow has additional objectives shared by other types of priority treatment projects. In general, these include increased average vehicle occupancies, more efficient and effective freeway operation, reduced fuel consumption and vehicle emissions, etc. The extent to which each of these objectives are achieved depends on traffic conditions existing prior to contraflow operation, specific characteristics of the contraflow lane (i.e., length, types of vehicles authorized to use the lane, etc.) and the nature of other transportation improvements implemented in conjunction with the contraflow lane (e.g., freeway ramp metering, park-and-ride lots, etc.) (37).

Implementation of the North Freeway Contraflow Lane

Characteristics of the North Freeway Corridor

I-45 North Freeway is a full standard 6- and 8-lane Interstate Highway that serves one of the fastest growing corridors of the Houston metropolitan area (Figure 3). The population of the North Freeway corridor is estimated to have increased 58% between the years of 1970 and 1979 to a population of over 500,000 persons. Average weekday traffic on the North Freeway increased from 96,000 vehicles in 1970 to 135,000 vehicles in 1979. Parallel arterial streets experienced similar growth rates (38).

During this same time period, the increased demand for peak period trips resulted in severe traffic congestion along I-45 North. Travel time surveys originating in the Houston central business district (CBD) revealed that a distance of 18 miles could be traveled in 30 minutes during the afternoon peak period in 1969. By 1976, however, only 11 miles could be traveled. The length of the peak periods also increased. In 1978, both morning and afternoon peak hour travel speeds averaged about 20 mph for 10 miles with hourly volumes ranging from 1,800 to 1,900 vehicle per lane. In addition, certain freeway segments typically experienced congestion for more than 2 hours during each peak period (38).

With corridor travel increasing at a rate of almost 5% each year during the 1970's, there appeared to be no immediate solution to the problem of accommodating an anticipated demand of 200,000 vehicles per day on the North Freeway by 1988. Although plans to widen I-45 North were included as part of a 10-year regional transportation improvement program, that improvement would not offer any relief in the near future. In response to this problem, the State Department of Highways and Public Transportation and the City of Houston

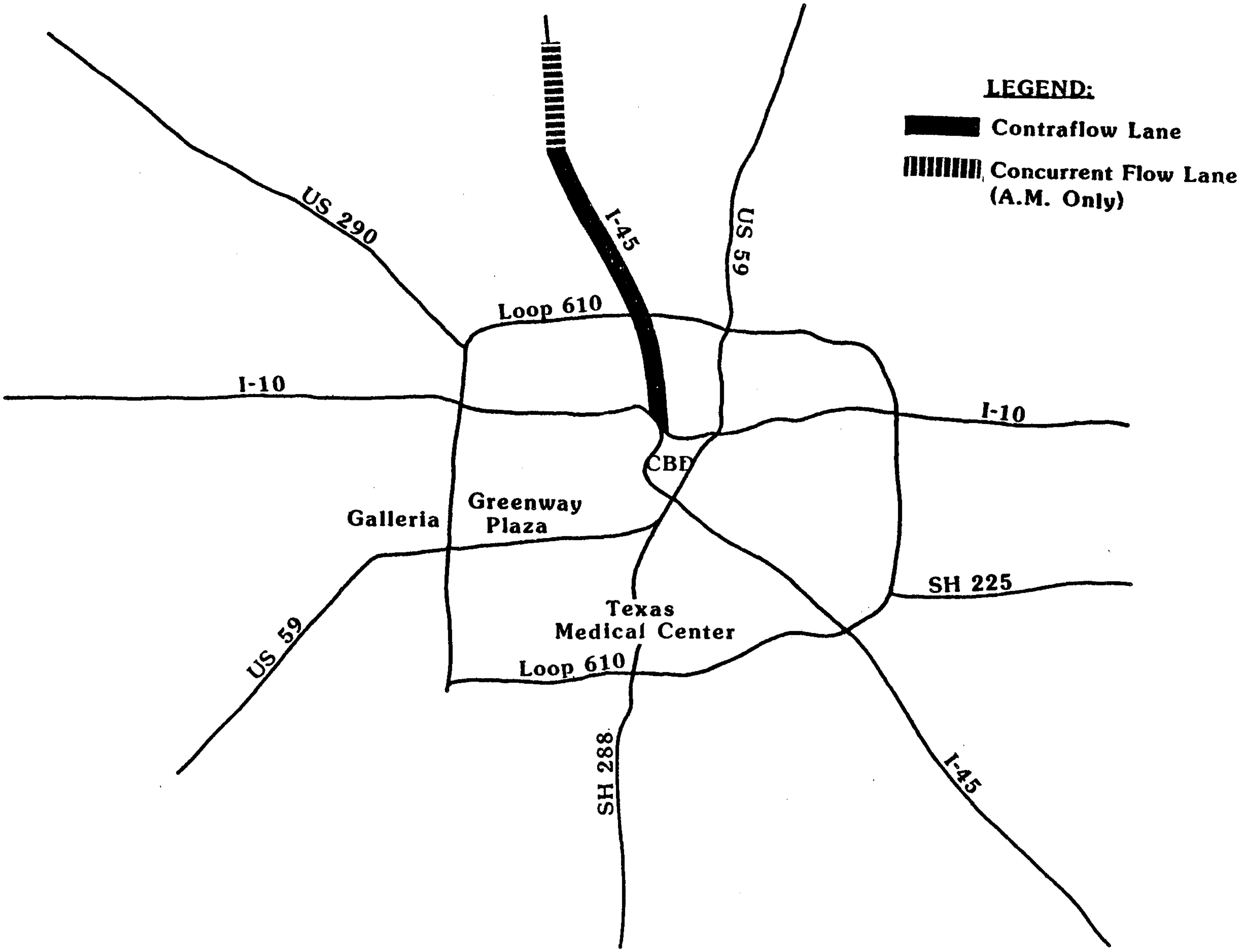


Figure 3: Location of the North Freeway Contraflow Lane

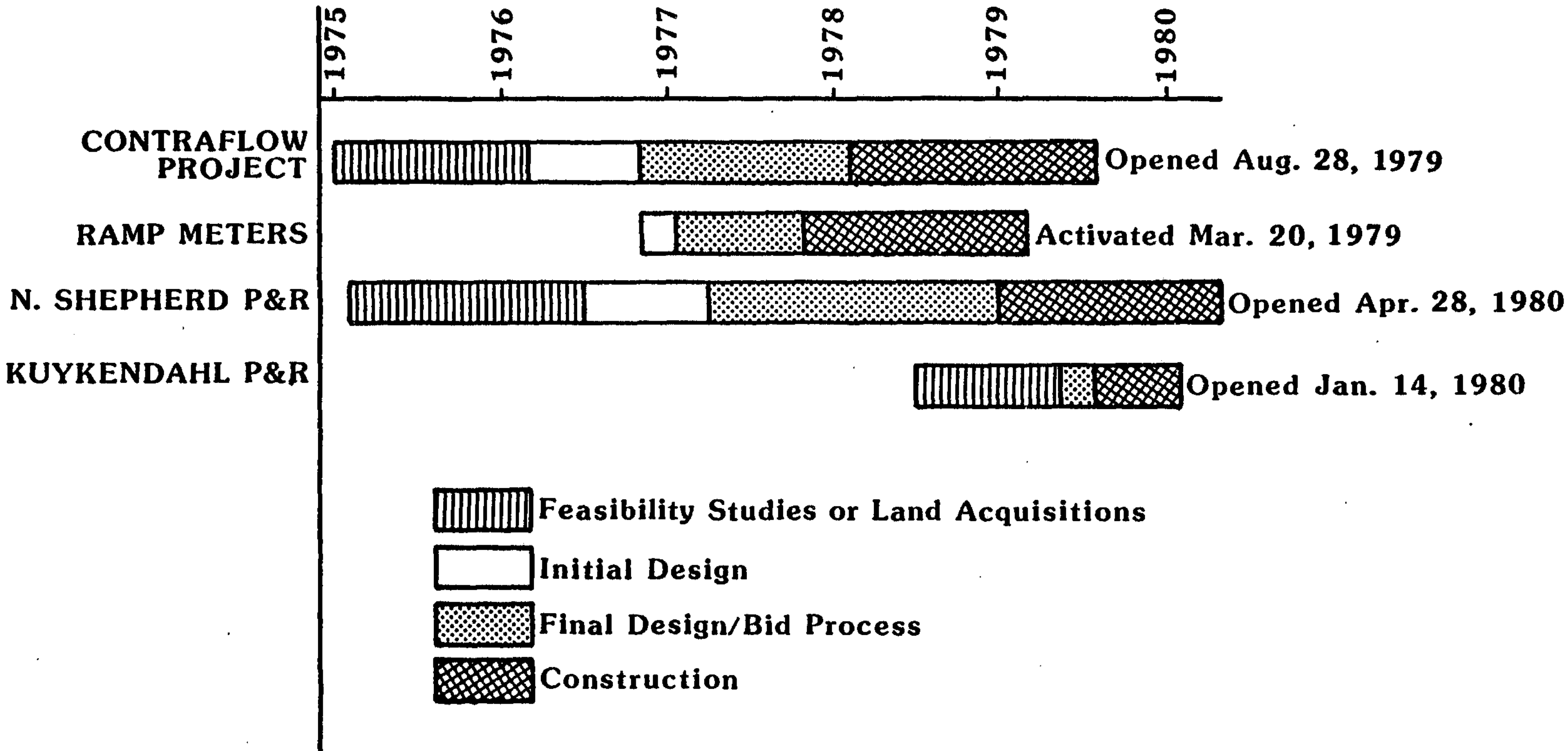
Office of Public Transportation* jointly proposed the construction of a contraflow lane to serve as an immediate short-term interim solution to the serious capacity problem developing along the North Freeway corridor. The implementation of a contraflow lane would also demonstrate the public's response to the provision of priority bus service (38).

An evaluation of the I-45 North Freeway corridor revealed that the 65/35 directional distribution of traffic between peak and off-peak was considered acceptable and only a few sections were considered critical from a capacity standpoint when one lane was removed from service to the off-peak traffic. Also, the North Freeway corridor had sufficient capacity on alternate routes to accommodate traffic diverted from the freeway. Finally, the North Freeway corridor had a great potential for transit patronage for work trips to the central business district (CBD).

Development of the Contraflow Lane

The planning, designing, funding and construction of the contraflow lane and its support facilities was a complex series of tasks which involved the cooperation and effort of many governmental agencies (local, state and federal). Approximately 5 years transpired between the initial feasibility study and the opening of the contraflow lane and other corridor improvements (Figure 4). A detailed chronology of the development of the contraflow project is presented in TTI Research Report 205-9 (39). To summarize the series of events briefly, the project was initiated in 1974 when the City of Houston requested the SDHPT to assist in the development of a demonstration project

*No regionwide transit authority in Houston existed in 1975. The City of Houston operated the bus system and executed transit plans after purchasing the system from a private operator in 1974. The Metropolitan Transit Authority was created by popular vote in October 1978, and assumed responsibility from the City as of January 1979.



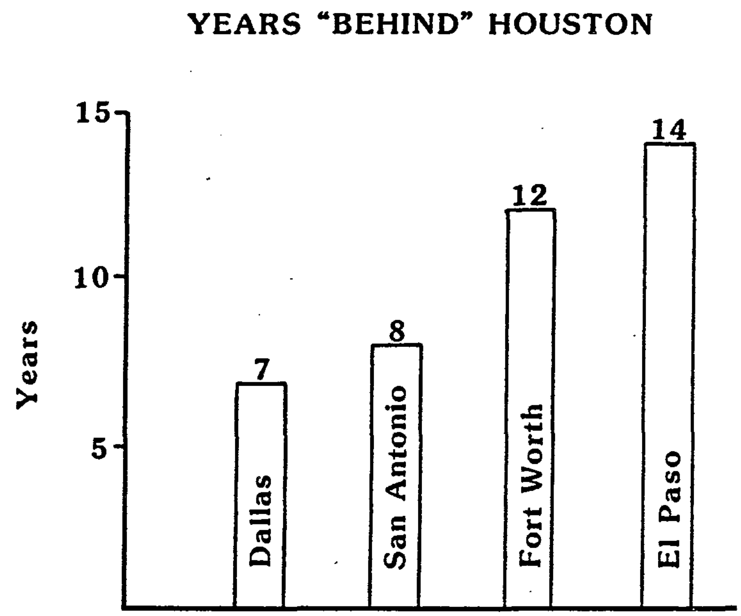
Source: Reference 38.

Figure 4: Timetable for the North Freeway Corridor Improvement Elements

to provide priority treatment for buses on Houston's freeways. In 1975, a grant for a Service and Methods Demonstration (SMD) Project was received from UMTA. A feasibility report and schematics of the project were approved in 1976. Plans and specifications were prepared and a contract was awarded to Brown & Root in November 1977. Construction began in February 1978 and was completed about 16 months later. The contraflow lane was officially opened on August 28, 1979.

There were three other elements in the North Freeway corridor that contributed to the CFL project. A ramp metering system which was to be installed by the SDHPT in 1980-81 to relieve congestion, was moved forward in order to provide control of traffic demands for both peak and off-peak directions while the CFL was in operation. This ramp metering system was completed in March 1979. Two park-and-ride lots, one at North Shepherd and one at Kuykendahl were also part of the project. The Kuykendahl lot, funded by METRO was completed in January 1980, while the North Shepherd lot, funded by Federal Aid-Urban System Funds, was completed in April 1980.

During the 5 years it has been in operation, the contraflow lane has proven to be a highly effective priority treatment measure which may have application to other freeways in Texas in the near future. A recent study of relative mobility levels in Texas (40) revealed that Dallas, San Antonio, Fort Worth and El Paso will be confronted with significant problems during the 1980's in an effort just to maintain - not necessarily improve - mobility. In fact, unless actions are taken to reverse historical trends, within 10 years Dallas and San Antonio will be as congested as Houston is today; and within 15 years the Fort Worth and El Paso areas will experience similar levels of congestion (Figure 5). Congestion also continues to increase in other Texas cities. The horizon for planning and implementing the necessary improvements is limited. Therefore, a detailed evaluation was performed in order to identify those factors which have been instrumental in its operational success and determine what types of conditions must exist for contraflow to operate effectively in other major Texas cities.



Source: Reference 41.

Figure 5: Time Until Houston Congestion Levels are Attained

THE NORTH FREEWAY CONTRAFLOW CONCEPT

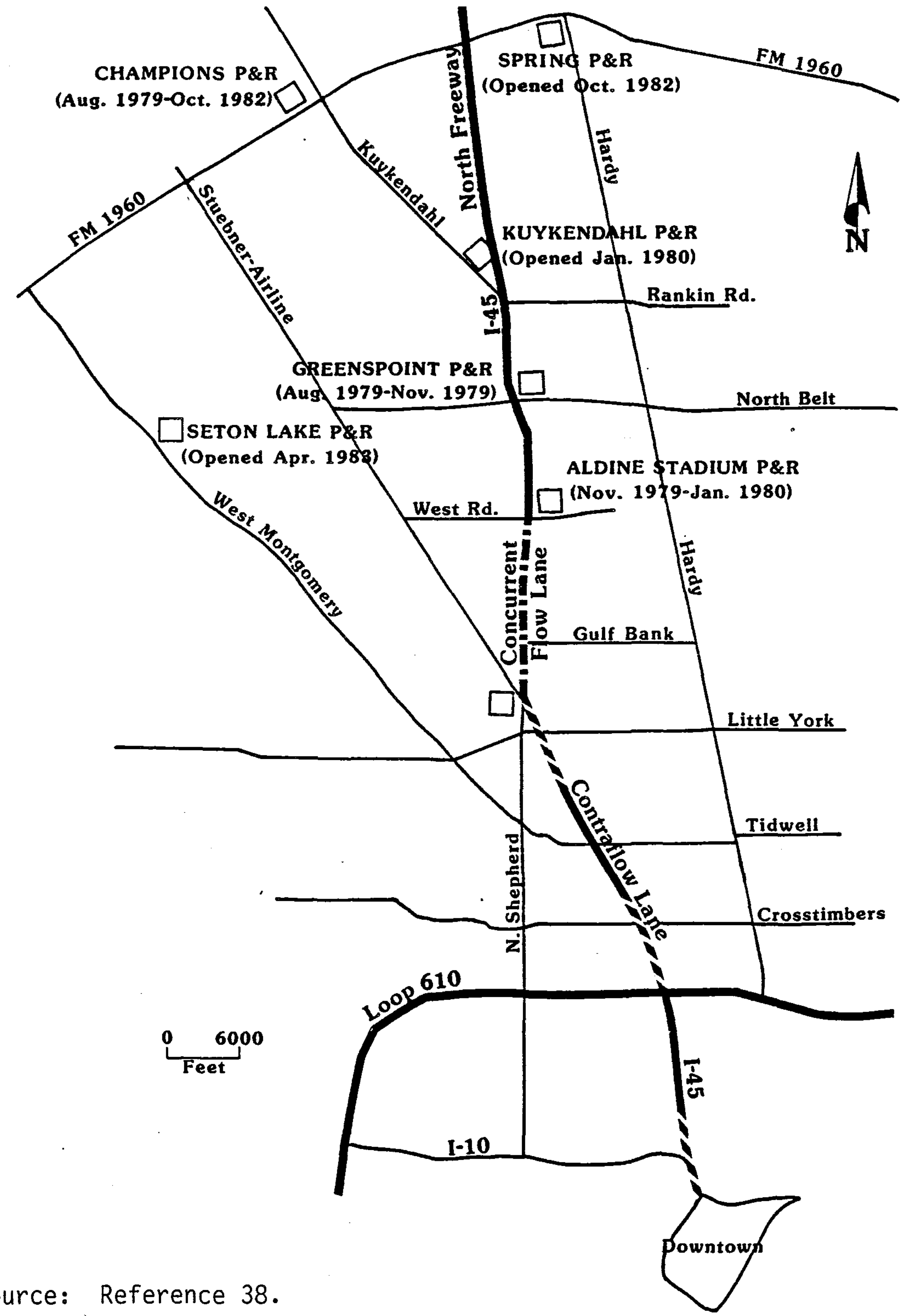
As shown in Figure 6, the I-45 North Freeway contraflow lane extends north from downtown Houston to the North Shepherd Drive interchange, a total distance of 9.6 miles. The CFL borrows the lane adjacent to the median shoulder in the off-peak direction for the exclusive use of authorized buses and vanpools. The CFL operates inbound in the morning from 6:00 a.m. to 8:30 a.m. and outbound in the afternoon from 4:00 p.m. to 6:30 p.m. Pylons placed in the pavement at 20- to 40-foot intervals are the only barrier separating the contraflow traffic from the opposite direction of flow.

The North Freeway contraflow lane is the first major preferential treatment operation in Texas reserved for the exclusive use of high occupancy vehicles. Although several major cities in the country have implemented HOV facilities, the Houston CFL is unique in that:

- It is the longest freeway contraflow project in operation;
- It is the only contraflow project that operates during both the morning and afternoon peak periods;
- It is the first project to have a midpoint crossover for entry and exit; and
- It is the only such project that is available for use by authorized vanpools as well as buses.

Because of these unique operating characteristics, no other HOV facility in the country is comparable to the North Freeway contraflow project.

In addition to the contraflow lane, a number of other improvements in transportation services were implemented by METRO and the SDHPT in the North Freeway corridor. These included the construction of North Shepherd and Kuykendahl Park-and-Ride lots, the expansion of express bus service to and from downtown Houston, freeway ramp metering and closures at selected locations during peak periods and the expansion of the previously established Car Share regional ridesharing brokerage program to include vanpools.



Source: Reference 38.

Figure 6: North Freeway Corridor

METRO's objectives in implementing the contraflow lane and related improvements were to (37):

- Decrease (or slow the growth of) corridor vehicle miles of travel (VMT) and the associated fuel consumption and vehicle emissions;
- Increase the average vehicle occupancy in the corridor;
- Reduce congestion, and thus reduce travel time; and
- Encourage the acceptance and use of public transportation.

When implementation of a contraflow lane was first proposed for the North Freeway in 1974, the North Shepherd Drive interchange was the northernmost point of recurring congestion. By the time the CFL opened 5 years later, traffic conditions had worsened causing buses and vanpools entering the freeway during the morning peak to experience severe congestion and delays in getting to the contraflow lane entrance. Because the design and operational characteristics of the North Freeway did not permit extending the contraflow lane further north, an alternative means of bypassing the congestion was needed.

A concurrent flow lane was proposed in early 1980, but the severity of congestion north of the North Shepherd interchange made restricting the use of an existing mixed flow lane to HOVs impossible. Instead, the median shoulder was designated as the concurrent flow lane for a.m. operation. Signs were installed, lanes were restriped to widen the shoulder over bridge decks and bridge railings were reinforced. A new exclusive lane connector ramp was paved in the North Shepherd interchange median to aid the transition for buses and vans from concurrent flow travel to contraflow travel. Construction of these improvements began in November 1980 and were completed 4 months later.

The operating period for the 3.3-mile concurrent flow lane is the same as for the contraflow lane during the morning peak (6:00 a.m. to 8:30 a.m.) and the 2 lanes are essentially treated as one priority treatment facility.

Those buses and vanpools which are authorized to use the contraflow lane are also authorized to travel on the concurrent flow lane.

Cost and Funding

The various capital costs associated with the implementation of the North Freeway corridor improvements and the funding sources for each are summarized in Table 16.

Table 16: Capital Costs for the North Freeway Corridor Improvements

Corridor Improvement	Cost	Funding Source
Contraflow Lane Construction	$2,176,000	
UMTA SMD		$ 408,000
UMTA Section 5		1,608,000
City of Houston		60,000
Texas Public Transportation Fund		100,000
Ramp Metering Construction	$ 396,000	
Federal Aid Interstate		$ 277,000
SDHPT		119,000
North Shepherd Park-and-Ride Lot	$2,160,000	
FAUS (FHWA funding source)		$1,512,000
SDHPT		648,000
Kuykendahl Park-and-Ride Lot	$2,100,000	
METRO		$2,100,000
Concurrent Flow Lane Construction	$ 138,000	
SDHPT		$ 100,000
METRO		38,000
Total	$6,970,000	

Source: Reference 37.

Approximately 93% of the capital costs for the CFL were financed by various federal funding sources. Local matching funds to cover the remaining costs were provided by the City of Houston and the Texas Public Transportation

Fund. Federal funding sources covered approximately 70% of the cost of the ramp metering improvements and the construction of the North Shepherd Park-and-Ride lot while the SDHPT funded the remaining 30%. The $2.1 million Kuykendahl Park-and-Ride lot was funded entirely by METRO and METRO also contributed $38,000 toward to construction of the concurrent flow lane with the SDHPT funding the remaining $100,000. The total capital costs for the North Freeway corridor priority treatment facilities came to $6,970,000.

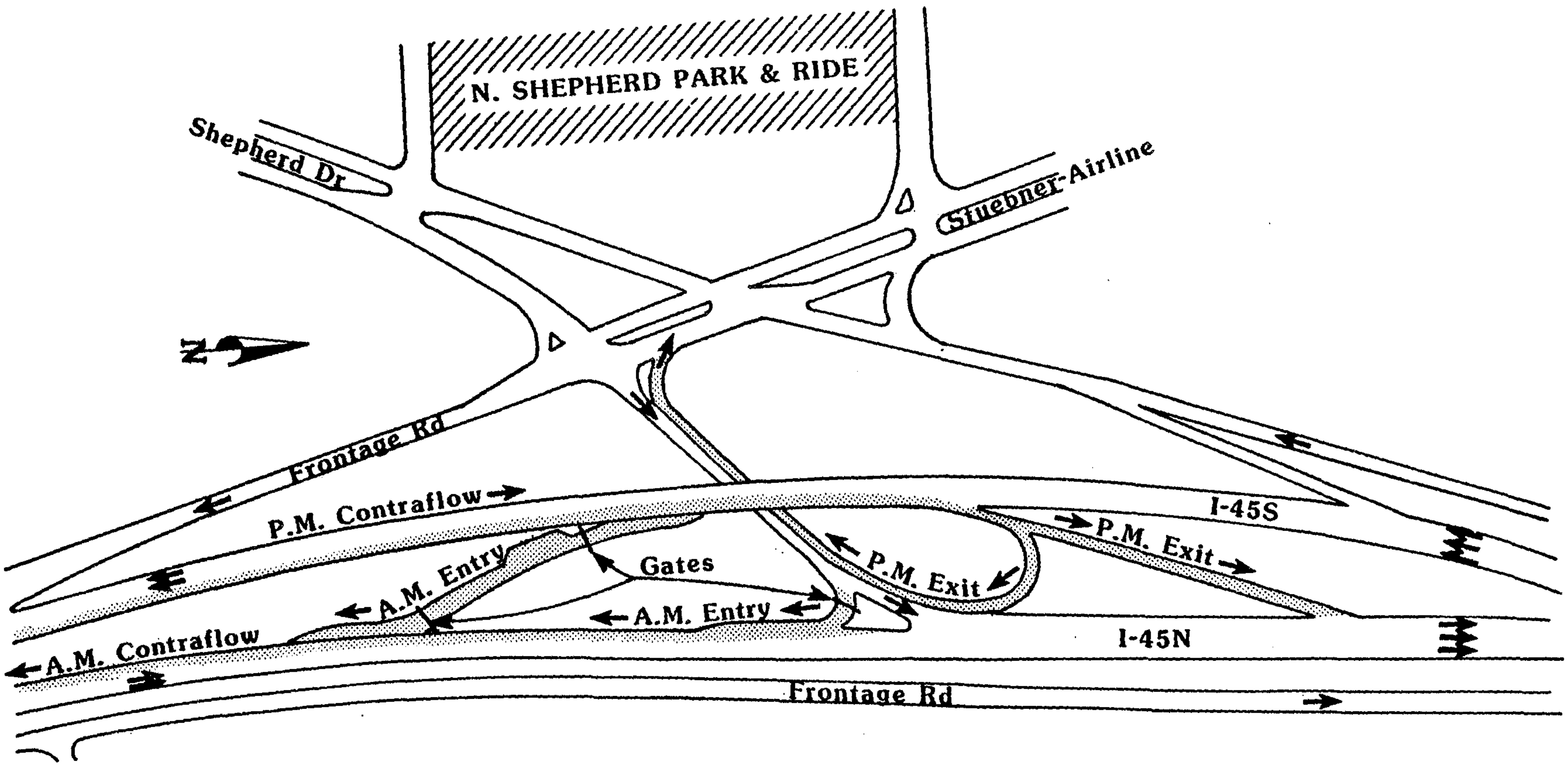
NORTH FREEWAY CONTRAFLOW LANE DESIGN

The 9.6-mile contraflow lane portion of the project actually consists of 3 types of priority facilities: a contraflow lane, a reversible flow lane which uses the freeway shoulder, and a separately constructed reversible busway (Figures 7 and 8). The reversible flow shoulder lane operation was necessary to avoid the conflict with the lefthand entrance ramp in the interchange with I-10. The separate busway was constructed to transfer the HOVs from the freeway to the CBD street system.

Entry into the CFL is controlled by entrance ramp gates which are manually operated by the METRO field crew. Police enforcement of the lane is accomplished at those locations. Stationary signs with flashing yellow beacons are activated to warn off-peak direction traffic when oncoming vehicles are in the CFL (Figure 9). Lane control signals which reveal either a red x, a yellow x, or a green arrow, are located over the CFL and adjacent lanes at critical locations (Figure 10). White diamonds which designate an HOV reserved lane are painted on the CFL (Figure 11). Yellow plastic pylons are inserted into predrilled holes in the pavement at 40-foot intervals, except in critical geometric sections where the spacing is reduced to 20-foot intervals (Figure 12). Additional fixed and changeable message signing is located at all approaches to the CFL project to provide adequate warning to motorists and information to CFL vehicles on the operation status of the lane.

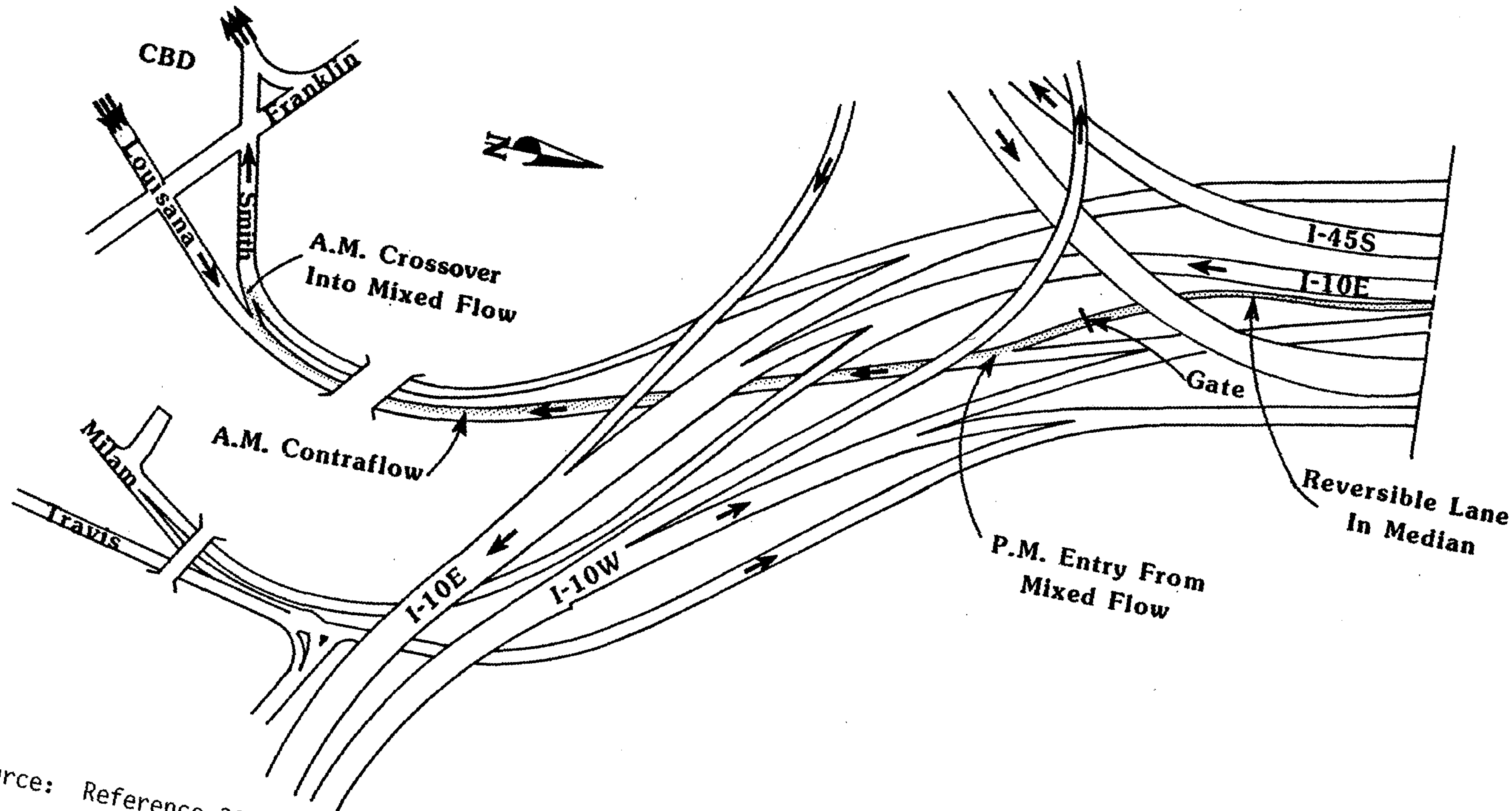
Special signing, lane designations, and channelization by plastic pylons mark the beginning of the contraflow section. Crossover ramps were constructed at the following locations:

- At the transition point from the reversible flow shoulder lane to contraflow;



Source: Reference 39.

Figure 7: North Shepherd Terminus to Contraflow



Source: Reference 39.

Figure 8: Downtown Terminus to Contraflow

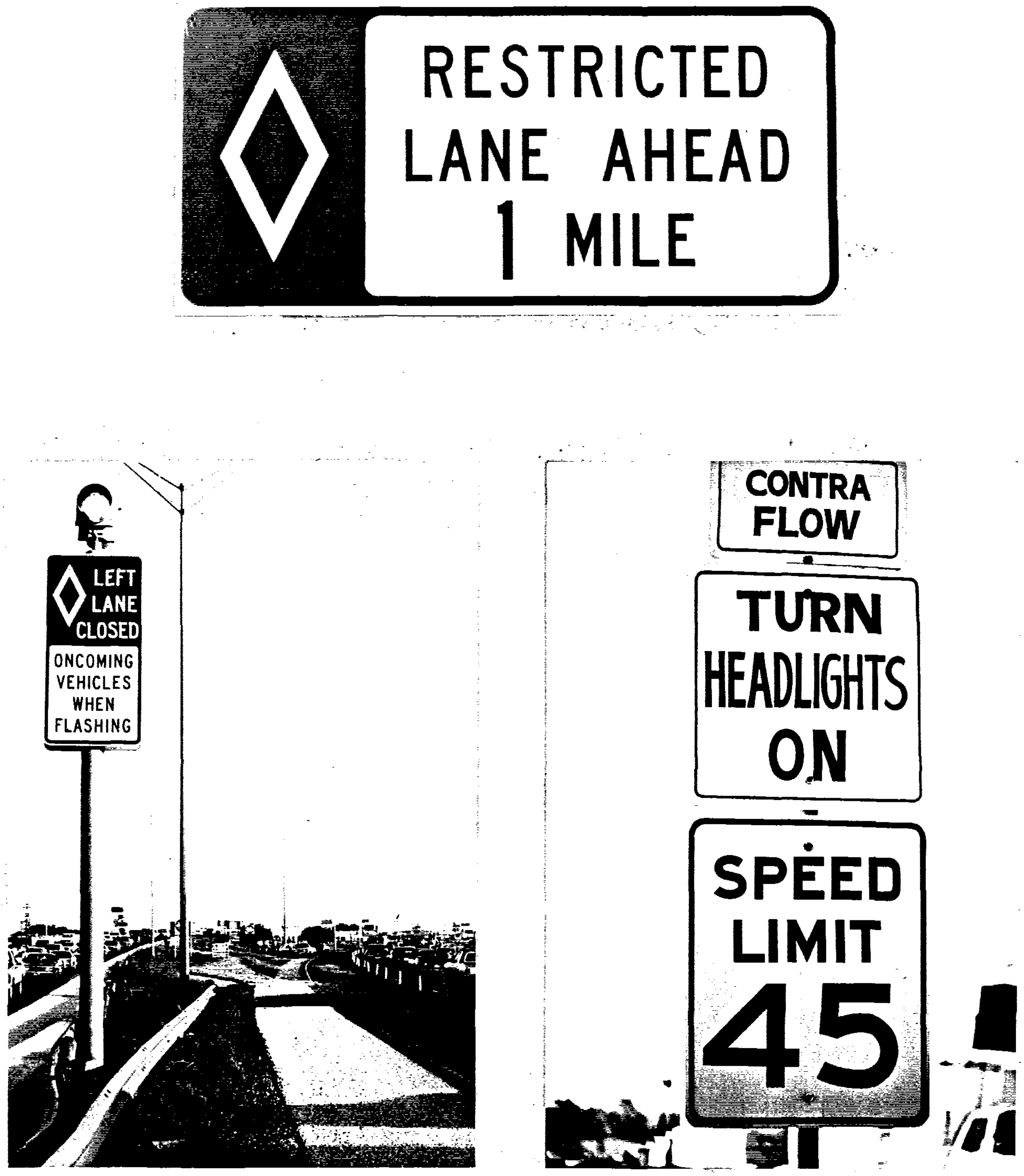


Figure 9: Contraflow Lane Warning Signs and Flashing Yellow Beacons

Figure 10: Lane Control Signals

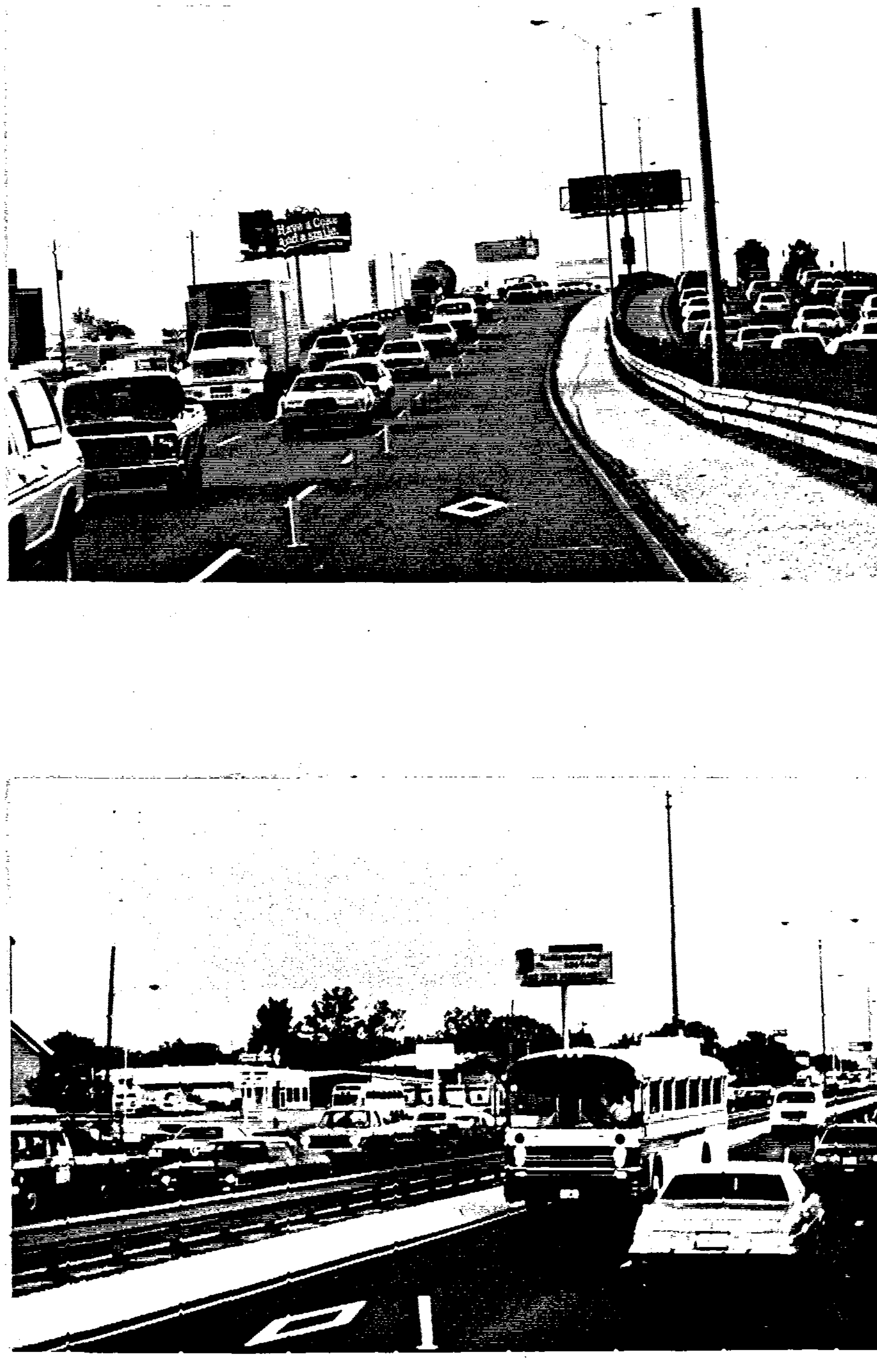


Figure 11: White Diamond Lane Marking to Denote an HOV Lane

Figure 12: Plastic Pylons Separating the Contraflow Lane from the Off-Peak Direction Traffic

- At the midpoint along the project at the I-610 interchange for CFL intermediate entering and exiting and for emergency diversion of CFL traffic in the event of a vehicle breakdown or accident blocking the lane further downstream; and
- At the northern terminal for access to I-45 northbound lanes or to one of the park-and-ride lots at the North Shepherd drive interchange.

Operation of the Contraflow Lane

The contraflow project is operated by METRO on an interstate freeway which is operated and maintained by the SDHPT. As such, a joint management team was established to be responsible for the project. This team meets on a regular basis to review CFL operating procedures. Modifications to the facility or operating plan must be approved by joint concurrence prior to implementation. The responsibility for maintaining CFL improvements on I-45 is shared by both agencies.

Vehicle Authorization

To ensure the safety of contraflow users as well as other freeway users, strict requirements regarding both CFL vehicle authorization and CFL driver certification were adopted and enforced. Every vehicle using the lane must display an official CFL authorization decal, and every person driving on the lane must carry a valid CFL driver identification card.

Vehicles eligible for contraflow authorization include:

- All METRO transit vehicles;
- Buses operated under contract to METRO;
- Other full-sized transit vehicles used for regularly scheduled service (i.e., intercity buses, airport shuttles, etc.); and
- Vans designed to carry 8 or more passengers including driver.*

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*In August 1979 when the contraflow lane opened, the requirement for vans was that they be able to seat a minimum of 12 people including the driver. This was modified to 8 in April 1980.

All vehicles, except official METRO vehicles, had to satisfy the following requirements in order to be granted authorization to use the lane:

- Vanpools must have at least 8 passengers registered including the driver. The driver is required to keep a monthly log of the vanpool's ridership which is subject to inspection by METRO.
- Proof of current, valid vehicle liability insurance has to be furnished to METRO. Acceptable minimum coverage is $250,000 per person for bodily injury, $500,000 per occurrence for bodily injury and $100,000 for property damage;
- Vehicles must display a valid State of Texas inspection sticker;
- Vehicles must pass a METRO vehicle inspection and display a valid CFL authorization decal in the front and back windows;
- Vehicles can only be driven on the CFL by a certified CFL driver.

To become certified to operate an authorized vehicle on the CFL, every driver (including substitute and back-up drivers) is required to:

- Have a State of Texas chauffers license;
- Have a good driving record (no more than 2 moving violations within the past year) and be in good physical condition;
- Complete the METRO contraflow drivers training course which includes passing a written exam;
- Maintain in possession their CFL drivers identification card while driving on the lane;
- Abide by all rules and regulations regarding the use of the CFL; and
- Assume responsibility for moving their vehicle to a place of safety should it break down on the CFL.

Cost of Operating the Contraflow Lane

Operating costs for the contraflow lane averaged $50,200 per month (or $602,400 on an annual basis) during the first year and a half of operation. A Service and Methods Demonstration (SMD) grant covered approximately half of the CFL operating costs during the initial 18-month demonstration period and METRO funded the remaining half. After the SMD demonstration period ended, METRO began assuming the entire cost associated with operating the CFL and currently budgets $600,000 annually for the purpose.

TRANSIT SERVICE AND RIDERSHIP

Transit ridership in the North Freeway corridor increased dramatically after the implementation of the contraflow lane and the expansion of transit service within the area.

Park-and-Ride Lots

Prior to the implementation of the contraflow lane, several church and shopping center parking lots were used on an informal basis as park-and-ride facilities for the 2 private bus routes which served the North Freeway corridor at that time. Once the feasibility of the contraflow lane was determined, expanded park-and-ride service into the North Freeway corridor was also proposed and approved.

In 1979 when the CFL was ready to open, it became evident that the Kuykendahl and North Shepherd Park-and-Ride facilities would not be ready by the CFL opening date. In order to allow the CFL to open upon completion, 2 temporary park-and-ride lots were established: one at Greenspoint Mall and the other at the Fritz Rd. Church of Christ in the Champions subdivision (Figure 13).

The Champions and Greenspoint Park-and-Ride lots opened simultaneously with the CFL in August 1979. The Greenspoint Park-and-Ride lot remained in operation until December 1979 when the Christmas shopping activity at the mall necessitated moving the park-and-ride operation to Aldine High School Stadium. The Aldine Park-and-Ride operation was terminated with the opening of the Kuykendahl facility in January 1980. The 350-space Champions lot continued to operate along with the 1,300-space Kuykendahl lot and the 750-space North Shepherd lot which opened in April 1980. Approximately 2,400 spaces were provided by these 3 lots during the initial years of CFL operation.

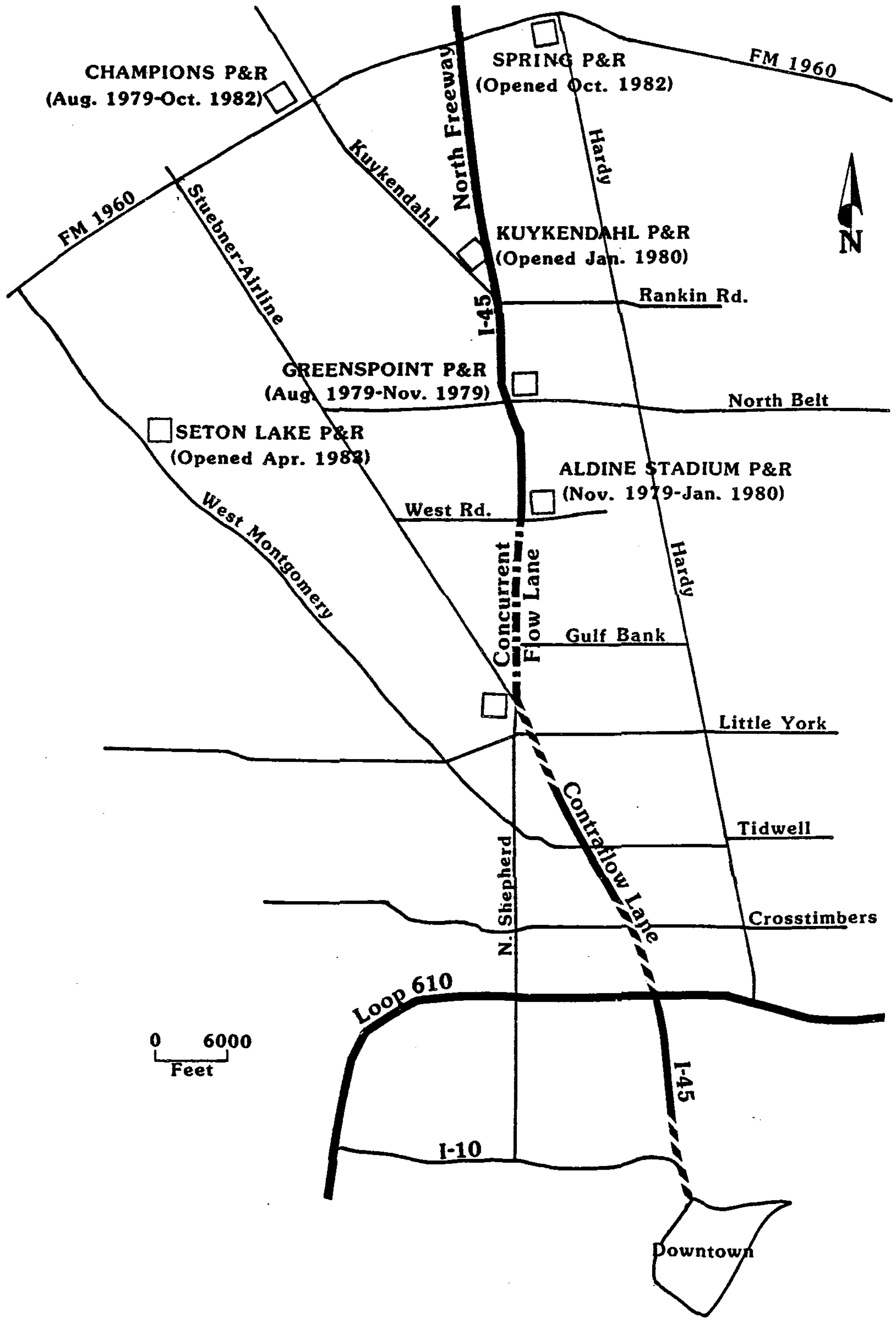


Figure 13: North Freeway Corridor Park-and-Ride Lots

In October 1982, a 1,280-space facility opened in the Spring area and the Champions facility was terminated. Six months later (April 1983) the Seton Lake Park-and-Ride lot containing 1,286 spaces was completed. Also in 1983, the North Shepherd and Kuykendahl Park-and-Ride lots were expanded to 1,605 and 2,245 spaces, respectively, bringing the total number of park-and-ride spaces currently available to North Freeway corridor residents to just over 6,400 (Figure 13).

The Kuykendahl, North Shepherd, Spring and Seton Lake lots all have kiss-and-ride drop off areas, handicapped spaces, covered bus boarding areas, security lighting and fencing, and other amenities available to park-and-ride patrons (Figures 14 and 15).

Transit Service

At the time the contraflow lane feasibility study was conducted, a total of 25 HouTran* bus trips per day with an average peak period ridership of about 25 persons per trip were run along the North Freeway between the Cross-timbers interchange and downtown. These 25 buses were considered potential contraflow lane users upon the construction of a CFL entrance/exit at the I-610 interchange, the midpoint of the CFL. However, because the midpoint entrance was never opened to general use (due to the amount of weaving required to make the transfer between I-610 and the CFL), these buses were never able to take advantage of the CFL.

*The City of Houston, through the Houston Transit System (HouTran) operated public transit service prior to the formation of METRO in January 1979. HouTran's service was primarily concentrated within the Houston city limits which only extended as far north as the North Shepherd Drive interchange.

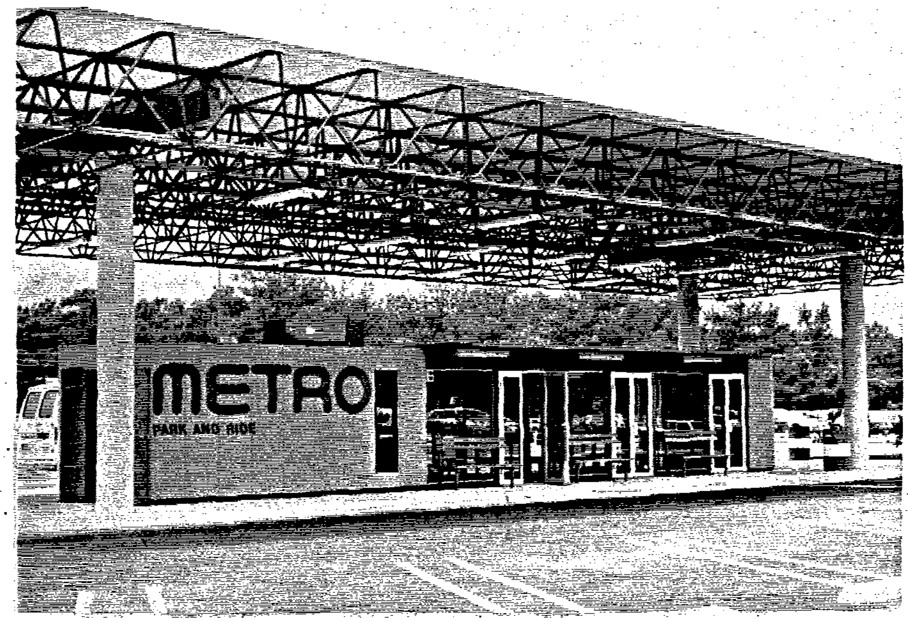


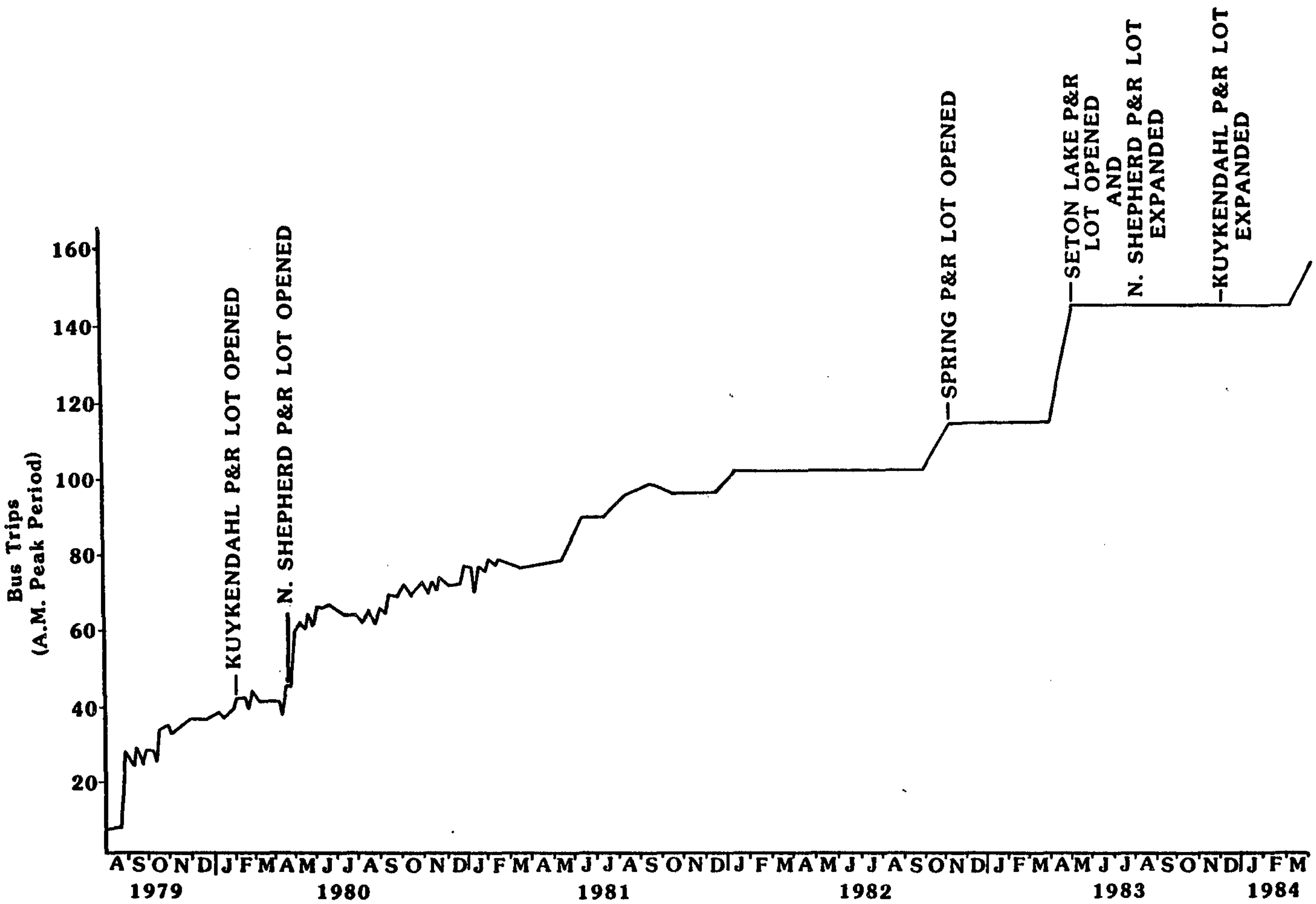
Figure 14: Bus Shelter and Covered Boarding Area at the Kuykendahl Park-and-Ride Lot

Figure 15: Covered Bus Loading Area and Other Amenities Provided at the North Shepherd Park-and-Ride lot

In addition to the HouTran buses, Oliver Bus Lines operated 2 private commuter routes on the North Freeway prior to CFL implementation. Both bus routes had a line haul distance of about 25 miles and entered the North Freeway at or north of the North Shepherd Drive interchange. In January 1979, the area in which these routes operated became part of METRO's jurisdiction and METRO contracted with Oliver to continue providing service. These 2 routes (FM 1960 Express and FM 149 Express) were averaging 265 a.m. peak period riders just before CFL implementation.

When the CFL opened in August 1979, a total of 4 bus routes were able to use the lane: the FM 1960 Express, FM 149 Express, the Champions Park-and-Ride, and the Greenspoint Park-and-Ride. The Champions Park-and-Ride operated non-stop to downtown. In addition, 2 of the Champions buses continued from downtown to the Texas Medical Center, the Galleria/Post Oak area and the Greenway Plaza area each peak period.

The growth of the bus service in the North Freeway corridor, since the opening of the contraflow lane, is presented in Figure 16. The actual use of the CFL by buses during the first 4 months of operation averaged about 28 trips per peak period. In January 1980 when the Kuykendahl route replaced the Greenspoint route, additional trips were added and the average number of trips on the CFL rose to about 42. At the end of April 1980, 16 more bus trips were added with the opening of the North Shepherd Park-and-Ride lot. Other bus trips were added on an "as needed" basis and by May 1982, there was an average of 103 bus trips using the CFL each peak period. With the addition of the Spring and Seton Lake routes, the average number of bus trips using the CFL increased to 144 by December 1983 (37, 42).



Source: References 37, 42 and 43.

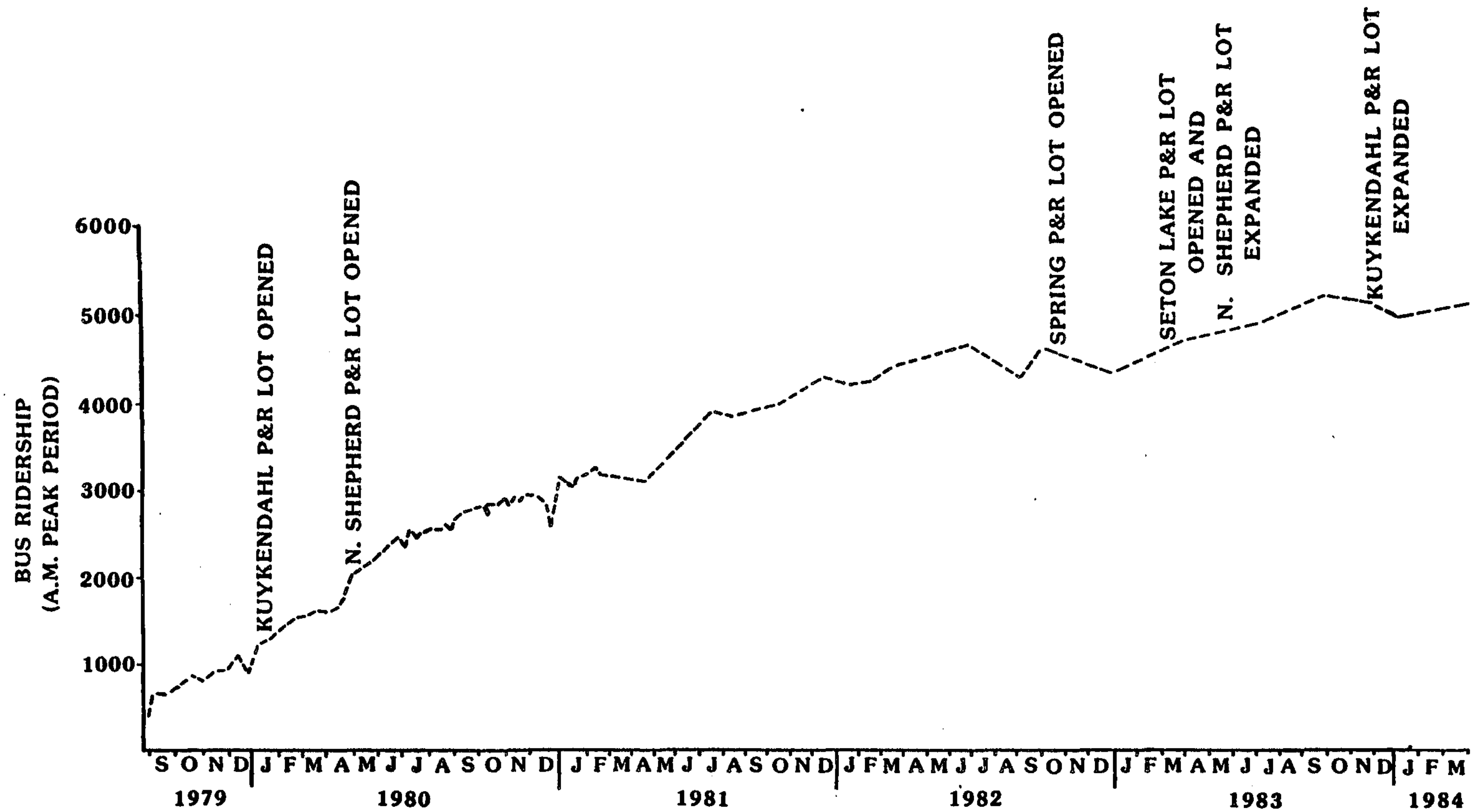
Figure 16: Growth in North Freeway Contraflow Lane Bus Service

Transit Ridership

The growth in average daily a.m. peak period bus ridership on the North Freeway between August 1982 and March 1984 is presented in Figure 17. As shown in Figure 17, daily a.m. peak ridership averaged 265 passengers just prior to the opening of the CFL. Once operation of the CFL began along with the expanded transit service, ridership rose sharply to about 4,500 after 53 months of CFL operation (May 1982). This represented an increase of 1,600% (37). Ridership stabilized in the months that followed and then began to increase once again at the end of 1983. By March 1984, a.m. peak-period ridership averaged over 5,000 passengers which represents about a 1,787% increase over the 265-passenger corridor average prior to the operation of the CFL (42). Major deviations to the generally steady increase occurred in December of 1979, 1980, 1982 and 1983 with slight decreases corresponding to the Christmas holidays.

Some of the increase in transit ridership between August 1979 and May 1982 was undoubtedly the result of increased transit availability. Yet, the fact that the average load factors increased by 17.3% (from .75 immediately prior to CFL implementation to .88 in May 1982) suggests that other improvements in transit service (e.g., the CFL) also contributed to this increase in ridership (37). When the Seton Lake and Spring Park-and-Ride lots opened in 1983, the average load factor dropped to about .73. Part of the reason for this decrease lies in the fact that the market areas for the park-and-ride lots overlap to a certain extent.

Some insight into the influence of transit availability relative to other improvements can be gained by examining ridership trends of those 2 routes which were in operation prior to CFL implementation. Average daily a.m. peak period ridership on the 2 bus routes in operation prior to opening



Soruce: References 37, 42 and 43.

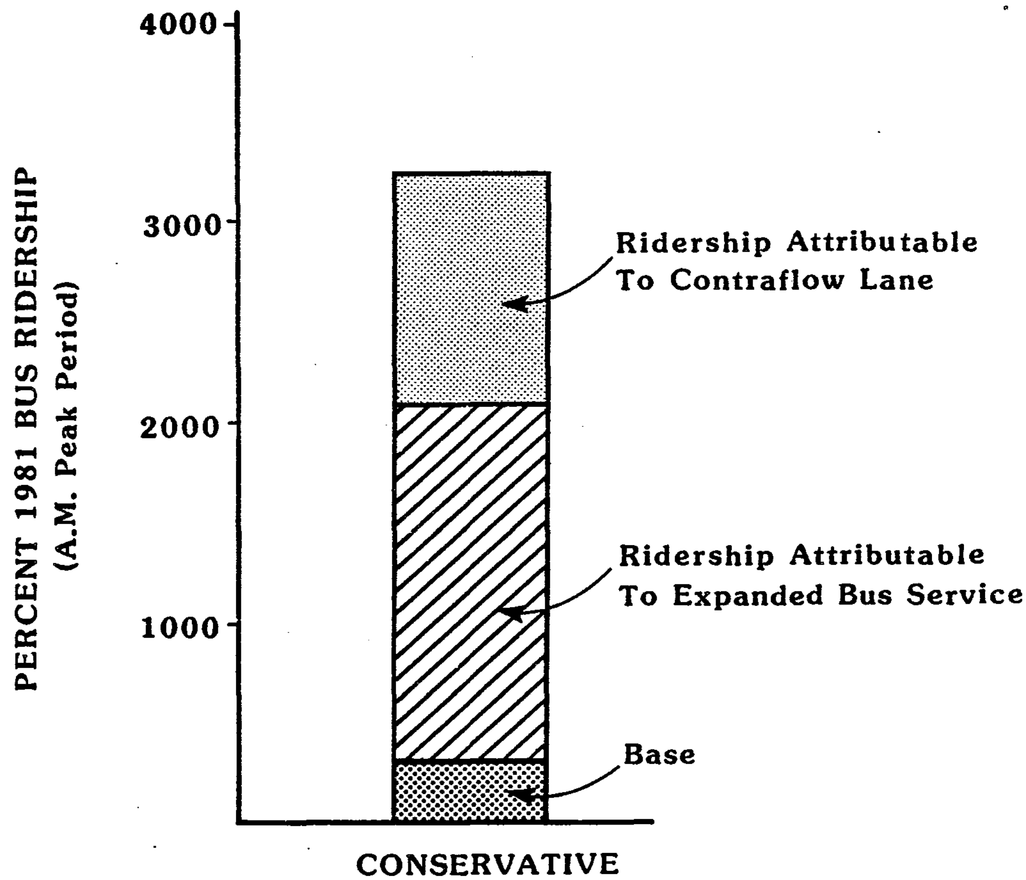
Figure 17: Growth in North Freeway Contraflow Lane Bus Ridership

of the CFL was 265. After 9 weeks of CFL operation, this figure dropped to 225. This decrease can probably be attributed to shifts in ridership to the 2 new routes which began operation when the CFL was opened, since the service area of these routes overlapped (37).

Beginning in November 1979, ridership on these 2 routes increased steadily at a rate of about 7 new riders per week through April 1980 when the North Shepherd lot was opened for service. After April 1980 ridership increases were still recorded, but the increase had dropped to about 0.9 new riders per week. By February 1981 ridership had reached about 460 a.m. peak period passengers - a 75% increase relative to ridership levels existing before CFL implementation. Relative to ridership at the end of October (i.e., accounting for those riders attracted to new routes which began service when the CFL began operation), this represents a 100% increase (37).

During this same time period, the total person movement along the North Freeway increased by 31.7%. No major service improvements were made to these 2 transit routes (additional bus trips were added only when demand exceeded capacity), and there were no significant increases in the price of gasoline. Assuming, then, that the CFL had not been put into operation, ridership on these 2 transit routes would have increased in proportion to total corridor travel. Therefore, it is theorized that morning peak period ridership would have been 297 (225 buses with a 31.7% increase) rather than the 460 which was experienced with CFL implementation. This would suggest that the CFL has been responsible for a 54.9% increase in ridership on these 2 routes (37).

Assuming that rate of ridership increase resulting from the CFL operation for these 2 routes would also apply to the other bus routes which served the North Freeway, an estimate of the total bus ridership which would have existed without the implementation of CFL was developed. Using the average morning peak-period ridership for February 1981 of about 3,200, a conservative corresponding ridership level without the CFL was estimated at 2,066 (Figure 18) which implies that about 35.4% of those riding the bus would not have done so without the contraflow lane (37). This 1981 estimate closely parallels the results of a 1984 on-board survey question in which 33% of 1,140 North Freeway park-and-ride users responded that they would not be using park-and-ride if the CFL did not exist. (Note: An in depth discussion of the results of this on-board survey is presented in a subsequent section of this report).



Source: Reference 37.

Figure 18: Estimated Influence of Contraflow Lane on Bus Ridership in the North Freeway Corridor

Park-and-Ride Lot Demand

As would be expected, the demand for park-and-ride spaces corresponded to the demand for transit service in the North Freeway corridor. The 330-space Champions lot was used at or above capacity from February 1980 (6 months after CFL implementation) until October 1982 when the lot was terminated (37).

The Kuykendahl lot, which contained 1,300 spaces averaged about 300 vehicles per day when it opened in January 1980. After one year in service utilization averaged about 885 vehicles. By July 1981, demand exceeded capacity and this trend continued until November 1983 when the lot was expanded to 2,246 spaces. By the end of May 1984, an average of 1,372 or 61% of the Kuykendahl spaces were being utilized (37, 42).

Initially, about 400 of 750 spaces available at the North Shepherd lot were being used on an average day. However, within 6 months, usage was at near capacity. The lot continued to operate well above capacity until it was expanded to 1,605 spaces in April 1983. By the end of May 1984, approximately half of its capacity was being utilized on an average day.

The 1,280-space Spring lot, which was put into service in October 1982, averaged about 557 vehicles during its first few months of service. Utilization has steadily increased and 846 spaces (or about 66% of the lot's capacity) were used on a typical day by the end of May 1984.

The newest lot, Seton Lake, was put into service in April 1983. At the close of May 1984, approximately 46% of its 1,286-spaces were being utilized on an average day.

VANPOOL UTILIZATION OF THE CONTRAFLOW LANE

Initially, the contraflow lane was designed and constructed to be used exclusively by bus transit vehicles. Prior to the opening of the lane, however, the feasibility and acceptability of allowing other classes of vehicles (i.e., carpools, vanpools, trucks and taxis) to use the lane was studied. The intent of allowing other vehicles to use the CFL was to improve the efficiency of the lane and to decrease the headways of the CFL vehicles. Vanpools were determined to be an acceptable class of vehicles that could be regulated and managed by the operators of the CFL.

As indicated by the figures in Table 17, allowing vanpools to use the CFL did have a significant effect on the total number of vehicles and persons using the lane. In fact, vanpoolers outnumbered the bus passengers until the 22nd week of CFL operation. By the end of March 1984, average daily contraflow lane utilization totaled 969 vehicle trips and 15,891 person trips. Vanpools accounted for 658 (68%) of the total vehicle trips and 6,060 (38%) of the total person trips (Figure 19).

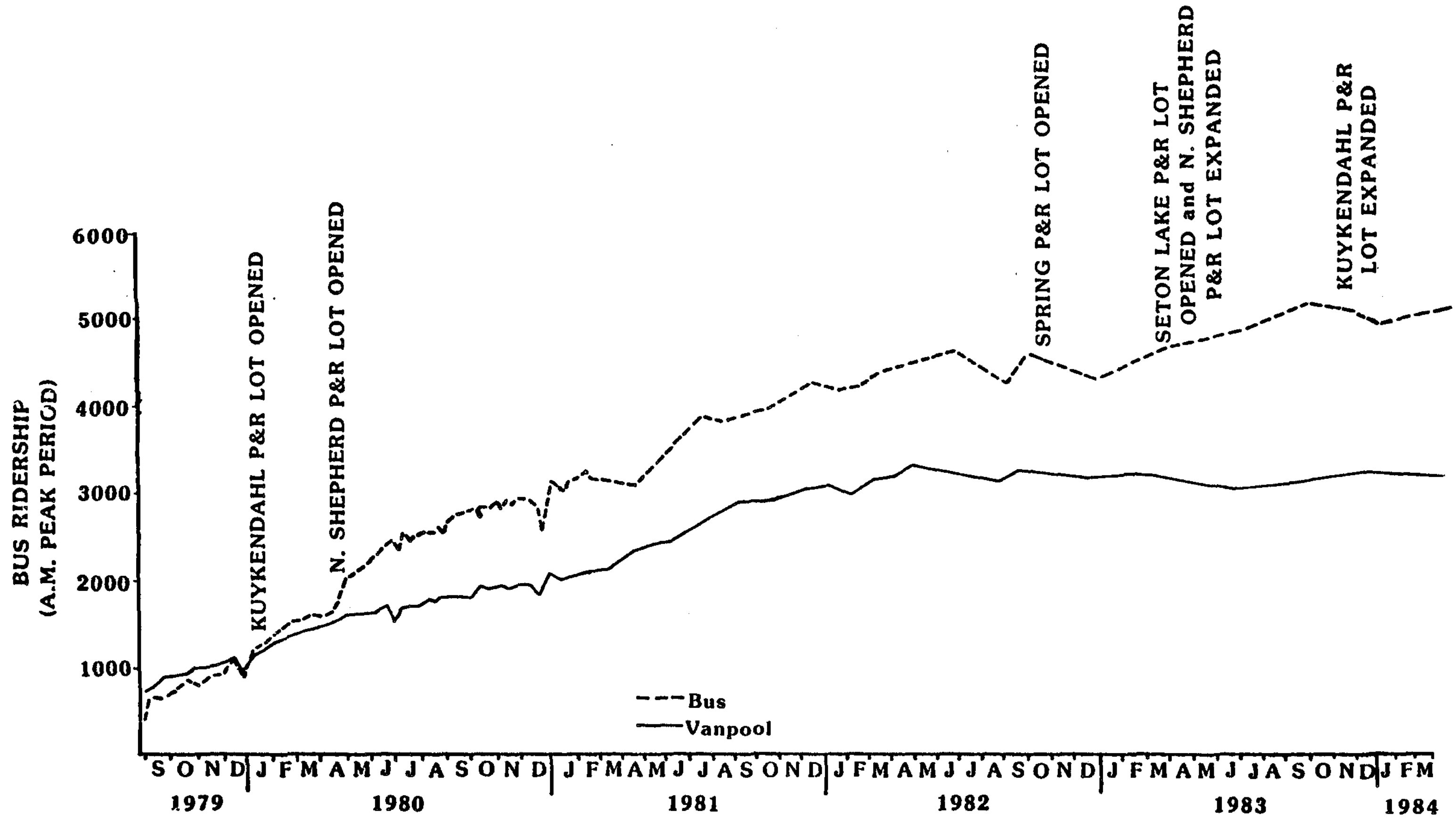
In examining the growth of vanpooling along the North Freeway corridor, it is rather difficult to determine to what extent the implementation of the contraflow lane influenced vanpool ridership. Unlike bus ridership, there are no counts available for vanpool ridership prior to the opening of the contraflow lane. However, the results of a vanpool drivers survey conducted in December 1980 as part of a Service and Methods Demonstration evaluation can be used to estimate the possible effect of the CFL on vanpool utilization along the North Freeway. Approximately 99.6% of all vanpool drivers on the CFL were surveyed with about 90.2% responding. From these surveys, the formation dates of those vanpools responding were determined. Figure 20 illustrates the number of vanpools formed each month and Figure 21 presents the cumulative

Table 17: Average Daily CFL Utilization by Week During the First Year CFL Operation

Week	Bus		Vanpool		Total	
	Bus Trips	Passenger Trips	Vanpool Trips	Person Trips	Vehicle Trips	Person Trips
1	57	804	164	1539	221	2343
2*	60	1308	170	1596	230	2904
4*	60	1398	214	1819	274	3217
6*	66	U/A	216	1836	282	U/A
8	71	1674	221	1878	292	3552
10	70	1655	236	2005	306	3660
12	70	1831	236	2005	306	3836
14	75	1877	242	2057	317	3934
16	73	2241	268	2278	341	4519
18	75	1725	234	1989	309	3714
20	75	2530	275	2337	350	4867
22	80	2650	283	2405	363	5055
24	85	2908	298	2652	383	5560
26	82	3043	313	2786	395	5829
28	81	3161	315	2803	396	5964
30	83	3330	329	2928	412	6258
32	81	3202	334	2973	415	6175
34	88	3425	336	2990	424	6415
36	120	4140	363	3231	483	7371
38	120	4335	367	3266	487	7601
40	122	4530	376	3347	398	7877
42	127	4710	376	3347	503	8057
44	128	4938	384	3417	512	8355
46	127	5057	388	3453	515	8510
48	124	5036	397	3534	521	8570
50	121	5175	406	3532	527	8707
52	125	5140	412	3584	537	8724

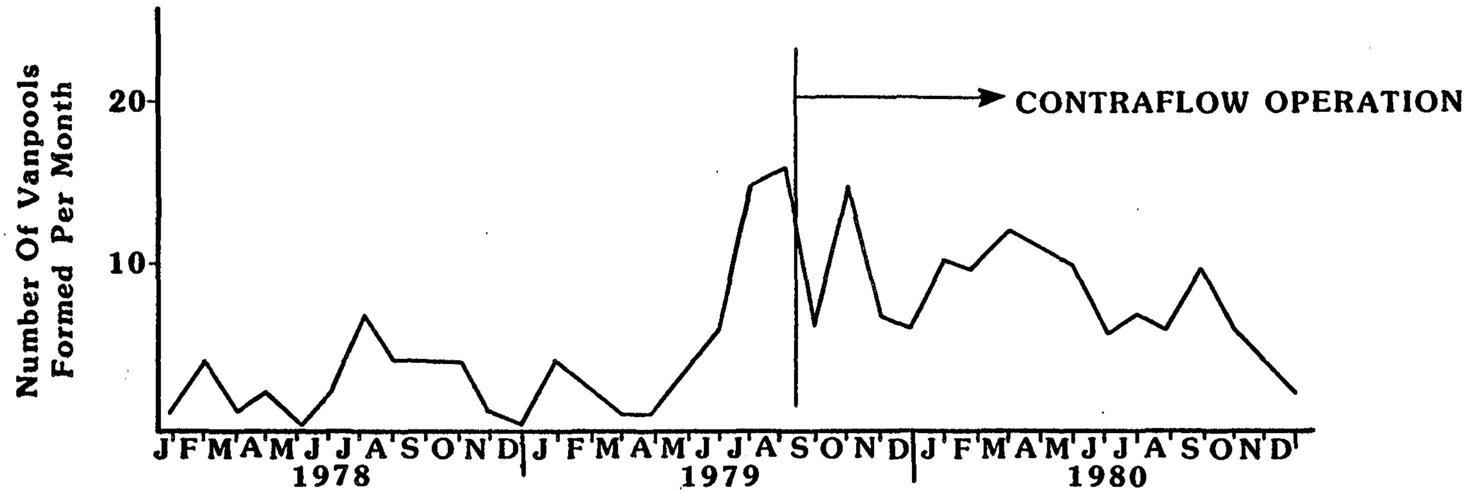
*Estimated from P.M. Surveys

Source: Reference 39.



Source: References 37, 42 and 43.

Figure 19: Growth in North Freeway Contraflow Lane Vanpool Ridership Relative to Bus Ridership



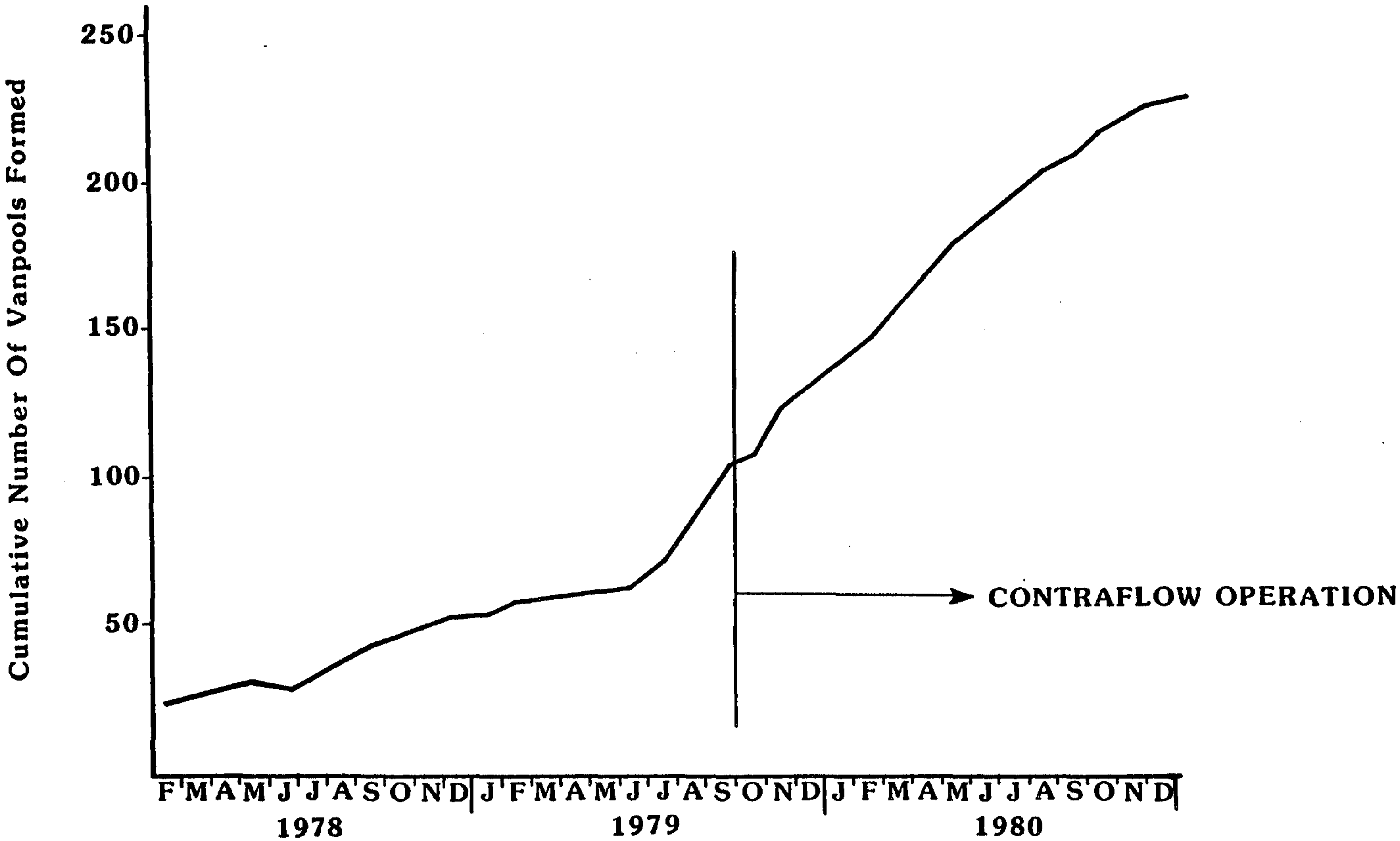
Source: Reference 37.

Figure 20: Vanpool Formation by Month

number of vanpools formed between the period from January 1978 and December 1980. As shown in Figure 20, the vanpool formation rate averaged 2.7 per month between January 1978 and June 1979. In July and August of 1979, however. a total of 31 vanpools (44% of all vanpools existing at the time the CFL opened) were formed. Once the contraflow operation began, the vanpool formation rate dropped from an average of 15.5 per month in July and August 1979 to 7.9 per month for September through December 1979. These figures appear to indicate that the decision to allow vanpools on the CFL, which was made in the spring of 1979, may have been instrumental in the formation of a number of vanpools immediately prior to the opening of the lane. Although the vanpool formation rate after the CFL began operation was only about half of that for July and August 1979, it was nevertheless 3 times higher than the average rate for the period between January 1978 and June 1979. This would also suggest that the CFL had a positive effect on vanpooling (37).

The effect of the contraflow lane on vanpooling might have been even more pronounced had it not been for the intensive transit improvement program that began the same time the CFL opened. It is theorized that many people who might have considered vanpooling chose to use the new park-and-ride service for work trips instead. If, in fact, park-and-ride service was competing with vanpooling, any major change in the supply of park-and-ride service would be expected to be reflected in the trend of vanpool ridership. With the exception of the new routes added when the contraflow lane opened, two major changes in the park-and-ride supply characteristics can be identified:

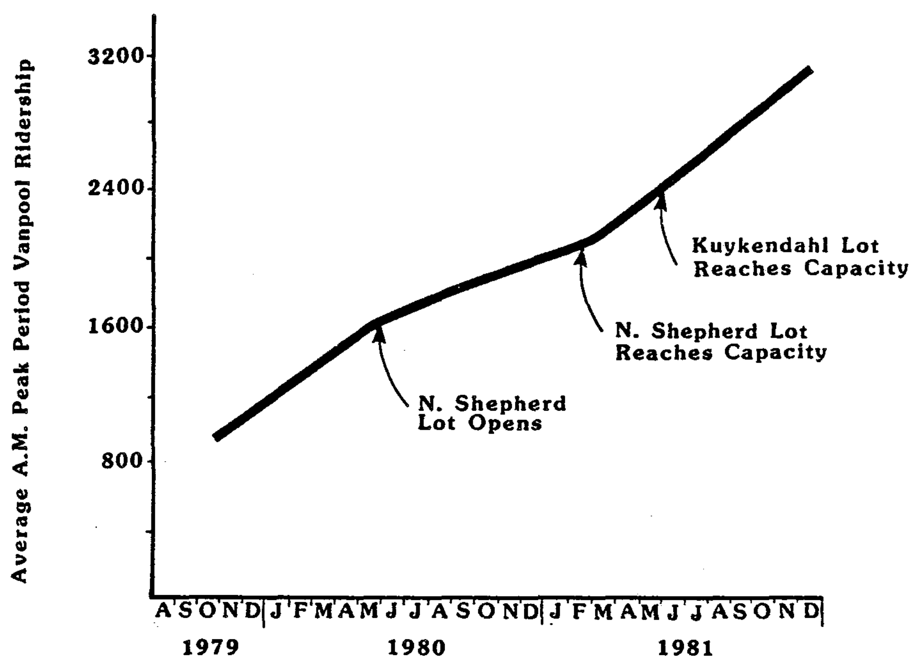
- Opening of the North Shepherd Park-and-Ride lot in April 1980, which increased the number of bus trips on the contraflow lane by about a third; and
- Utilization of the North Freeway corridor park-and-ride facilities at or above capacity, which began to occur in February 1981.



Source: Reference 37.

Figure 21: Cummulative Number of Vanpools

The general trend in a.m. peak period vanpool ridership in relationship to these two changes in bus supply characteristics is presented in Figure 22. As this shows, within one month of the beginning of North Shepherd Park-and-Ride service, the rate of increase in vanpool ridership decreased from an average of about 93 to 63 new vanpoolers per month. At about the same time that utilization of the North Shepherd Park-and-Ride lot began to reach capacity, the rate of increase in vanpool ridership increased from an average of 63 to about 102 new vanpoolers per month. While these results are by no means conclusive, they do tend to support the theory that park-and-ride and vanpooling are to a certain extent competing as alternatives to travel by auto in the North Freeway corridor (37).



Source: Reference 37.

Figure 22: Vanpool Ridership Relative to Bus Supply Characteristics

SURVEYS OF PARK-AND-RIDE USERS AND NONUSERS

Park-and-ride has proven to be a popular and effective means of aggregating transit demand from low-density residential development that characterizes cities in Texas. Park-and-ride service was initiated in the Houston metropolitan area in March 1977 with the opening of a lot in southwest Houston at a Sage Department Store. Interest in park-and-ride flourished during the years that followed and, today Houston has the most extensive park-and-ride program in the state. Fifteen different lots with more than 15,000 spaces are currently operated by METRO. Four of these lots, which have a combined capacity of more than 6,400 spaces, are located in the North Freeway corridor and utilize the contraflow lane during peak periods. On-board transit user surveys were conducted at these 4 lots in January 1984. In addition, on-board transit user surveys were also conducted at 4 park-and-ride lots which do not have any form of priority treatment available. In April 1984, telephone surveys of non park-and-ride users were also performed: one concentrated in the market area of the North Shepherd Park-and-Ride lot (which is served by the CFL) and the other focused on the market area of the Addicks Park-and-Ride lot (which does not have priority treatment available). The purpose of these surveys was to:

- Obtain information on their assessment of whether or not the CFL has been successful in achieving its goals of increasing transit ridership, reducing the demand for activity center parking, etc.;
- Identify both user and nonuser attitudes toward the provision of priority treatment for high occupancy vehicles; and
- Identify the effect of priority treatment on modal split.

In addition, those persons in the North Freeway corridor were questioned about their use of the priority bus service (park-and-ride). Finally, socioeconomic data for both the users and nonusers was also obtained.

Park-and-Ride User Survey

On-board surveys were conducted at a total of 4 park-and-ride lots along the North Freeway corridor, 3 lots along the Southwest Freeway corridor and 1 lot along the Katy Freeway corridor (Figure 23). Approximately 30% of the buses serving each of the lots was surveyed. For each bus surveyed, a 100% sample of riders was taken. Copies of the questionnaires and a description of the survey procedures are presented in Appendix B.

Characteristics of the Park-and-Ride Users

Personal Characteristics

To obtain a profile of park-and-ride patrons in each of the corridors surveyed, questions were asked concerning age, sex, education and occupation. The responses to these questions are summarized in Table 18.

Age Group. As indicated in Table 18, park-and-ride users are relatively young. In fact, 81% of the users surveyed in the North Freeway corridor and 82% of those surveyed in the other corridors are less than 42 years of age.

Sex. Park-and-ride patrons in all corridors surveyed were found to be predominantly female.

Education. Park-and-ride users are an educated group of persons. In fact, at least 79% of the patrons along the North Freeway have attended college and 69% of those are college graduates. More than 88% of the Katy and Southwest Freeway patrons have attended college and 66% of those graduated.

Occupation. Data showing the occupations of park-and-ride users are also presented in Table 18. Again, data for both the CFL lots and the non CFL lots show strong similarities; high percentages of professionals and clerical workers appear in both. Professional, managerial, and clerical occupations constitute approximately 93% of the total for both the CFL lots and the non CFL lots.

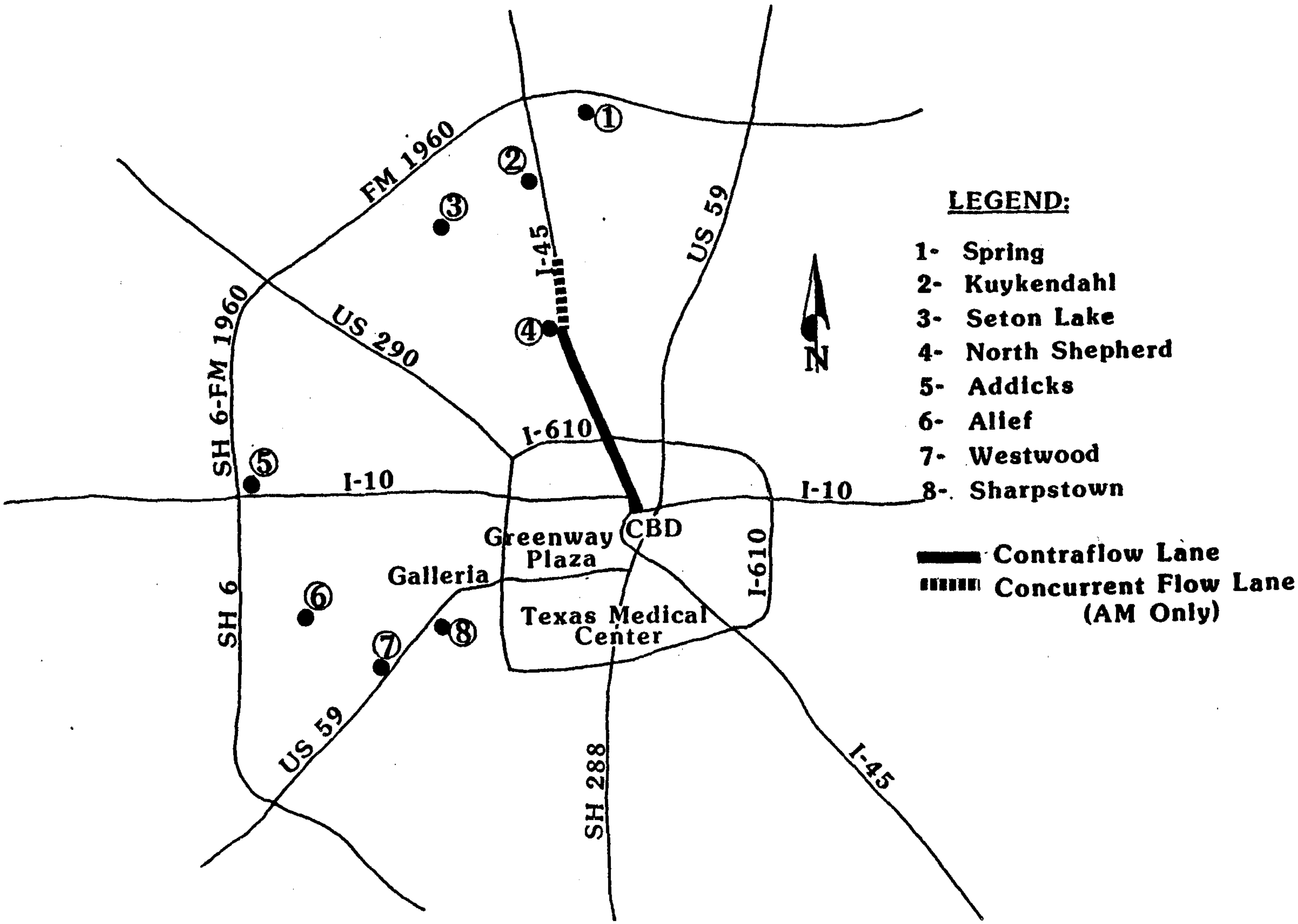


Figure 23: Location of the Park-and-Ride Lots Included in the On-Board Survey

Table 18: Summary of Personal Charateristics of Park-and-Ride Users

Characteristic	North Freeway CFL Lots	Katy & SW Freeway Non CFL Lots	Total Sample
Age Groups	(n = 1118)	(n = 573)	(n = 1691)
Less than 18	0%	0%	0%
18-21	4	2	3
22-31	43	53	46
32-41	34	27	32
42-51	13	10	12
52-61	6	7	6
62 and over	0	1	1
Sex	(n = 1106)	(n = 563)	(n = 1669)
Male	43%	44%	44%
Female	57	56	56
Highest Level of Education	(n = 1105)	(n = 566)	(n = 1671)
Less than high school	1%	0%	1%
High school graduate	20	12	18
Some college	24	30	26
College graduate	41	45	42
More than college	14	13	13
Occupation	(n = 1089)	(n = 561)	(n = 1650)
Unemployed	0.0%	0.2%	0.1%
Student	0.5	0.7	0.5
Laborer	0.1	1.3	0.5
Operative	0.6	0.5	0.6
Service Worker	0.2	1.3	0.5
Craftsman	1.2	0.7	1.0
Clerical	36.6	25.8	33.0
Sales	4.1	2.7	3.7
Managerial	15.7	12.8	14.7
Professional	41.0	54.0	45.4

Transportation Characteristics

In the on-board surveys, several questions were asked that relate to the travel patterns of park-and-ride users. These questions addressed items such as previous mode of travel, mode of arrival at the park-and-ride lot and how long park-and-ride has been used.

Mode of Arrival at Park-and-Ride Lot. From 82% to 87% of the park-and-ride users surveyed indicated that they drove themselves to the lot. An additional 12% to 15% stated that they had been driven to the lot by someone else. The remaining 1% to 3% had walked to the lot (Table 19). The average distance park-and-ride users drove to reach the lot ranged from 3.5 miles for the North Freeway users to 5.8 miles for Katy and Southwest Freeway users; average distances for users who were driven to the lot by someone else ranged from 4.9 miles for the North Freeway users to 5.8 miles for the Katy and Southwest Freeway users.

Table 19: Mode of Arrival at Park-and-Ride Lots

Mode and Distance	North Freeway CFL Lots (n = 1122)	Katy & SW Freeway Non CFL Lots (n = 570)	Total Sample (n = 1692)
Mode			
Drove	87%	82%	85%
Rode with someone else	12	15	14
Walked	1	3	1
Distance (average)			
Drove (miles)	3.5	5.8	5.1
Driven (miles)	4.9	5.8	5.2
Walked (blocks)	2.0	5.0	3.0

Length of Time Using Park-and-Ride Service. As illustrated in Figure 24, the length of time park-and-ride patrons have used the service shows strong similarities between both the CFL lots and the non CFL lots; the length of park-and-ride utlization averaged 21.5 months for the North Freeway CFL lots and 20.9 months for the Katy and Southwest Freeway non CFL lots.

Previous Mode of Travel. As expected, the highest percentage of park-and-ride users from both the CFL lots and the non CFL lots had driven alone to their destinations prior to using park-and-ride (Table 20).

Table 20: Previous Mode of Travel for Users of Park-and-Ride

Mode and Distance	North Freeway CFL Lots (n = 1131)	Katy & SW Freeway Non CFL Lots (n = 559)	Total Sample (n = 1690)
Drove Alone	45%	44%	45%
Carpool	14	9	12
Vanpool	8	7	8
Regular route bus	4	10	6
Didn't make trip	26	27	26
Other	3	3	3

Table 20 also shows that a high percentage of park-and-ride users from both groups of lots indicated that they did not previously make the trip. While a latent demand would be expected to exist, it does not appear that a 26-27% of the total park-and-ride trips would be represented by latent demand. Part of the reason for the high response to "did not make trip" lies in the answers to questions pertaining to whether or not the users had changed jobs or their place of residence since the park-and-ride service began. As shown in Table 21, sizable percentages of users have changed jobs and/or residential locations since park-and-ride service in their area began. Approximately 40% of the Katy and Southwest Freeway users who had changed job locations indicated that the availability of park-and-ride service was a factor

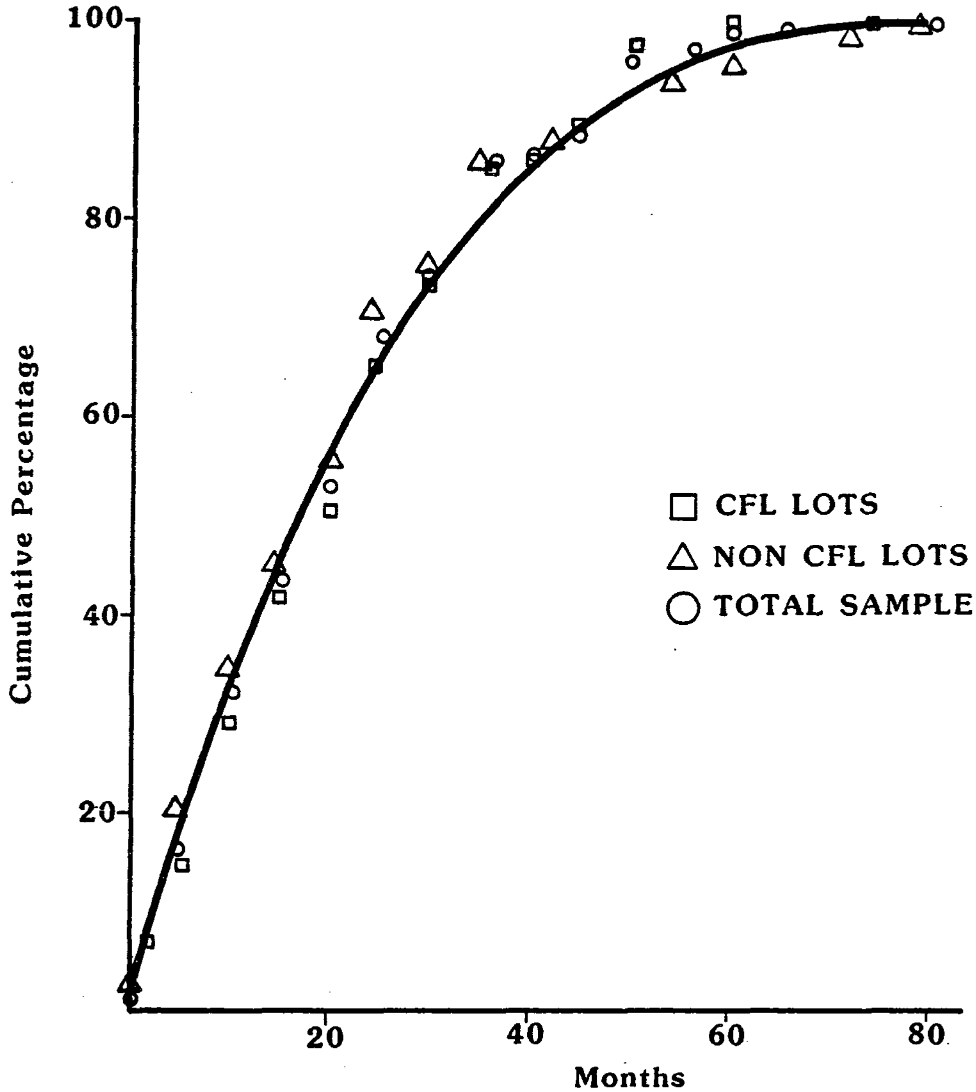


Figure 24: Length of Time Using Park-and-Ride

in their decisions to make the change(s). For the North Freeway users, however, about 51% of those who had changed job locations and 57% who had changed residential locations stated that the availability of park-and-ride service and the contraflow lane influenced their decisions. These higher percentages for the North Freeway users suggests that the availability of priority treatment made park-and-ride even more attractive.

Table 21: Changes in Job and Residential Locations Since Park-and-Ride Lot Opened

Question	North Freeway CFL Lots	Katy & SW Freeway Non CFL Lots	Total Sample
Have your changed job locations since Park-and-Ride (or P&R and CFL) opened?	(n = 1118)	(n = 558)	(n = 1676)
Yes	41%	27%	36%
No	59	73	64
If "yes", did the availability of Park-and-Ride (or P&R and CFL) influence decision?	(n = 445)	(n = 147)	(n = 592)
Yes	51%	40%	48%
No	49	60	52
Have you changed residential locations since Park-and-Ride (or P&R and CFL) opened?	(n = 1122)	(n = 563)	(n = 1685)
Yes	55%	54%	55%
No	45	46	45
If "yes", did the availability of Park-and-Ride (or P&R and CFL) influence decision?	(n = 603)	(n = 303)	(n = 906)
Yes	57%	50%	54%
No	43	50	46

Reasons for Using Park-and-Ride

Time/Money Savings

Patrons were asked whether they saved time and/or money by using the park-and-ride service. Follow-up questions asked the amount of time and/or money saved or lost.

Time Savings. As would be expected, the contraflow lane along the North Freeway allows a time savings not usually associated with lots not having priority treatment (Table 22). In fact, 87% of those surveyed from the North Freeway lots reported to save time using park-and-ride, while only 47% of those surveyed from the Katy and Southwest Freeway lots reported to save time. The extent of time savings (or losses) experienced by using park-and-ride are influenced by the availability of the CFL, bus headways, and the local routing of buses at the activity center (i.e., how close to the final destination does the bus stop in relation to where the employee would normally park his or her vehicle).

Table 22: Perceived Time Saved or Lost Using Park-and-Ride

Time Saved or Lost	North Freeway CFL Lots	Katy & SW Freeway Non CFL Lots	Total Sample
Save time using park-and-ride	(n = 1116)	(n = 532)	(n = 1648)
Yes	87%	47%	74%
No	9	44	20
Same	4	8	5
Not sure	-	1	1
Minutes saved using park-and-ride (per 1-way trip)	(n = 920)	(n = 225)	(n = 1145)
50th percentile	23	14	19
85th percentile	34	20	30
Minutes lost using park-and-ride (per 1-way trip)	(n = 88)	(n = 203)	(n = 291)
50th percentile	13	13	13
85th percentile	23	18	20

Money Savings. Responses to the question concerning possible money savings realized as a result of using park-and-ride and the perceived amount saved or lost are presented in Table 23. It appears that dollar savings are a major reason for using park-and-ride at all lots surveyed.

Table 23: Money Saved or Lost by Using Park-and-Ride

Money Saved or Lost	North Freeway CFL Lots	Katy & SW Freeway Non CFL Lots	Total Sample
Save money using park-and-ride	(n = 1090)	(n = 553)	(n = 1643)
Yes	88%	92%	90%
No	7	5	6
Same	4	2	3
Not sure	1	1	1
Dollars saved using park-and-ride (per month)	(n = 844)	(n = 434)	(n = 1278)
50th percentile	48	45	48
85th percentile	96	90	96
Dollars lost using park-and-ride (per month)	(n = 48)	(n = 16)	(n = 64)
50th percentile	17	9	18
85th percentile	30	20	27

Influence of the Contraflow Lane in Decision to Use Park-and-Ride. To determine the effect of the contraflow lane on park-and-ride utilization, users from the North Freeway lots were asked how important was the availability of the CFL in their decision to park-and-ride. A follow-up question asked if they would use park-and-ride if the CFL did not exist. Their responses to these questions are presented in Table 24.

Table 24: Importance of the Contraflow Lane to North Freeway Park-and-Ride Users

Question	North Freeway CFL Lots
In deciding to use park-and-ride, how important was the availability of the CFL?	(n = 1139)
Not important	1%
Not a factor	4
Very important	95
Would you use park-and-ride if the CFL did not exist?	(n = 1140)
Yes	24%
No	33
Not sure	43

As Table 24 indicates, the availability of priority treatment was very important to 95% of those surveyed. In fact, one-third of all the North Freeway park-and-ride users surveyed stated that they would not use the service if the CFL did not exist, and another 43% are not sure if they would use park-and-ride if it were not for the availability of the CFL.

Primary Reason for Using Park-and-Ride. When questioned about their primary reason for using park-and-ride, from 23% to 25% of the users indicated that "convenience" was the main reason they chose to use the service (Table 25). Reasons such as "don't like to drive," "traffic" and "less stress," (which are all interrelated) accounted for an additional 31% from both groups of users. It is interesting to note that only 3% of the North Freeway users specifically listed the contraflow lane as the primary reason for using the service. However, an additional 18% of the North Freeway users indicated that their primary reason for using park-and-ride was that it saves time over driving or riding a regular bus route and most of this time savings can probably be attributed to the CFL.

Table 25: Primary Reason for Using Park-and-Ride

Primary Reason	North Freeway CFL Lots (n = 1080)	Katy and SW Freeway Non CFL Lots (n = 554)	Total Sample (n = 1634)
Convenience	23%	25%	24%
Don't like to drive	14	16	14
Economical	10	18	13
Traffic	14	12	13
Faster than driving	12	2	9
Conserves natural resources	1	-	-
Contraflow lane	3	-	2
Parking rates are high	1	2	2
Saves wear and tear on car	2	3	2
Flexibility provided by schedules	2	2	2
Faster than regular route bus	6	-	4
Less stress	3	3	3
Employer pays for park-and-ride	1	2	1
Comfort	-	2	1
Opportunity to read, relax, sleep	1	3	2
Do not own a car	1	-	1
Availability	1	2	1
Others	5	8	6

Attitudes Toward the Contraflow Lane

A final set of questions asked of park-and-ride users related to their opinion of whether or not the contraflow lane has been successful in achieving the goals of increasing transit ridership, reducing travel time for users, reducing traffic congestion along the North Freeway and reducing auto parking requirements downtown. Their responses to these questions are summarized in Table 26. Generally speaking, a large majority of the North Freeway park-and-ride users agreed that the contraflow had been successful in achieving each of the goals listed above. Smaller majorities of the Katy and Southwest

Freeway park-and-ride patrons also felt that the CFL had been effective in increasing transit ridership, reducing travel time for users and reducing parking demand and 47% felt the CFL had helped to reduce traffic congestion. As would be expected, a rather significant proportion of the Katy and Southwest Freeway park-and-ride users were unsure of the effects of the contraflow lane. However, when asked if they were in favor of a reserved lane (or transitway) for use by buses and vanpools along the Southwest (or Katy) freeway, 93% responded "yes" which suggests that they do indeed approve of giving priority treatment to high occupancy vehicles.

Table 26: Park-and-Ride User Attitudes Toward the Effectiveness of the Contraflow Lane

Has the CFL been successful in achieving the goals of:	North Freeway CFL Lots	Katy and SW Freeway Non CFL Lots	Total Sample
Increasing transit ridership?	(n = 1106)	(n = 530)	(n = 1636)
Yes	88%	66%	81%
No	1	1	1
Not sure	11	33	18
Reducing travel times for users?	(n = 1109)	(n = 532)	(n = 1641)
Yes	92%	86%	90%
No	2	1	1
Not sure	6	13	9
Reducing congestion on I-45N?	(n = 1104)	(n = 527)	(n = 1631)
Yes	67%	47%	60%
No	12	13	13
Not sure	21	40	27
Reducing demand for parking?	(n = 1101)	(n = 529)	(n = 1630)
Yes	80%	62%	74%
No	2	5	3
Not sure	18	33	23

Non Park-and-Ride User Survey

For the survey of non park-and-ride users, the market areas associated with the North Shepherd lot on the North Freeway and the Addicks lot on the Katy Freeway were identified. Next, a telephone listing was obtained for each area and a random sample of telephone numbers was selected. The desired sample of approximately 600 completed interviews per market area was obtained. Copies of the questionnaires and a description of the survey procedures are presented in Appendix B.

In general, participants in the telephone surveys performed were defined as nonusers of park-and-ride if they: 1) reside in the area served by a park-and-ride lot; 2) work in an activity center (downtown) served by the park-and-ride service; and 3) were not current park-and-ride users. By this definition, approximately 9% of the North Shepherd market area participants and 14% of the Addicks market area participants were considered nonusers. Their responses to the survey questions are presented in the following pages.

Characteristics of the Non Park-and-Ride Users

Personal Characteristics

To obtain a profile of the nonusers of park-and-ride, questions concerning age, sex, education and occupation were posed during the telephone interview. The responses to these questions are summarized in Table 27.

Age Group. As indicated in Table 27, the majority of nonusers in both market areas are less than 42 years old. It is also interesting to note that 56% of the Addicks lot market area participants fall into the 32-41 age category.

Sex. Data on the sex of the nonusers, also presented in Table 27, show that about 56% of the nonuser participants from both market areas are male.

Table 27: Summary of Personal Characteristics of Non Park-and-Ride Users

Characteristic	North Shepherd CFL Lot Market Area	Addicks Non CFL Lot Market Area	Total Sample
Age Groups	(n = 52)	(n = 81)	(n = 133)
Under 18	-	1%	1%
18-21	4%	1	2
22-31	33	22	26
32-41	25	56	44
42-51	15	10	12
52-61	19	10	14
62 and over	4	-	1
Sex	(n = 52)	(n = 81)	(n = 132)
Male	56%	56%	56%
Female	44	44	44
Highest Level of Education	(n = 52)	(n = 80)	(n = 132)
Less than high school	10%	1%	5%
High school graduate	36	7	19
Some college	44	23	31
College graduate	8	40	27
More than college	2	29	18
Occupation	(n = 51)	(n = 80)	(n = 131)
Student	2.0%	1.2%	1.5%
Operative	5.9	0.0	2.3
Service Worker	7.8	3.7	5.4
Craftsman	17.7	2.5	8.4
Clerical	39.2	11.3	22.1
Sales	0.0	13.7	8.4
Managerial	9.8	28.8	21.4
Professional	17.6	38.8	30.5

Education. Approximately 92% of the Addicks market area respondents have at least some college education, while only 54% of the North Shepherd market area participants have attended college.

Occupation. Occupation data summarized in Table 27 show that approximately 81% of the Addicks area nonusers, compared to 27% of the North Shepherd area nonusers, have occupations classified as professional, managerial or sales. These findings are consistent with the educational data.

Transportation Characteristics

In addition to questions pertaining to the personal characteristics of nonusers, a series of questions was also included in the telephone survey to identify past and present travel patterns of the nonusers. These questions addressed mode of travel to work (or school), use of local bus service, use and knowledge of park-and-ride service and perceived need for an automobile during the day. The responses received from the telephone interviews pertaining to travel characteristics are highlighted in the following paragraphs.

Mode of Travel. When asked how they normally travel to work or school, the majority of respondents in both study areas reported that they drive alone, although a sizable percentage of the nonusers from the North Shepherd area carpool and about 6% use regular route transit (Table 28).

Table 28: Mode of Travel to Work or School For Nonusers of Park-and-Ride

Mode	North Shepherd CFL Lot Market Area (n = 52)	Addicks Non CFL Lot Market Area (n = 81)	Total Sample (n = 133)
Drive alone	58%	83%	73%
Carpool	27	10	17
Vanpool	9	6	7
Regular route bus	6	1	3

Use of Local Bus Service. Participants in the telephone survey were also asked how frequently they used the METRO regular route service. The responses to this question, as summarized in Table 29, show that very few use local bus service on a regular basis. In fact, at least 92% of those surveyed in each study area reported that they seldom, if ever, ride a METRO bus.

Table 29: Use of Local Bus Service by Nonusers of Park-and-Ride

Frequency of Use	North Shepherd CFL Lot Market Area (n = 52)	Addicks Non CFL Lot Market Area (n = 82)	Total Sample (n = 134)
Every day	6%	4%	4%
About once a week	2	1	2
Seldom	11	13	13
Never	81	82	81

Use and Knowledge of Park-and-Ride Service. In addition to being asked about their use of local bus service, the telephone survey participants were also asked several questions concerning their use and knowledge of the park-and-ride service in their area. From their responses, as summarized in Table 30, it appears that while more than 80% from each study area have never tried the service, from 79% to 90% at least know the location of the nearest lot and 37% or more have sufficient knowlege of the service to confidently begin using it.

Perceived Need for an Auto. An additional question in the telephone survey asked if the participant's job required him or her to have an automobile available during the day. Generally, those who have jobs which require

Table 30: Nonusers Use and Knowledge of Park-and-Ride

Question	North Shepherd CFL Lot Market Area	Addicks Non CFL Lot Market Area	Total Sample
Have you ever used park-and-ride?	(n = 52)	(n = 82)	(n = 134)
Yes*	19%	17%	18%
No	81	83	82
Do you know the location of the park-and-ride lot nearest your home?	(n = 43)	(n = 68)	(n = 111)
Yes	79%	90%	86%
No	12	9	10
Not sure	9	1	4
Do you know enough about the park-and-rdie service to confidently begin using it?	(n = 42)	(n = 68)	(n = 110)
Yes	38%	37%	37%
No	52	54	53
Not sure	10	9	10

*Respondents who answered "yes" to this question were not asked the following 2 questions.

them to have a vehicle available during the day are not potential park-and-ride patrons. Responses to the question are presented in Table 31.

Table 31: Need for an Automobile Available During the Day for Work Purposes

Job Requires Auto Available During Workday	North Shepherd CFL Lot Market Area (n = 52)	Addicks Non CFL Lot Market Area (n = 81)	Total Sample (n = 133)
Yes	36%	56%	48%
No	62	43	50
Occassionally	2	1	2

Parking/Bus Pass Expense. Nonusers of park-and-ride were also asked if their employer paid all, part or none of their parking cost at the work location. A follow-up question asked if their employer paid all, part or none of their bus pass expense if they chose to ride a bus rather than drive. Approximately 57% of those in the Addicks study area and 47% of those in the North Shepherd study area indicated that their employer paid at least part of the cost of parking (Table 32). This group of nonusers would not realize as great a savings as those who do not have any of their parking costs subsidized. In fact, 65% of those in the Addicks study area and 25% of those in the North Shepherd study area who stated that their employer paid at least part of their parking cost also stated that their employer paid none of the expense for a bus pass.

Table 32: Employer's Subsidization of Nonusers Parking and Bus Pass Costs

Question	North Shepherd CFL Lot Market Area	Addicks Non CFL Lot Market Area	Total Sample
Employer pay for parking cost	(n = 52)	(n = 81)	(n = 133)
Yes (all)	35%	48%	43%
Yes (part)	11	9	10
No	54	43	47
Employer pay for bus pass	(n = 52)	(n = 81)	(n = 133)
Yes (all)	25%	11%	17%
Yes (part)	13	9	10
No	50	71	63
Don't know	12	9	10

Reason for Not Using Park-and-Ride

As expected, when asked to give their primary reason for not using park-and-ride to travel to and from work, significant percentages from both study areas indicated that they needed an auto available during the day (Table 33). Other popular responses included the following: works odd or irregular hours, park-and-ride is inconvenient, I would rather drive (carpool or vanpool), and I have a company vehicle.

Table 33: Primary Reason Nonusers Do Not Regularly Use Park-and-Ride

Primary Reason	North Shepherd CFL Lot Market Area (n = 52)	Addicks Non CFL Lot Market Area (n = 80)	Total Sample (n = 132)
Needs auto during the day	23%	34%	30%
Works odd or irregular hours	12	10	11
Inconvenient	2	13	8
Enjoy carpooling or vanpooling	12	6	8
Have a company vehicle	10	4	6
Rather drive	8	5	6
Park-and-ride not compatable with work hours	4	6	5
Driving is faster than park-and-ride	-	4	2
Too far to lot	6	-	2
Need more information on service	2	3	2
No midday service	2	1	2
Don't like riding buses	-	3	2
Route too far from office	-	3	2
No reason to use it	2	1	2
Work in different areas of city at times	2	1	2
Bus doesn't leave early enough	4	-	2
Regular bus stop closer than park-and-ride lot	4	-	2
Other reasons	7	6	6

Factors That Would Encourage Switch to Park-and-Ride

As a follow-up to the question concerning why they do not use park-and-ride, nonusers were asked what, if anything, would encourage them to begin using the service. Approximately one-third of the nonusers from both study areas indicated that nothing would encourage them to switch (Table 34). Furthermore, many of the other items listed as reasons for not using the service are factors over which METRO has no control.

Table 34: Factors that Would Encourage Nonusers to Switch to Park-and-Ride

Factor	North Shepherd CFL Lot Market Area (n = 52)	Addicks Non CFL Lot Market Area (n = 81)	Total Sample (n = 133)
Nothing	33%	36%	35%
Different job; different work hours	6	7	7
If I could no longer carpool/ vanpool	8	4	6
Better scheduling	6	5	5
If I didn't need car for work or errands	4	5	5
Lower fares	8	3	5
Don't know	4	4	4
If lot was closer to my house	10	-	4
If I lost use of company car	6	3	4
Need more information on service	2	5	4
More frequent service	2	3	3
Midday service	2	1	2
When transitway is completed	-	3	2
Lower fares & faster service			
If I couldn't afford to drive	2	3	2
If Park-and-ride was faster than driving	-	1	2
If buses left lot earlier	4	-	2
Other reasons	3	17	8

Attitudes Toward the Contraflow Lane

Nonusers of park-and-ride were also asked a series of questions which related to their opinion of whether or not the contraflow lane has been successful in achieving various goals. Their responses to these questions are summarized in Table 35. In general, a large majority of the nonusers from both study areas thought that the CFL has been successful in reducing travel times for users. Smaller majorities from both study areas also felt the CFL had helped to reduce the auto parking requirements downtown. In addition, 62% of the North Shepherd market area nonusers (as compared to only 40% of the Addicks market area nonusers) thought that the CFL had been effective in increasing transit ridership. Between 45% and 49% of the nonusers felt the CFL had not reduced traffic congestion along the North Freeway. As was expected, a rather sizable percentage of the Addicks lot market area nonusers were unsure of the effects of the CFL. Nevertheless, 81% of the Addicks area nonusers reported that they were in favor of the Katy Freeway transitway currently under construction and 40% indicated that they would be able to use the transitway when completed.

Comparison of User and Nonuser Characteristics

Characteristics of both users and nonusers of park-and-ride have been presented previously. Table 36 summarizes selected characteristics of these 2 groups. As this table indicates, nonusers of park-and-ride tend to be slightly older than the users. Also, the majority of nonusers employed in the major activity centers served by park-and-ride are male, whereas the majority of park-and-ride users are female. Both users and nonusers are highly educated; professional occupations are more prevalent among the user groups. Finally, although a larger percentage of nonusers typically drive alone to work or

Table 35: Non Park-and-Ride User Attitudes Toward the Effectiveness of the Contraflow Lane

Has the CFL been successful in achieving the goals of:	North Shepherd CFL Lot Market Area	Addicks Non CFL Lot Market Area	Total Sample
Increasing transit ridership?	(n = 52)	(n = 82)	(n = 134)
Yes	62%	40%	49%
No	19	25	22
Not sure	19	35	29
Reducing travel time for users?	(n = 52)	(n = 81)	(n = 133)
Yes	86%	80%	83%
No	4	3	3
Not sure	10	17	14
Reducing congestion on I-45N?	(n = 51)	(n = 81)	(n = 132)
Yes	43%	28%	34%
No	49	45	46
Not sure	8	27	20
Reducing demand for parking?	(n = 51)	(n = 82)	(n = 133)
Yes	63%	51%	56%
No	23	20	21
Not sure	14	29	23

school (compared to the percentage of users who used to drive along prior to utilizing park-and-ride), this difference is likely due to the significant percentage of users who reported that they did not make the trip at all prior to using park-and-ride.

Comparison of Users and Nonusers Attitudes Toward the Contraflow Lane

Generally speaking, larger percentages of users feel that the contraflow lane has been successful in increasing transit ridership, reducing travel

Table 36: Overview of Selected Characteristic of Users and Nonusers of Park-and-Ride

Characteristic	CFL Lots		Non CFL Lots		Total Sample	
	Users	Nonusers	Users	Nonusers	Users	Nonusers
Age Group						
Under 18	0%	0%	0%	1%	0%	1%
18-21	4	4	2	1	3	2
22-31	43	33	53	22	46	26
32-41	34	25	27	56	32	44
42-51	13	15	10	10	12	12
52-61	6	19	7	10	6	14
62 and over	0	4	1	0	1	1
Sex						
Male	43%	56%	44%	56%	44%	56%
Female	57	44	56	44	56	44
Highest Level of Education						
Less than high school	1%	10%	0%	1%	1%	5%
High school graduate	20	36	12	7	18	19
Some college	24	44	30	23	26	31
College graduate	41	8	45	40	42	27
More than college	14	2	13	29	13	18
Occupation						
Clerical	36.6%	39.2%	25.8%	11.3%	33.0%	22.1%
Sales	4.1	0.0	2.7	13.7	3.7	8.4
Managerial	15.7	9.8	12.8	28.8	14.7	21.4
Professional	41.0	17.6	54.0	38.8	45.4	30.5
All others	2.6	33.4	4.7	7.4	3.2	17.6
Mode of travel to work*						
Drive alone	45%	58%	44%	83%	45%	73%
Carpool	14	27	9	10	12	17
Vanpool	8	9	7	6	8	7
Regular route bus	4	6	10	1	6	3
Didn't make trip	26	-	27	-	26	-
Other	3	-	3	-	3	-

*This is the previous mode of travel for park-and-ride users and the current mode of travel for nonusers.

times for CFL users, reducing traffic congestion along the North Freeway and reducing the demand for activity center parking (Table 37).

Table 37: Overview of User and Nonuser Attitude Toward the Contraflow Lane

Has the CFL been successful in achieving the goals of:	CFL Lots		Non CFL Lots		Total Sample	
	Users	Nonusers	Users	Nonusers	Users	Nonusers
Increasing transit ridership?						
Yes	88%	62%	66%	40%	81%	49%
No	1	19	1	25	1	22
Not sure	11	19	33	35	18	29
Reducing travel time for users?						
Yes	92%	86%	86%	80%	90%	83%
No	2	4	1	3	1	3
Not sure	6	10	13	17	9	14
Reducing congestion on I-45N?						
Yes	67%	43%	47%	28%	60%	34%
No	12	49	13	45	13	46
Not sure	21	8	40	27	27	20
Reducing demand for parking?						
Yes	80%	63%	62%	51%	74%	56%
No	2	23	5	20	3	21
Not sure	18	14	33	29	23	23

EFFECT OF THE CONTRAFLOW LANE ON MODAL SPLIT

The telephone surveys described in the previous section also provided an indication of modal split data for the park-and-ride service. Modal splits, as identified through the home telephone interviews, are presented in Table 38.

Table 38: Modal Split* Data for the North Shepherd and Addicks Park-and-Ride Facilities, Travel to Activity Center from Lot Market Areas

Market Area	Percent of Travel by Park-and-Ride
North Shepherd (n = 77)	33
Addicks (n = 97)	15

*Modal split is defined as the percent of the market area population working in the activity center served by park-and-ride that uses the park-and-ride service.

As Table 38 indicates, the modal split value for the North Shepherd market area is impressive. Approximately one-third of those trips originating in the North Shepherd market area and terminating downtown are being served by park-and-ride, whereas, only 15% of those trips from the Addicks market area to downtown are being served by park-and-ride. While these figures suggest that the contraflow lane lot is serving a greater modal share than the non contraflow lane lot, this could be true because relatively more parking spaces are provided at the 1,605-space North Shepherd facility than at the 1,119-space Addicks lot. However, an examination of lot utilization rates reveals that the North Shepherd and the Addicks lots are currently operating at 50% and 30% capacity, respectively. Because the demand for spaces does not exceed the supply at either location, the provision of fewer spaces at the Addicks lot is not the reason for that park-and-ride lot's lower modal share. What is more likely the case is that the provision of priority treatment for buses along the contraflow lane has increased the modal split by 120%.

In the survey of non park-and-ride users, 19 (25%) of the 77 from the North Shepherd area and 46 (47%) of the 97 from the Addicks market area reported that their work required them to have an automobile available during the day. Since park-and-ride cannot effectively serve those individuals, they would not be considered potential users. Therefore, it can be said that based on the results of the telephone survey, park-and-ride may be serving approximately 43% of the eligible market in the North Shepherd lot area and about 29% of the eligible market area in the Addicks lot area. Again, it appears that the higher market share for the North Shepherd lot may be attributed to the CFL.

EFFECTS OF THE CONTRAFLOW LANE ON FUEL CONSUMPTION AND AIR POLLUTANTS

A detailed evaluation of the effects of the contraflow lane on fuel consumption and air pollutants was performed after the first year of CFL operation. The findings of this evaluation, which are documented in TTI Research Report 205-9 (39), are highlighted in this section.

Fuel Consumption

The implementation of the contraflow lane has affected energy consumption in several ways. The most direct and measurable effects are vehicle miles of travel and vehicle operation characteristics. Other indirect effects could be the reduction in automobile parking facilities and additional transportation facilities. However, for this analysis, only the direct effects were considered.

Vehicle Miles of Travel

At the end of its first year of operation, the CFL was carrying 8,724 persons over a distance of 9.6 miles in 537 buses and vans each day. Assuming that without the CFL, all persons would ride in passenger cars with an average vehicle occupancy ratio of 1.4 persons per vehicle, the savings in vehicle miles which resulted from the CFL would be:

$$\frac{8{,}724 \text{ persons}}{1.4 \text{ persons/vehicle}} - 537 \text{ vehicles} \quad \times \quad 9.6 \text{ miles} = 54{,}667 \text{ vehicle miles/day}$$

A conservative estimate of fuel consumption for vehicle operation on a freeway at 30 mph at Level-of-Service F is 17 mpg. Assuming the same rate of consumption for travel in the CFL, the fuel savings would be 3,216 gallons of gasoline per day or 803,919 gallons per year.

However, realistically speaking, not all of the persons now using the CFL traveled in passenger cars prior to CFL operation. For example, the persons traveling in HOVs at the beginning of the CFL operation and in the 12 bus trips serving the Houston Intercontinental Airport did not make a mode choice because of the CFL. In addition, a certain number of vanpools formed since the implementation of CFL would have done so regardless of the CFL; but, for this analysis, the benefits of fuel conservation for new vanpools were assigned to the CFL.

The growth in transit ridership in the North Freeway corridor is a direct result of the availability of the CFL and the park-and-ride support facilities. Fuel consumption cannot be attributed to one or the other of these corridor improvements, but should be credited to the total program. Table 39 presents the fuel savings that are achieved by the reduction in vehicle miles of travel as a result of the CFL and other corridor improvements.

Vehicle Operational Characteristics

Fuel consumption rates vary with average speed and level-of-service (LOS). The average fuel rate of 12 mpg for the CFL is used because the lower rates for buses offset the higher rates for vans traveling at 50 mpg.

The CFL has not changed the operating characteristics of the peak direction of travel and thus has not affected the fuel consumption.

In the off-peak direction, however, average speeds and conditions have been reduced from 55 mph and free-flow. During the a.m. period, speeds in the 4.4-mile section from I-610 to North Shepherd Drive have been lowered to 45 mph and 40 mph with Levels-of-Service D and E. In the afternoon, speeds were lowered to 40 mph and 35 mph at Levels-of-Service D and E. For an average volume of 1,600 HOV per lane, the changes in fuel consumption are shown in Table 40.

Table 39: Fuel Consumption Reduction Due to Modal Shift

Bus Passengers	Bus Trips
5,140 at 52nd week	125
-800 at 1st week	-29
-180 from bus shuttle	-12
4,160 persons	84 trips

$$\left(\frac{4{,}160 \text{ persons}}{1.4 \text{ persons/vehicle}} - 84 \text{ vehicles}\right) \text{X } 9.6 \text{ miles} = \frac{27{,}719 \text{ veh. miles}}{\text{day}}$$

$$\frac{27{,}719 \text{ veh. miles/day}}{17 \text{ mpg}} = \frac{1{,}631 \text{ gallons of fuel}}{\text{day}}$$

Vanpool Passengers	Vanpool Trips
3,584 at 52nd week	412
-1,539 at 1st week	-164
2,045 persons	248 trips

$$\left(\frac{2{,}045 \text{ persons}}{1.4 \text{ persons/vehicle}} - 220 \text{ vehicles}\right) \text{X } 9.6 \text{ miles} = \frac{11{,}911 \text{ veh. miles}}{\text{day}}$$

$$\frac{11{,}911 \text{ veh. miles/day}}{17 \text{ mpg}} = \frac{701 \text{ gallons of fuel}}{\text{day}}$$

Total Fuel Savings = 2,332 Gallons of Fuel/Day

2,332 Gallons X 250 days = 583,000 Gallons of Fuel/Year

Source: Reference 39.

Some traffic was diverted from the freeway in this section. For each peak period, it was estimated that 1,000 vehicles now use the frontage road or similar type arterial street during the time the CFL is in operation. The average running speed on the alternate routes is 35 mph. There is an average delay of 3 minutes at traffic signals, and 6 stops per trip. The change in fuel consumption for the diverted traffic was calculated as shown in Table 41.

Table 40: Changes in Off-Peak Fuel Consumption
Due to Speed and LOS Changes

Operating Period	Volume (vph)	Time (hours)	Distance (miles)	Speed (mph)	LOS	Fuel Consumption Rate* (gal./veh. mi.)	Fuel Consumed (gallons)
Morning							
Before CFL	3,200	2.5	4.4	55	C	0.0613	2,158
After CFL	3,200	1.5	4.4	45	D	0.0538	1,136
After CFL	3,200	1.0	4.4	40	E	0.0531	748
						Fuel Saved Per Day	274
Afternoon							
Before CFL	3,200	2.5	4.4	55	C	0.0613	2,158
After CFL	3,200	1.5	4.4	40	E	0.0531	1,121
After CFL	3,200	1.0	4.4	35	F	0.0516	727
						Fuel Saved Per Day	310

Total Fuel Saved = 584 Gallons/Day or 146,000 Gallons/Year

*Type 1 vehicle

Source: Reference 39.

Table 41: Changes in Fuel Consumption for Diverted Traffic
for Morning and Afternoon Peak Periods

Before/After CFL	Daily Volume (vehicles)	Distance or Change	Speed (mph)	Fuel Consumption Rate* (gallons per unit)	Fuel Consumed (gallons)
Before CFL	2,000	4.4 miles	55	0.0613/veh. mi.	539
After CFL	2,000	4.4 miles	35	0.0434/veh. mi.	382 } 537
After CFL	2,000	6 changes	35-0	0.00980/change	118 } 537
After CFL	2,000	3 min/veh idling time		0.370/hour	37 } 537

Total Fuel Saved to Diverted Traffic = 2 Gallons/Hour or 500 Gallons/Year

*Type 1 vehicle

Source: Reference 39.

The buses and vanpools have a decrease in fuel consumption as a result of the smoother flow at LOS B in the contraflow lane (Table 42).

Table 42: Changes in Fuel Consumption for Contraflow Lane Users - Morning and Afternoon Periods

Before/After CFL	Daily Volume (vehicles)	Distance or Changes	Speed (mph)	LOS	Fuel Consumption Rate (gallons per unit)	Fuel Consumed (gallons)	
Before CFL	125 buses	9.6 miles	30	F	0.1577	189	416
	412 vanpools	9.6 miles	30	F	0.0574	227	
Before CFL	125 buses	10 changes	35-20	-	0.1170	14	36
	412 vanpools	10 changes	35-20	-	0.00524	22	
After CFL	125 buses	9.6 miles	55	B	0.1687	202	433
	412 vanpools	9.6 miles	55	B	0.0585	231	

Total Change in Fuel Consumption = -19 Gallons/Day or -4,750 Gallons/Year

Source: Reference 39.

In summary, the reduction in speed on the main lanes of the freeway and the alternate routes as a result of the reduction in capacity in the off-peak direction produces a positive benefit in fuel conservation.

One factor that was not included in this analysis was the impact that incidents have on the speeds and level-of-service in the reduced section. For example, if an incident occurs such that half of the traffic experiences delay, the freeway fuel consumption as calculated in Table 40 for the After Period would change the following way:

Volume	Time	Distance	Speed	LOS	Fuel Cons. Rate	Fuel Consumed
3,200 vph	1.25 hrs.	4.4 miles	40 mph	E	0.0531	935 gal.
3,200 vph	1.25 hrs.	4.4 miles	20 mph	F	0.0772	1,359 gal.
						2,294 gal.

This would be an additional 428 gallons consumed per incident day. If we assumed an incident of this magnitude occurred 20 percent of the time, the annual fuel consumption would increase by 42,800 gallons.

Similar events could occur on the frontage road or alternate streets, but their impact would be considerably less than the freeway incidents.

Fuel Consumed to Operate the Contraflow Lane

The operations field crew requires 1 wrecker, 2 trucks, 1 pickup truck, 2 police vehicles, and 1 supervisor vehicle. During one day of operation each of these vehicles will travel the length of the CFL several times. Estimates of the gallons of fuel these vehicles consume on a normal day of operation is presented in Table 43.

Table 43: Fuel Consumption for Contraflow Lane Operators

Types of Vehicles	Miles of Travel (veh. mi.)		Fuel Consumption Rate (gallons per veh. mi.)	Fuel Consumed (gallons)	
Operations Crew					
METRO vehicles	380	540	0.2249	85	111
Houston police	160		0.1649	26	

Annual Fuel Consumed = 27,750 Gallons

Source: Reference 39.

A summary of all the events that effect fuel consumption indicates that the CFL might have generated a saving of 663,700 gallons of fuel per year (Table 44).

Air Pollution

The environmental impacts of the CFL were estimated in a similar manner as fuel consumption. Changes in air pollutants due to modal shifts were determined for the 27,686 vehicle miles of passenger vehicle travel transferred to buses and the 11,914 vehicle miles of passenger vehicle travel transferred

Table 44: Summary of Change in Annual Fuel Consumption as a Result of the Contraflow Lane

Event	Gallons
Modal Shift	-583,000
Peak Direction	No Change
Off-Peak Direction	-146,000
Alternate Route	- 500
CFL Vehicles	- 4,750
Incidents	+ 42,800
CFL Operating Crew	+ 27,750
Total	+663,700

Source: Reference 39.

to vans (Table 39). If not for the CFL, these vehicles would have operated in the peak direction of flow under condition of 30 mph and LOS F (Table 45).

Table 45: Changes in Air Pollution Due to Modal Shift

Mode	Daily Vehicle-Miles of Travel	Pollutants at 30 mph		
		CO (kgms)	HC (kgms)	NO (kgms)
Passenger Vehicles	-39,600	-1,202	-127	-168
Buses	806	110	11	9
Vanpools	2,381	72	8	10
Total	-36,413	-1,020	-108	-149

Source: Reference 39.

The provision of the CFL for all buses and vanpools results in a further change in air pollutants because the CFL vehicles will be operating at an average speed of 55 mph (Table 46).

For off-peak travel, the changes in travel conditions and the resultant changes in air pollutants are shown in Table 47. For diverted traffic, the

Table 46: Changes in Air Pollution Due to Users of the CFL

Before/After CFL	Daily Volume (vehicles)	Distance (miles)	Speed (mph)	Pollutants at Specified Speeds CO (kgms)	HC (kgms)	NO (kgms)
Before CFL	125 buses	9.6	30	164 } 286	17 } 30	14 } 31
	419 vanpools	9.6	30	122	13	17
After CFL	125 buses	9.6	55	135 } 212	12 } 22	16 } 35
	419 vanpools	9.6	55	77	10	19
Change in Pollutants				-74	-8	+4

Source: Reference 39.

changes in air pollutants at a freeway speed of 55 mph to the alternate route speed of 35 mph is calculated in Table 48.

Table 47: Changes in Air Pollutants Due to Speed and LOS Changes in the Off-Peak Direction

Operating Period	Volume (vph)	Time (hours)	Distance (miles)	Speed (mph)	Pollutants at Specified Speeds CO (kgms)	HC (kgms)	NO (kgms)
Morning							
Before CFL	3,200	2.5	4.4	55	648	85	177
After CFL	3,200	1.5	4.4	45	432	52	100
After CFL	3,200	1.0	4.4	40	318	37	64
Change in Pollutants for Morning Operation					102	4	-13
Afternoon							
Before CFL	3,200	2.5	4.4	55	648	85	177
After CFL	3,200	1.5	4.4	40	478	56	97
After CFL	3,200	1.0	4.4	35	363	40	62
Change in Pollutants for Afternoon Operation					193	11	-18
Total Change					295	15	-31

Source: Reference 39.

Table 48: Changes in Air Pollutants for Diverted Traffic

Before/After CFL	Volume (vehicles)	Distance or Vehicle Idle Time	Speed (mph)	Pollutants at Specified Speeds		
				CO (kgms)	HC (kgms)	NO (kgms)
Before CFL	2,000	4.4 miles	55	162	21	44
After CFL	2,000	4.4 miles	35	227	25	39
After CFL	2,000	3 min./veh.		88	5	1
Change in Pollutants				153	9	-4

Source: Reference 39.

Based on actual fuel consumption records, the average speeds for vehicles used in the operation of the CFL were 15 mph for METRO vehicles and 10 mph for police vehicles. The air pollution, added to the freeway corridor as a result of the operators, is calculated in Table 49.

Table 49: Changes in Air Pollutants Due to Operators of Contraflow Lane for Morning and Afternoon Periods

Type of Vehicles	Distance Traveled (veh. mi.)	Speed (mph)	Pollutants at Specified Speeds		
			CO (kgms)	HC (kgms)	NO (kgms)
Operations Crew					
METRO vehicles	380	15	90	9	4
Houston Police	160	10	15	1	1
Total	540		105	10	5

Source: Reference 39.

The potential for incidents is increased with the CFL operation. It was estimated that 42,800 gallons of fuel would be burned due to the additional delay caused by these incidents. If we assume an average speed of 20 mph during this period, the air pollutants can be estimated as follows:

$$\frac{42{,}800 \text{ gallons}}{.0772 \text{ gallons/veh. mile}} = 554{,}404 \text{ veh. miles traveled at 20 mph}$$

The pollutants calculated in metric tons:	CO	HC	NO
	26	2	2

A summary of the total change to the air pollutants as a results of the CFL is presented in Table 50.

Table 50: Summary of Changes in Annual Quantities of Air Pollutants as a Result of the Contraflow Lane

Factor	Pollutants		
	CO (metric tons)	HC (metric tons)	NO (metric tons)
Modal shift	-255	-27	-37
Peak direction	No Change	No Change	No Change
Off-peak direction	74	4	- 8
Alternate route	38	2	- 1
CFL vehicles	- 19	- 2	1
Incidents	26	2	2
CFL operating crew	26	3	1
Total	-110	-18	-42

Source: Reference 39.

Summary of the Effect of the Contraflow Lane on Fuel Consumption and Air Pollutants

In summary, the implementation of the contraflow lane and other corridor improvements is estimated to have reduced the fuel consumption for North Freeway users by 663,700 gallons per year. In addition, the CFL operation is also estimated to have reduced the air pollutants of CO, HC and NO by 110, 18 and 42 metric tons, respectively, per year. These reductions in fuel consumption and air pollutants for the first year of the CFL operation are the result of reductions in the number of vehicle miles traveled (VMT) since the CFL opened. As transit and vanpool ridership continues to increase, the VMT continues to decrease and further reductions in fuel consumption and air pollutants will result.

ACCIDENTS

Accidents in the Contraflow Lane

After 51 months of contraflow operation, there were only 15 accidents involving vehicles in the contraflow lane. These accidents resulted in 3 fatalities and a number of serious injuries. Twelve of the 15 accidents involved non priority vehicles swerving into the contraflow lane (for various reasons) and colliding with an authorized bus, van or METRO operations crew vehicle.

The first of the 3 contraflow lane related fatalities occurred in April 1980 during rainy weather conditions. An auto driver skidded out of control, entered the CFL and was killed instantly. The driver of the van suffered broken bones and 4 of the vanpool's passengers received minor injuries.

The second fatality occurred in September 1980 and the third occurred in June 1982. In each instance, the fatality was the result of a CFL bus striking a pedestrian who was attempting to cross the freeway.

Accidents in the Non Priority Lanes

The number of peak-period accidents which occurred in the 12 months prior to the opening of the controflow lane was compared to the number which occurred during the 12 months after CFL implementation. Peak periods were defined to include the CFL set-up and take-down procedures as well as the actual CFL operation. The morning peak was defined to extend from 5:00 a.m. to 9:00 a.m. and the afternoon peak included the hours between 3:00 p.m. and 7:00 p.m. (39).

Morning Peak Period

During the a.m. peak period, the accident frequency in the peak direction of flow was reduced by 34% (Table 51). Most of the reduction occurred after January 1980 when the ramp closure controls went into effect. In the off-peak direction of flow, the number of accidents was reduced by 10% overall. However, the section of the freeway which extends from North Shepherd Drive to the Houston Belt and Terminal (HB&T) Railroad, was critically affected by the reduced capacity and experienced a 33% increase in accident frequency (39).

Table 51: Number of Accidents on the North Freeway During the Morning Peak Period

Direction and Time Period	Hogan Street to HB&T (3.2 miles)	HB&T to North Shepherd (4.4 miles)	North Shepherd to Beltway (4.2 miles)	Total (11.8 miles)
Peak Direction				
12 months before CFL	41	50	36	127
12 months after CFL	22	35	27	84
Off-Peak Direction				
12 months before CFL	24	27	11	62
12 months after CFL	14	36	6	56

Source: Reference 39.

Afternoon Peak Period

As shown in Table 52, the frequency of accidents during the p.m. peak direction was not significantly affected by the contraflow operation. The off-peak direction, however, did experience a significant increase in accidents in 2 of the 3 sections where traffic congestion was most severe. For example, the approach to the CFL from the north in the North Shepherd to Beltway section showed an increase of 25 accidents which represents a 150% change. The application of control management in the form of ramp closures in the critical freeway sections has greatly reduced congestion and is also expected to reduce the frequency of accidents (39).

Table 52: Number of Accidents on the North Freeway During the Afternoon Peak Period

Direction and Time Period	Hogan Street to HB&T (3.2 miles)	HB&T to North Shepherd (4.4 miles)	North Shepherd to Beltway (4.2 miles)	Total (11.8 miles)
Peak Direction				
12 months before CFL	43	62	22	127
12 months after CFL	47	59	24	130
Off-Peak Direction				
12 months before CFL	37	45	17	99
12 months after CFL	20	66	42	128

Source: Reference 39.

PLANNING GUIDELINES BASED ON THE EXPERIENCE OF THE NORTH FREEWAY CONTRAFLOW LANE

The North Freeway contraflow lane has proven to be a highly effective means of increasing the effectiveness of transit operations along the North Freeway travel corridor. The extent to which contraflow can operate equally as effectively on freeways in other Texas cities depends on a number of factors including:

- The design characteristics of the freeway;
- The availability of excess capacity in the off-peak direction;
- The severity of peak direction congestion;
- The length of contraflow lane;
- The hours of operation;
- The types of vehicles authorized to use the lane;
- Support facilities implemented along with the contraflow lane;
- The travel time savings realized by using the lane;
- The improvements to transit service;
- Rate of population growth along the freeway corridor;
- Capital and operating costs; and
- Other considerations.

Design Characteristics of the Freeway

Freeway design is a primary consideration in assessing the feasibility of implementing a contraflow operation. In general, the minimum freeway cross section where contraflow is applicable is a 6-lane facility which allows 2 lanes in the off-peak direction during contraflow operation. A second factor to consider in the freeway design is the location of entrance/exit ramps. On the North Freeway, for example, the location of the northern terminus of the CFL was to a large extent determined by the existence of entrance/exit ramps on the left side of the highway. A third important consideration is the existence of a median shoulder which would allow continued operation of the CFL in the event of vehicle breakdowns, accidents, etc.

Excess Capacity in Off-Peak Direction

A contraflow operation offers potential over other HOV alternatives when the off-peak direction has relatively light volumes and the removal of a lane would not cause a drop below Level-of-Service C. Minimum peak/off-peak directional splits should generally fall into the range of 64/36 for 6 lanes, 62/38 for 8 lanes and 60/40 for 10 lanes. On the North Freeway, the directional split of traffic was quite favorable at the time the contraflow lane was initially proposed. However, with corridor travel increasing at a rate of almost 5% per year during the 1970's, traffic considerations (particularly in the afternoon) were somewhat marginal when the project was actually completed 4 years later. In response to this problem, ramp metering and selected ramp closures were implemented in an effort to divert some of the North Freeway main lane traffic to the frontage roads. This, in effect, served to forestall the time when the contraflow operation would no longer be feasible.

Severity of Peak Direction Congestion

Another factor to consider in assessing the need for a contraflow operation is the severity of peak-period congestion. On the North Freeway, average weekday traffic increased from 96,000 vehicles in 1970 to 135,000 by 1979. During this same time period, the increased demand for peak-period trips resulted in severe traffic congestion. In 1978, both a.m. and p.m. peak-hour travel speeds averaged only 20 mph for 10 miles with hourly volumes ranging from 1,800 to 1,900 vehicles per lane. Furthermore, certain segments of the North Freeway typically experienced congestion for more than 2 hours during each peak period.

Length of the Contraflow Lane and Travel Time Savings to CFL Users

The desired length of a contraflow operation depends on the traffic congestion and design characteristics of the freeway. Generally speaking, the entrance to the CFL should be located upstream of the most severe traffic congestion to allow CFL users to realize the maximum travel time savings. On the North Freeway, the contraflow lane extends a distance of 9.6 miles which makes it the longest such operation in existence. The fairly large average travel time savings (based on on-board survey results) of 25 minutes each way can be attributed to the length of the lane and the implementation of the concurrent flow lane during the a.m. peak to bypass congestion prior to entering the CFL.

Hours of Contraflow Operation

The hours of contraflow operation must obviously coincide with peak travel periods in order for the lane to be most effective. Additional time must also be allowed for set-up and take-down functions. In Houston, the North Freeway contraflow lane operates during both the morning and afternoon peak periods. The schedule for weekday CFL operation is shown below:

Weekday Mornings

4:30 - 6:00 a.m.	Set-up
6:00 - 8:30 a.m.	Contraflow operation
8:30 - 9:30 a.m.	Take-down

Weekday Afternoons/Evenings

2:30 - 4:00 p.m.	Set-up
4:00 - 6:30 p.m.	Contraflow operation
6:30 - 7:30 p.m.	Take-down

To minimize adverse effects to the off-peak direction traffic and assure safer deployment of the yellow plastic safety pylons, CFL set-up is carried out with the flow of traffic closing off the lane behind the platoon of set-up vehicles. CFL take-down is accomplished in the contraflow direction in order to open the lane to mixed-flow traffic behind the CFL platoon. More than 1,200 pylons are required in Houston's CFL placed at 20- to 40-foot intervals. These pylons are the only barrier between the CFL vehicles and the opposite flow of traffic.

Types of Vehicles Authorized to Use the CFL

In deciding which types of vehicles should be allowed to utilize a proposed contraflow lane, consideration should be given to authorizing vanpools as well as buses. For example, the decision to open North Freeway CFL to authorized vanpools with 8 or more persons increased the vehicle utilization by more than 325% and person-trips by more than 30% during the first year alone. It should be noted, however, that these results would not have occurred if it had been for the extensive employer-based vanpooling programs in Houston.

Support Facilities and Increased Transit Service

In addition to the implementation of a contraflow lane, support facilities such as park-and-ride are warranted if they do not already exist. In the North Freeway corridor, for example, approximately 2,400 spaces were provided at 3 park-and-ride lots during the initial years of CFL operation. By the end of 1983, 4 park-and-ride lots with more than 6,400 spaces were in operation. The total number of North Freeway corridor bus trips increased from 25 per day before the CFL (and park-and-ride) to 57 per day after the first week of CFL operation, an increase of 128%. By March 1984, the number of bus trips utilizing the CFL on the average day reached 311, which represents an increase of 1,144% over the original 25 trips prior to the opening of the CFL. Daily a.m. peak period ridership averaged 265 passengers just prior to the opening of the CFL. Once operation of the CFL began (along with the park-and-ride service) ridership rose sharply. By March 1984, a.m. peak-period ridership averaged over 5,000 passengers which represents about a 1,787% increase. The telephone surveys further revealed that approximately one-third of those trips originating in the North Shepherd market area and terminating downtown are being served by park-and-ride, whereas only 15% of those trips from the Addicks market area to downtown are being served by park-and-ride. If the contraflow lane had been implemented without providing expanded park-and-ride service, there would have been little opportunity for such major increases in transit ridership or modal shift.

Another factor which influenced the increase in transit ridership is the population growth in the North Freeway. The on-board survey revealed that approximately 55% of the North Freeway park-and-ride users had moved to the area after the implementation of the CFL. Furthermore, 56% of those who had moved indicated that the availability of the CFL and park-and-ride service was a factor in their decision to move to that area. The implementation of CFL in urban areas which are not experiencing such rapid population growth would probably not realize as dramatic an increase in transit ridership.

Cost Considerations

Yet another important consideration in assessing the feasibility of a contraflow project is the cost of constructing and operating the facility.

The implementation of a contraflow lane, while considerably less expensive than constructing an exclusive HOV lane, nevertheless involves a substantial capital outlay. For example, the costs of constructing the various initial improvements to the North Freeway corridor were:

- Contraflow Lane $2,176,000
- Ramp Metering System $ 396,000
- Park-and-Ride Lots $4,260,000
- Concurrent Flow Lane $ 138,000

In addition to the $6,970,000 capital costs associated with implementing the CFL, operating costs run approximately $600,000 per year. Federal funding sources paid for about 55% of the capital costs with the SDHPT, METRO and the City of Houston providing the remaining 45%. A Service and Methods Demonstration Grant paid for about half of the operating costs during the initial 18 months of CFL operation and METRO funded the remaining half. After the 18-month demonstration period, METRO began assuming the entire cost of operating the lane ($600,000 per year).

Effect of Contraflow on Energy Consumption, Air Pollution, Traffic Congestion and Accidents

With the implementation of a contraflow lane, certain benefits may be realized. These benefits are highlighted below.

Energy Consumption

Because a contraflow lane encourages mode shifts to high occupancy vehicles, a reduction in vehicle miles traveled is realized. This in turn leads to reductions in fuel consumption and air pollutants. For example, it was estimated that the contraflow lane on the North Freeway has been responsible for reducing fuel consumption by 663,700 gallons per year. In addition, a reduction of CO, HC, and NO air pollutants by 110, 18 and 42 metric tons, respectively, was also estimated to have occurred as a result of the CFL.

Traffic Congestion

Because the contraflow concept involves borrowing a lane from the off-peak direction for use by high occupancy vehicles traveling in the peak direction, more severe impacts to off-peak direction traffic are likely to result while the lane is in operation. On the North Freeway, peak-period direction travel has not been affected by the CFL. The reduced demand caused by a shift to CFL has been offset by traffic growth in the corridor. Traffic in the off-peak direction of travel has suffered reduced levels-of-service and displacement to alternate routes. The alternate routes are capable of providing an acceptable level-of-service to the diverted traffic. In addition, the reduced service was initially termed acceptable in that it occurs along only 4.4 miles of the 9.6 miles CFL. Subsequent LOS reductions led to a decision to terminate CFL and replace it with a median transitway.

Accidents

Yellow plastic safety pylons are the only barrier between the CFL vehicles and opposite flow of traffic. Therefore adequate signing, lane designations, etc. are essential for the safety of all vehicles. In Houston, the CFL is well marked and has had a good safety record. Only 15 accidents have occurred between August 1979 and December 1983. Most of these involved a non priority vehicle swerving into the CFL and colliding with a CFL vehicle. A total of 3 accidents resulted in fatalities; the driver of a non priority vehicle was killed when he lost control and slid into the CFL, and 2 pedestrians were killed when they attempted to cross the freeway.

Although some sections of the freeway have experienced high percentage increases in accidents during the 12 month period following the implementation of the CFL, the total number of accidents for the North Freeway in both directions in both peak periods has decreased 4%. Further decreases are expected as a result of ramp metering procedures implemented.

Conclusions

The implementation of contraflow lanes and support facilities along heavily congested travel corridors in Texas cities offer many potential benefits including a travel time savings to users, and reductions in vehicle miles traveled, fuel consumption and air pollutants. Peak-period traffic congestion may also be reduced, although this reduction may be offset by increased travel demand. While all of the above are certainly important concerns, perhaps the greatest benefit from implementing contraflow lies in its ability to encourage the acceptance and use of public transportation. Any type of priority lane will bring about this increased utilization.

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APPENDIX A

APPENDIX A

This bibliography of technical reports and journal articles was compiled from the data base of the Urban Mass Transportation Research Information Service (UMTRIS), the Transportation Research Information Services (TRIS), and the Highway Research Information Service (HRIS). All of the citations in this appendix relate to some facet of transit performance evaluation and are intended to provide transit professionals with additional guidance in the task of developing systems for measuring the efficiency and effectiveness of transit services.

This appendix is arranged in two sections. The first section contains abstracts arranged alphabetically by title of publication. The second section is an index of sources which contains the addresses of the agencies from which the reports can be obtained.

ABSTRACTS

1. AN ANALYSIS OF TRANSIT PERFORMANCE MEASURES USED IN NEW YORK STATE

Zerrillo, RJ; Keck, CA; Schneider, NR

New York State Department of Transportation Transit Division, 1220 Washington Avenue, Albany, New York 12232

Dec. 1980, 27 p.

A recent NYSDOT study developed transit performance measures to be applied to the full range of the state's transit operations. This paper expands on this initial effort by examining: (1) factors which affect the fifteen performance measures previously developed; (2) the interrelationships between measures; (3) the ability of the measures to describe changes in operator performance; and, (4) the feasibility of using multimodal measures. The results of this analysis show that the fifteen performance measures were not highly intercorrelated or influenced by the component variables used to compute them. The levels of a number of measures did not significantly differ between service types, suggesting use in multimodal performance evaluations. A preliminary review of the second year's performance levels reveals the usefulness of the measures as a diagnostic tool to identify possible operator performance problems. Future year's operator levels would be monitored to chart industry changes and identify the need to modify the Department's "acceptable" and "desirable" attainment levels. (Author).

2. ANALYSIS OF URBAN TRANSPORTATION CRITERIA

Zakaria, T

American Society of Civil Engineers

ASCE Journal of Transportation Engineering Vol. 101 No. TE3, Aug. 1975, pp. 521-536

The criteria should accurately account for the quality of the transportation service, accessibility to various land-use opportunities, economic efficiency, system and traffic characteristics, community disruption, pollution of the environment, adaptability to changes in technology and travel behavior, and esthetic quality of transportation facilities. The results of an attitudinal survey conducted by the Deleware Valley Regional Planning Commission (DVRPC) indicate that individuals can adequately rank well-defined criteria. The examination of the criteria ranks by population groups of different socioeconomic characteristics shows no larger variations from the ranking by the total population in the sample. The DVRPC survey indicates that safety and security is the most important criterion in transportation followed by reliability, air pollution, travel time, preservation of neighborhood, comfort, noise pollution, esthetics, job opportunities, transfers, duration of service, construction cost, and shopping opportunities.

AVAILABLE FROM: ESL

3. **ANALYZING TRANSIT OPTIONS FOR SMALL URBAN COMMUNITIES. VOLUME ONE: TRANSIT SERVICE OBJECTIVES AND OPTIONS**

James, DH

Peat, Marwick, Mitchell and Company, Manual UMTA-IT-06-9020-78-1, Jan. 1978, 109 p.

The information and analytical techniques contained in this manual are designed to assist in the planning of new or improved transit services in small urban communities with less than 200,000 residents, that are currently sponsoring, promoting, providing, or considering such services. Portions of the manual will be useful in larger urban areas. Techniques are presented to assist in planning for both conventional bus transit and paratransit alternatives and for estimating alternatives. Opportunities for Federal and State financial assistance are summarized, Federal requirements are described, and the experience of urban communities involved in local mass transportation is illustrated. Volume One contains Chapters 1 through 4, and presents a generalized process for planning transit and paratransit options in small urban communities. The process consists of a logical sequence of steps which combine the form basic tasks. These tasks are outlined in the report. Information is presented to assist in the first and second set of activities in the planning process, which includes discussions of the relationship between goals, standards, and criteria; the importance of transit service objectives; guidelines for establishing local transit goals and objectives for assessing the local need for transit service; and the range of characteristics that differentiate between transit service alternatives. In addition, the capabilities of specific modal opportunities are summarized, and their relationship to the achievement of local transit service objectives are addressed. A Listing of Publications is included for guidance in preparing the design of the alternatives. /UMTA/

Sponsored by the Urban Mass Transportation Administration. This manual consists also of "Volume Two: Analysis Methods" and "Volume Three: Summary of Management and Operations Experience". (Three volume set available as PB-291449).

AVAILABLE FROM: NTIS PB-291450/AS

4. **ANALYZING TRANSIT OPTIONS FOR SMALL URBAN COMMUNITIES. VOLUME TWO: ANALYSIS METHODS**

James, DH

Peat, Marwick, Mitchell and Company, Manual UMTA-IT-06-9020-7802, Jan. 1978, 181 p.

The information and analytical techniques contained in this manual are designed to assist in the planning of new or improved transit services in small urban communities with less than 200,000 residents, that are currently sponsoring, promoting, providing, or considering such services. Portions of the manual will be useful in larger urban areas. Techniques are presented to assist in planning for both conventional bus transit and paratransit alternatives, and for estimating the demand, cost, and revenue implications of various transit service alternatives. Opportunities for Federal and State financial assistance are summarized. Federal requirements are described, and the experience of urban communities involved in local mass transportation is illustrated. Volume Two contains Chapter 5 of the manual. The transit planning process in small urban communities consists of a logical sequence of steps, which combine to form basic tasks, and are outlined in Volume One. Volume Two presents information and techniques designed to assist in the third set of activities in the planning process. Evaluation is an activity that continues throughout this process, and is based on: (1) the degree to which each alternative achieves transit service objectives set by the community or transit manager; and (2) the financial implications of each alternative in relation to transit service cost limits or budgets set by the community. In this volume, 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, which are the key elements in evaluating transit service alternatives. References are also contained herein. /UMTA/

Sponsored by the Urban Mass Transportation Administration. This manual consists of "Volume One: Transit Service Objectives and Options" and "Volume Three: Summary of Management and Operations Experience". (Three volume set available as PB-291440.)

AVAILABLE FROM: NTIS PB-291451/3ST

5. ANALYZING TRANSIT PERFORMANCE

Levinson, HS

Connecticut University, Storrs 1983, n.p.

This paper summarizes detailed analyses of transit speeds, delays, and dwell times based on surveys conducted in a cross section of U.S. cities. The relationships and parameters provide inputs for planning service changes and assessing their impacts. The surveys and analyses find that car speeds are consistently 1.4 to 1.6 times as fast as bus speeds; the typical bus spends about 48-75 percent of its time moving, 9-26 percent at passenger stops and 12-26 percent in traffic delays; and peak-hour bus travel times approximate 4.2 min/mile in suburbs, 6.0 min/mile in the city, 11.50 min/mile in the central business district. Bus dwell times (including door opening and closing) approximate 5 plus 2.75 times the number of passengers; during peak hours local buses stop at 68-78 percent of the designated stops. Bus travel times and speeds were derived as a function of stop frequency, stop duration, and bus acceleration and deceleration times observed in the field. Reducing bus stops from 8/mile to 6/mile and dwell times from 20 to 15s would reduce travel times from 6 to 4.3 min/mile--a time savings greater than that to be achieved by eliminating traffic congestion. Transit performance should be improved by keeping the number of stopping places to a minimum. Fare collection policies, as well as door configurations and widths, are important in reducing dwell time, especially along high density routes. Such times saving will likely exceed that achieved from providing bus-priority measures or improving traffic flow.

Prepared for the 62nd Annual Meeting of the Transportation Research Board, and appears in TRB Record 915.

AVAILABLE FROM: TRB Publications Office

6. THE APPLICATION OF STATISTICAL CONTROL MEASURES TO TRANSIT PERFORMANCE INDICATORS

Austin, JA; Stone, TJ

Journal of Advanced Transportation, Vol. 14 No. 3, 1980, pp. 213-236

This article develops a framework for the use of route-specific performance data to determine which routes in a transit system require special attention. Two indicators of performance are used: Passengers per bus mile and passengers per bus hour. Statistically-derived control charts are developed to display the value of each route's performance indicator and the values of the upper and lower control limits for similar routes in the system. The routes are then placed in internally consistent functional groups so that each route's performance can be compared to the overall performance of that group. The control limits show the range of values which would be anticipated for a "normally" performing route. If a route's indicator is above or below the norm, it is a candidate for attention. An application of this methodology to data from the Regional Transportation District of Denver, Colorado is used to illustrate the concept. The authors stress the importance of updating performance indicator data on a regular basis to monitor trends and identify changes.

AVAILABLE FROM: ESL

7. APPLICATION OF TRANSIT PERFORMANCE INDICATORS

Stone, TJ; Austin, JA; Siegel, RL; Taylor-Harris, A

Utah University, Urban Mass Transportation Administration Final Rpt. UTEC-CE-79-117, UMTA-UT-11-0001-79-1, Sept. 1979, 282 p.

Decreasing transit ridership and increasing operating and capital costs have resulted in a situation whereby the Urban Mass Transportation Administration (UMTA) is requiring transit operators to develop comprehensive data reporting schemes. Transit operators are realizing the need for measurement of transit system productivity, efficiency, and effectiveness, in order to make decisions on where to add, modify, or delete service. The research provides an internal route-specific product, which is a comprehensive decision framework for applying transit performance indicators. Two performance indicators were selected for use in the research, namely, passengers per bus mile and passengers per bus hour. These indicators are used primarily because the data are relatively easy to obtain. The application methodology is general, however, in that it can also be used for other route-specific indicators. The decision-making techniques which are used in other fields such as quality control. Two case studies were used in this framework to apply indicators to the measurement of performance of the bus transit systems of the Regional Transportation District of Denver, Colorado, and the Utah Transit Authority of the Salt Lake City, Utah region. Guidelines are given to assist transit operator programs.

AVAILABLE FROM: NTIS PB80-121569

8. APPROACHES TO PERFORMANCE MEASUREMENT: A REPORT OF THE APTA PLANNING AND POLICY COMMITTEE, TRANSIT PERFORMANCE DIVISION

American Public Transit Association Dec. 1979, n.p.

This report is a practitioner-oriented collection of articles and other materials illustrating performance measurement among APTA's member properties. The document includes excerpts from several properties' service evaluation documents, two papers on management-by-objectives, a collection of articles on performance measurement reprinted from APTA publications, and a directory of performance coordinators and contacts in major U.S. transit systems. Also included is APTA's February 1979 revised policy statement on transit performance.

AVAILABLE FROM: APTA

9. THE APPROPRIATE MEASURES OF PRODUCTIVITY AND OUTPUT FOR THE EVALUATION OF TRANSIT DEMONSTRATION PROJECTS

Studenmund, AH

SYSTAN, Inc., Urban Mass Transportation Administration, Final Rpt. UMTA-MA-06-0049-81-9, DOT-TSC-UMTA-82-6, Mar. 1982, 22 p.

Output and productivity, two economic concepts that have important applications in the evaluation of transportation demonstrations, are discussed in this paper. The focus of these discussions is on how the terms' typical definitions in transportation analysis differ from their accepted usages in the economic profession. This document is divided into three sections. Section 1 briefly outlines the pure economic theory of productivity, production, and market equilibrium. Section 2 explains why this model and its definitions must be modified for use in analyzing changes in urban transportation systems. The final section suggests an approach that might clarify present ambiguities in communication between the transportation industry and those outside observers (economists, politicians, union leaders, voters, etc.) with whom the industry must deal in order to obtain subsidies or carry out innovations. The major component of this suggested approach is that the measures of productivity and output presently being used by the transportation industry need to be modified for use in the evaluation of transit demonstration projects.

AVAILABLE FROM: GPO

10. AUTOMATIC VEHICLE MONITORING: EFFECTIVE TECHNIQUE FOR TRANSIT SYSTEM MANAGEMENT AND CONTROL

Lyles, RW; Lanman, MH, III

Transportation Research Board Record No. 854, 1982, pp. 30-37

In the context of searching for new approaches for efficient transportation system management and utilization, the Urban Mass Transportation Administration (UMTA) has funded a comprehensive demonstration of an automatic vehicle monitoring (AVM) system in Los Angeles. AVM coverage includes approximately 10 percent of the Southern California Rapid Transit District's (SCRTD) route miles and buses. The system is now operational, the AVM capabilities having been phased in over a year's time. Although the evaluation program on the part of UMTA and SCRTD continues, analysis of the impacts to date shows the benefits have accrued in several areas of transit system operations, including route scheduling and information management, improvement of day-to-day system reliability, rendezvous of scheduled and nonscheduled vehicles, and response to emergency situations. This paper appeared in Transportation Research Record No. 854, Bus Services.

AVAILABLE FROM: TRB Publications Office

11. BERKSHIRE REGIONAL TRANSIT AUTHORITY: TRANSPORTATION SYSTEM MANAGEMENT EVALUATION REPORT

Cook, CW

Berkshire County Regional Planning Commission, Urban Mass Transportation Administration Rpt. UMTA-MA-09-0050-80-1, Oct. 1979, 145 p.

Many transit operations have a need for an evaluation system which can measure existing service performance. To assist these operators, UMTA has been funding, through its Section 8 Technical Studies Program, local studies in service evaluations. The purpose of these studies is to evaluate existing transit service and to develop recommendations and plans for service improvements. This document summarizes the local evaluation study of the transit service provided by the Berkshire Regional Transit Authority (BRTA) in Pittsfield, Massachusetts. The purpose of the study was to review and evaluate the current transit services provided by the BRTA and to develop recommendations for service modifications which utilize low cost techniques to improve operating effectiveness. In this study, emphasis is on the three new routes in Pittsfield, the overall fare structure, and the priority locations for bus stop shelters. To collect the necessary information for this evaluation, a loading survey was conducted. This survey provided information on maximum loading, hourly ridership, passenger miles of travel and average trip length by route. The report serves as an excellent example of service evaluation within a small transit system.

AVAILABLE FROM: NTIS PB80-196777

12. BIBLIOGRAPHY OF TRANSIT PERFORMANCE INDICATORS

Transportation Systems Center, Urban Mass Transportation Administration DOT-TSC-OST-81-8, Nov. 1981, 17 p.

This bibliography is intended to provide those interested in transit performance measurement with a sampling of the reports, studies, and documents that have been published in recent years. The collection is not comprehensive, but rather is intended to illustrate the range of key issues and developments that have been explored. Work is continuing on a comprehensive annotated bibliography as well as a state-of-the-art overview on transit performance indicators. The bibliography is divided into two sections. Section I, General Analysis, highlights research from a variety of sources. Section II, Demonstration Programs, pertains to the actual implementation of performance indicators in transit system demonstration programs. The published selections listed in this bibliography may be obtained from technical, university, or transportation libraries. The reports for which PB numbers are indicated can be ordered from the National Technical Information Service, Springfield, VA.

AVAILABLE FROM: TSC

13. BUS PLANNING METHODS. 1. PROJECT EVALUATION

Skinner, RJ

Traffic Engineering and Control Vol. 21 No. 8/9, Aug. 1980, pp. 415-419

This article, the first of three dealing with methods for planning bus services, introduces a basic approach and gives some practical guidelines on how to set about evaluating alternative schemes. First, the advantages of two forms of evaluation are compared: an approach based on assessing extra passenger-miles generated; and a cost-benefit approach. The use of an evaluation framework is illustrated by considering a typical case of reducing service frequencies. Overall, the cost-benefit approach is shown to be both useful and manageable in evaluating most schemes for improving bus services.

AVAILABLE FROM: ESL

14. BUS PLANNING METHODS. 2. DATA COLLECTION

Skinner, RJ

Traffic Engineering and Control Vol. 21 No. 10, Oct. 1980, pp. 476-481

In the second of three articles dealing with methods for planning bus services, the main topics are: options available for collecting data; the costs of alternative options; and frequencies with which data should be collected to review the performance of each aspect of bus operations.

The salient features of survey methods are described and a combination of surveys suitable for most bus operations suggested. Comparison of survey costs shows that origin-destination surveys cost over twice as much as stage-to-stage surveys. For monitoring financial performance and checking bus loadings, it is shown that biennial stage-to-stage surveys of every service would in most cases be appropriate.

AVIALABLE FROM: ESL

15. BUS SERVICE EVALUATION PROCEDURES: A REVIEW

Attanucci, JP; Jaeger, L; Becker, J

Massachusetts Bay Transportation Authority, Tidewater Transportation District Commission Intrm. Report UMTA-MA-09-7001-79-1, Mar. 1979, 227 p.

Over the past few years, rising costs and limited budgets have encouraged transit authorities to evaluate the cost-effectiveness of the services they provide. The Massachusetts Bay Transportation Authority (MBTA) and the Tidewater Transportation District Commission (TTDC) are among many properties interested in updating and improving bus service evaluation programs. These programs include joint review of the state-of-the-art in bus service evaluation techniques across the country. This information will be used to develop bus service evaluating programs for both the MBTA and the TTDC. This report presents the results of a literature review and survey of 17 transit properties in the United States and Canada regarding the evaluation procedures currently in use. The focus of the study was to identify service performance indicators and criteria used to evaluate bus service on a route-by-route basis. Three types of evaluation indicators: service design measures; operating performance measures; and economic or productivity measures, were identified. The range of standards developed for each indicator are reported. Results are presented separately for transit properties owning less than 400 buses and for those owning more than 400 buses. Detailed appendices provide more complete information on the survey response. These appendices also provide the transit operator and the regional transit planner with a compendium of a wide range of performance measures, descriptions of how they are used and how the needed data is collected, a listing of contact persons in each property, and detailed information on available literature. The conclusions herein show that bus transit operators in the United States and Canada are aware that useful evaluation techniques are currently available, and that most systems recognize the importance of such techniques to ensure a more efficient and effective delivery service. /UMTA/ Sponsored by the Urban Mass Transportation Administration.

AVAILABLE FROM: NTIS PB-296314/AS

16. BUS TRANSIT MANAGEMENT AND PERFORMANCE

McShane, WP; Menaker, P; Roess, RP; Falcocchio, JC; Allen, WGJ

Transportation Research Board, 1980, 73 p.

The 13 papers in this report deal with the following areas: transit ridership in an intense transit environment; some observations; development and application of performance measures for a medium-sized transit system; diagnostic tools in transit management; portfolio model of resource allocation for the transit firm; evaluating potential effectiveness of headway control strategies for transit systems; what public transportation management should know about possible user reactions; as shown by the example of price sensitivity; use of federal Section 15 data in transit performance evaluation; Michigan program (abridgment); systematic procedure for analysis of bus garage locations; initial reactions to a central business district bus transit mall in Honolulu; recent experience with accessible bus services; operational improvements in a two-city bus transit corridor (abridgment); note on bus route extensions (abridgment); and hierarchical procedures for determining vehicle and crew requirements for mass transit systems. Library of Congress catalog card no. 80-19208. Also pub. as ISSN-0361-1981. Paper copy also available from Transportation Research Board, 2101 Constitution Ave., NW, Washington, DC 20418.

AVAILABLE FROM: NTIS PB80-211097

17. BUS TRANSIT MONITORING MANUAL. VOLUME 1: DATA COLLECTION DESIGN

Attanucci, J; Burns, I; Wilson, N

Multisystems, Inc., ATE Management and Service Company, Urban Mass Transportation Administration Final Report UMTA-IT-09-9008-81-1, Aug. 1981, 166 p.

Many transit operators have adopted sets of service performance measures and standards and have developed plans to use them in a systematic evaluation. In some cases, however, transit operators have not been able to implement the measures and standards because they have had difficulty in developing a cost-effective system to collect the needed information. To assist these operators, the Office of Planning Assistance of the Urban Mass Transportation Administration, through its Special Studies Program, has sponsored a study in data collection. This two-volume manual is the product of this study and it documents a method to develop comprehensive statistically-based data collection programs that will enable transit operators to collect passenger-related data in a cost-effective manner. The objective of the bus transit monitoring study is to develop this method in order for the bus transit industry to support the short range planning process. The two volumes of this manual document this method and provide transit operators with step-by-step procedures to develop their own individually-tailored programs. This volume, Volume 1, explains the various components of a comprehensive route-level data collection program, beginning with the determination of data needs and finishing with interpretation of the data. A two-stage approach is described with a baseline phase to produce detailed profiles for each bus route, and a monitoring phase to gather limited data on a periodic basis. The advantages and disadvantages of various data collection techniques are discussed in the report. Both the desired accuracy and the inherent variability of the data items are incorporated in the selection of a sampling plan. Allowance is made for the use of simple linear relationships between data items to reduce the overall cost of the data collection program where feasible. The recommended data collection program is shown to meet UMTA Section 15 reporting requirements for passenger-related data. (UMTA)

AVAILABLE FROM: NTIS PB 82-122227

18. BUS TRANSIT MONITORING MANUAL, VOLUME 2: SAMPLE SIZE TABLES

Attanucci, J; Burns, I; Wilson, N

Multisystems, Inc., ATE Management and Service Company, Urban Mass Transportation Administration Final Report UMTA-IT-09-9008-81-2, Aug. 1981, 330 p.

Many transit operators have adopted sets of service performance measures and standards and have developed plans to use them in a systematic evaluation. In some cases, however, transit operators have not been able to implement the measures and standards because they have had difficulty in developing a cost-effective system to collect the needed information. To assist these operators, the Office of Planning Assistance of the Urban Mass Transportation Administration (UMTA), through its Special Studies Program, has sponsored a study in data collection. This two-volume manual is the product of this study and it documents a method to develop comprehensive statistically-based data collection programs that will enable transit operators to collect passenger-related data in a cost-effective manner. The objective of the bus transit monitoring study is to develop this method so that the bus transit industry will support the short range planning process. The two volumes of the manual document this method and provide transit operators with step-by-step procedures to develop their own individually-tailord programs. This volume, Volume 2, provides an extensive set of tables for determining sampling sizes for systems and routes of varying size and operating characteristics. A two-stage approach is described with a baseline phase to produce detailed profiles for each bus route, and a monitoring phase to gather limited data on a periodic basis. The advantages and disadvantages of various data collection techniques are discussed in the report. Both the desired accuracy and the inherent variability of the data items are incorporated in the selection of a sampling plan. Allowance is made for the use of simple linear relationships between data items to reduce the overall cost of the data collection program where feasible. The recommended data collection program is shown to meet UMTA Section 15 reporting requirements for passenger related data. (UMTA)

AVAILABLE FROM: NTIS PB82-122235

19. BUS TRANSIT MONITORING STUDY: INTERIM REPORT 1: DATA REQUIREMENTS AND COLLECTION TECHNIQUES

Flusberg M; Kruger, J; Curry, J

Multisystems, Inc., ATE Management and Service Company, Inc., Intrm. Report UMTA-IT-09-9008-79-1, April 1979, 86 p.

In recent years, an interest in revitalizing public transportation has led to an increased awareness of the need to utilize existing resources more efficiently. This implies that transit properties must carefully evaluate, or re-evaluate, all services, both current and planned. As a result, the collection of passenger-related transit operations data has received much more attention. Research into the utilization of this data has considerably advanced the state-of-the-art of transit evaluation and, simultaneously, generated considerable controversy regarding its proper role. Some transit operators, faced with an increasing need to provide the most effective service, have adopted sets of performance measures and standards and have developed plans for using them in a systematic service evaluation. In many cases, however, transit operators have not been able to implement the measures and standards because they have had difficulty in developing a cost-effective system to collect need information. To assist these operators, UMTA's Office of Planning Assistance, through its Special Studies Program, has initiated a study in data collection. The purpose of this study is to develop a comprehensive statistically-based data collection manual that will enable transit operators to collect passenger-related data in a cost-effective manner which maximizes the usefulness of the overall data base. The first interim report presents the results of the first two tasks of the study, which were to identify current data collection techniques and data requirements. These two closely related tasks were conducted in parallel through three major activities: 1) a literature review; 2) a review of material collected by the Massachusetts Bay Transportation Commission in Norfolk, Virginia, in a study for UMTA, focusing on service evaluation techniques; and 3) discussions with forty-one transit properties in the United States and Canada. (UMTA)
Sponsored by DOT, UMTA

AVAILABLE FROM: NTIS PB80-161409

20. A CASE STUDY OF THE DEVELOPMENT AND APPLICATION OF TRANSIT PERFORMANCE MEASURES

Allen, WG, Jr; Zapalac, G

Transportation Research Forum Vol. 23 No. 1, 1982, pp. 351-361

This paper describes the development and use of a performance procedure for the transit system of Springfield, Missouri. The city and its bus system are briefly described, and the background behind the need for performance measurement is discussed. Declining financial productivity is identified as a primary motivation for examining performance at this time. The general framework for evaluation is described. First, the unique institutional and funding arrangements in Springfield are described. Then, the adopted goals, objectives, and perforamnce criteria are listed. The organization of performance measures is discussed. These measures consist of a route performance profile to rank individual routes, system measures and trends to gauge overall performance, and peer group analysis to compare Springfield with similar cities. Potential uses of performance measurement are proposed. The performance measurement system is applied to data from the Springfield transit system. The results are mixed: the system is operated in an efficient manner but suffers low ridership due to low density development and indirect routing. The process of formally adopting the concept and practice of performance measurement is described. The evaluation system is now in regular use by local planners to rate service development and has been in a subsequent study of route and schedule options. Proceedings of the 23rd Annual Meeting, Theme: Developing Concinnity in Transportation, held at Fairmont Hotel, New Orleans, La., October 28-30, 1982.

AVAILABLE FROM: Richard B. Cross Company

21. A CASE STUDY OF THE POSSIBILITY OF CONSENSUS ON PERFORMANCE INDICATORS BY TRANSIT MANAGERS

Derbonne, WL; Slakey, J

Washington State Transit Association 523.301, July 1979; 29 p.

This paper reports a beginning action of gathering data to answer the question: Can managers of transit properties reach a consensus on performance indicators to be used statewide for accountability, comparison and evaluation? Or, must they be the voiceless recipients of mandated regulations? A questionnaire survey was designed and distributed under the auspices of the Washington State Transit Association (WSTA). Ten of the fifteen transit properties in Washington responded. The respondents ranged from a service area population of 3,000 to an urban transit system using 800 buses. Transit system managers were asked what kinds of performance indicators they considered most important in three categories: (1) their internal management reporting; (2) for inclusion in public presentation of performance information; and (3) which factors should be considered to categorize and to make performance comparisons among systems. The first two categories were divided into subsections: Cost Effectiveness (Administration, Maintenance, Operations); and Service Effectiveness (Service Standards, Ridership). This paper includes a statement about the issue of accountability--its context and problems, a rationale of the questionnaire design, the response and recommendations drawn from the collation of responses. Appendices include a copy of the questionnaire, the raw data responses and a selected bibliography of sources of information relating to performance indicators.

AVAILABLE FROM: APTA

22. CHOOSING PERFORMANCE INDICATORS FOR SMALL TRANSIT SYSTEMS

McCrosson, DF

Transportation Eningeering, Vol. 48 No. 3, Mar. 1978, pp. 26-30

Providing adequate system deficit financing for publicly-owned and operated transit systems has been a source of great concern for federal, state, and local funding agencies. Marginal increases in tax revenues coupled with increased competition for existing financial resources has forced government agencies to search out the best investment for scarce funds and to insure that the greatest public good may be accomplished at the least cost to the taxpayer. Urban transportation systems, and their mass transit components in particular, have often been regarded as important cornerstones in the economic viability of urbanized areas. The focus of this review, therefore, is on the identification of select performance measures that would provide to the operators of Pennsylvania's small transit system, a simplistic means of measuring the impact of low-capital intensive system improvements as well as highlight existing or emerging operating problems. /Author/

23. A COMPREHENSIVE ANALYSIS OF URBAN BUS TRANSIT EFFICIENCY AND PRODUCTIVITY: PART I. DEFINITION AND MEASUREMENT OF URBAN TRANSIT PERFORMANCE

Sinha, KC; Jukins, DP

Purdue University, Urban Mass Transportation Administration Final Rpt. UMTA-IN-11-0003-79-2, Dec. 1978, 173 p.

This document presents a review of the concepts and definitions of efficiency, effectiveness, and productivity in the public transportation sector. The development of the appropriate performance indicators is discussed. The trend of bus transit performance indicators is examined separately for various classes of transit systems. In addition, a scheme of stratification is also presented on the premise that there exist many environmental and policy factors outside the control of the transit operator which impose constraints on the performance of transit systems. The transit systems considered herein include the entire set of bus systems reporting to the American Public Transit Association (APTA) in 1975. Finally, the report presents several potential uses of productivity concepts. Although these concepts are presently being used to allocate funds in some states, there are other uses such as for public policy evaluation, assessment of TSM strategies, as well as the establishment of clearly defined and measureable goals and objectives for urban transit. This report contains a list of references and a listing of urban bus transit systems selected for use in the Trend and Stratification Analysis (Appendix), as well as many tables charting the input and output variables used in trend analyses for 1972 (Appendix). /UMTA/ Other project reports are: Executive Summary (UMTA-IN-0003-79-1); Part II. Labor Aspects of Urban Bus Transit Efficiency and Productivity (UMTA-IN-11-0003-79-3); and Part III. Analysis of Options to Improve Urban Transit Performance (UMTA-IN-11-0003-79-4).

AVAILABLE FROM: NTIS PB-295221/6ST

24. COMPARATIVE ANALYSIS OF TRANSIT PERFORMANCE

Anderson, SC; Fielding, GJ

California University, Urban Mass Transportation Administration Final Report UMTA-CA-11-0020-82-1, Jan. 1982, 95 p.

The research tests the usefulness for performance analysis of data resulting from Section 15 of the Urban Mass Transportation Act of 1964, as amended. The 1978-79 statistics were used to validate a framework for performance analysis based upon efficiency and effectiveness. The purpose for examining the Section 15 data were (1) to assess data reliability; (2) to develop a small set of performance indicators; and (3) to produce a classification of bus systems based upon inherent characteristics. Nine dimensions of performance, developed from 60 measures, were used to develop a performance index that can be applied to individual transit properties. This report provides a brief history of Section 15 system, assesses its usefulness and concludes with suggestions for improvements to the system.

AVAILABLE FROM: NTIS PB82-196478

25. COST-EFFECTIVENESS ANALYSIS OF PUBLIC TRANSIT SYSTEMS

Nelson, KE; Nevel, WC

Traffic Quarterly Vol. 33 No. 2, April 1979, pp. 241-252

This article presents an approach that incorporates a cost/revenue technique of measuring transit performance. It employs effectiveness and efficiency concepts in addressing revenues and costs, and the marginal cost concept, by defining and using fixed and direct costs. The approach may be applied to small- and medium-size transit properties. It also compares the revenue/cost approach with other performance measurement techniques.

AVAILABLE FROM: ESL

26. DALLAS CREATES PERFORMANCE BENCHMARKS

Passenger Transport, Apr. 1979, n.p.

This article reports on Dallas' approach to evaluation of transit performance. Five performance measures (revenue cost ratio; net line revenues; revenue passenger per hour; revenue passenger per mile; and total passengers per trip) were developed in accordance with the fare policies adopted by the Dallas Transit System board. The policies serve as guidelines for generation of revenues and allocation of the revenues. Three service standards (route spacing and service convenience; frequency of service; and service adherence) are used to complement the five performance measures for local, express and crosstown service ranking. Those ranked in the lower 20% will be reviewed as potential "substandard routes."

AVAILABLE FROM: APTA

27. DATA RECORDING AND EVALUATION: THE BARNSTABLE COUNTY EXPERIENCE

Warren, RP; Collura, J

Transportation Research Record No. 696, 1978, pp. 55-65

A mechanism for collecting data on rider and operating characteristics of regionwide public transportation services is described. The mechanism, a serially numbered rider identification pass, is being tested as part of an ongoing demonstration project in Barnstable County, Massachusetts. Service is provided on a prearranged demand-response basis by use of ten 12-passenger vehicles. Passengers acquire passes in advance and complete a questionnaire on their socioeconomic characteristics and physical disabilities. When passholders telephone to schedule a trip, the dispatcher records their pass number, pickup time, trip purpose, and origin and destination. Special attention has been given to minimizing the data collected for all riders. These data may be used to (1) evaluate vehicle productivity and efficiency, (b) examine the impacts of local policy decisions, (c) assess the portion of a deficit to be paid by each town, (d) develop user charges and contractual agreements for use by social-service agencies, (e) identify those persons who are eligible for the services of a social-service agency and (f) describe user characteristics. The uses of the pass in fare collection and marketing are discussed, and capital and operating costs of the pass are estimated. /Author/ This paper appeared in TRB Record No. 696, Rural Public Transportation.

AVAILABLE FROM: TRB Publications Office

28. DESIGN OF BUS TRANSIT MONITORING PROGRAMS

Attanucci, J; Wilson, N; McCollom B; Burns, I

Transportation Research Record No. 857, 1982, pp. 7-14

A method is described for the design of a comprehensive, statistically based data-collection program that can support bus route planning and operations. A two-stage approach used in the design of the collection program is advocated. In the baseline phase, a detailed profile of each bus route is developed. This is followed by a monitoring phase in which limited data are collected to verify that the route profile developed in the baseline phase is still accurate. Both the desired accuracy and the inherent variability of the data items are considered in the design of the data-collection program. To reduce the overall cost of the data-collection program, consideration is given to the use of simple linear relationships between data items. The methodology discussed in this paper was developed under contract to the Urban Mass Transportation Administration and has been approved as meeting the Section 15 reporting requirements for passenger related data.

This paper appeared in Transportation Research Record No. 857, Bus Operations and Performance.

AVAILABLE FROM: TRB Publications Office

29. DESIGNING A TRANSIT PERFORMANCE MEASUREMENT SYSTEM

Heaton, C

Transit Journal Vol. 6 No. 2, 1980, pp. 49-56

An attempt is made to lay the basis for the development of a framework to guide the design and implementation of performance measurement systems. The three major issues to be considered in designing a transit performance measurement scheme are the intended uses of the measurement system, the relationship of the measurement system to transit system goals, objectives and constraints, and the level of resources and expertise available for the data collection and information processing. A number of potential uses of the performance measurement system are cited. Existing performance measurement systems exhibit a considerable diversity with respect to the number and types of measures being monitored and the nature and extent of utilization of these measures for various purposes. A practical consideration affecting the comprehensiveness and sophistication of a transit performance measurement system is the level of resources and staff expertise available for data collection and data processing. A simple, incremental approach is the soundest course of implementation. The approach would allow transit managers and operating personnel to learn through experience and strengths, limitations, and best applications of the transit performance measurement system.

AVAILBLE FROM: APTA

30. DEVELOPMENT AND APPLICATION OF PERFORMANCE MEASURES FOR A MEDIUM-SIZED TRANSIT SYSTEM

Allen, WG, Jr; Grimm, LG

Transportation Research Record No. 746, 1980, pp. 8-13

This paper summarizes the results of a study of service performance measurement and operating guidelines for the Delaware Authority for Regional Transit (DART) system. This fleet of 100 buses serves the Wilmington metropolitan area and is typical in many respects of many medium-sized bus systems across the country. The project consisted of several elements. First, a brief overview was presented of the historical perspectives on transit performance standards and the current state of the art, specifically noting activities at the state and regional level over the past few years. Next, a preliminary set of transit performance measures and operating guidelines was formulated for local review and comment. To assist in the evaluation of the adequacy of the preliminary performance measures and service standards, the draft standards were used to assess DART's existing operations. This assessment was hampered by a number of data inconsistencies, due primarily to the fact that much of the data required had been collected over a period of several years by using different data collection and analysis procedures. Efforts were made to minimize these inconsistencies and, where this could not be done, recommendations were made for improved data collection procedures to eliminate this problem in future years. As part of the service assessment, order-of-magnitude cost estimates were prepared to define the general range of capital and operating investment that would be required by DART to modify its current services so as to be in greater compliance with the proposed service standards and operating guidelines. The last step of the project was the preparation of guidelines to assist local agencies in the implementation of the service standards and operating guidelines and the continuous monitoring of DART's performance relative to these standards. This element of the project addressed the manner in which the current infrastructure for transit planning could be improved and described the appropriate level of detail and methodology for the continual evaluation of DART's performance. A discussion was presented of the basic procedures by which to amend or modify the service standards and operating guidelines. (Author) This paper appeared in TRB Record No. 746, Bus Transit Management and Performance.

AVAILABLE FROM: TRB Publications Office

31. DEVELOPMENT OF PERFORMANCE INDICATORS FOR TRANSIT

Fielding, GJ; Glauthier, RE; Lave, CA

California University, Irvine Institute of Transportation Studies, Urban Mass Transportation Administration Final Report UMTA-CA-11-0014-78-1, Dec. 1977, 133 p.

The objective of this research is to establish a rationale for the development of performance indicators for transit; to analyze potential indicators; and to apply a limited set of indicators to data collected from transit properties in the states of California and Washington. The focus herein is on the federal and state levels of government. The procedure is designed to develop and test criteria for the evaluation of performance of transit properties in different locations, of differing size, and with different operational procedures. This report presents the rationale and developmental structure for the evaluation of transit performance through quantitative performance indicators. It specifies efficient and effective transit service as appropriate goals to be encouraged by federal and state governments and identifies three efficiency and six effectiveness indicators which focus on signficant aspects of performance. Using operating and financial data collected from 47 public transit operators in California and 5 operators in Washington, the selected performance indicators are analyzed for comparability of values between different modes of transit, different service area population densities, and different organizational types. The performance indicator values for selected transit properties are individually interpreted to demonstrate the analytic use and limitations of indicators. Potential uses of performance indicators are identified and areas requiring additional research described. The Appendices include: a literature search; a listing of properties; operating and financial data; and a glossary. Sponsored by DOT, Urban Mass Transportation Administration.

AVAILABLE FROM: NTIS PB-278678

32. THE DEVELOPMENT OF SERVICE STANDARDS AND OPERATING GUIDELINES FOR THE DELAWARE AUTHORITY FOR REGIONAL TRANSIT (TASK B OF THE DART PLANNING PROGRAM)

Barton-Aschman Associates, Inc., Urban Mass Transportation Administration Research Report UMTA-IT-09-0061-80-1, Nov. 1979, 194 p.

The service standards project is one aspect of the Delaware Authority for Regional Transit (DART) planning program intended to increase DART's patronage, improve DART's operational efficiency, and increase the regional transit accessibility with the Wilmington urbanized area. It is anticipated that the service standards research project will help fulfill this goal by achieving the following objectives: 1) development of service standards relating to the users that contribute to the realization of an optimal traveling environment; 2) development of service standards that aid the transit operator by contributing to the efficiency of operations and service delivery; and 3) development of service standards to aid the community by contributing to the quality of life in the DART service area. Consistent with these basic project objectives, the study has resulted in the development of a group of proposed service standards and operating guidelines for DART which provide a firm framework for the future provision of public transportation services throughout the Wilmington metropolitan area. Although these standards and guidelines are intended initially for application only to DART operations, they developed in such a way as to allow their application in any portion of the New Castle County, Delaware-Cecil County, Maryland-Salem County, New Jersey SMSA. This report presents an introduction and background of transit performance measurement, a detailed description of the transit service standards and operating guidelines proposed for adoption by DART, and an assessment of the degree to which DART's current operations are in compliance with the suggested standards and basic planning guidelines. In addition, a preliminary estimate of the costs required to have DART's service meet these proposed standards and guidelines is included. (UMTA)

AVAILABLE FROM: NTIS PB80-196322

33. DISCUSSION OF THE REPORT OF THE INTERNATIONAL AUTOMATION COMMISSION: CALCULATION OF ROUTE PERFORMANCE AND OPERATING RESULTS OF PUBLIC TRANSPORT UNDERTAKING, AND ITS EFFECTS, TAKING INTO ACCOUNT ELECTRONIC DATA PROCESSING

Hoffstadt, J

Intl. Union of Public Transport/Belg/39th Intl. Congress, 1971, pp. 118-126

The author's detailed, schematic introduction to this paper presented to the full commission is followed by discussion of issues raised therein and by the two conclusions adopted by the commission with respect to this topic. The introduction covers five main subjects: (1) integration of the calculation of route performance and operating results with the commercial accounting system, (2) structure and method of calculation of route performance and operating results, (3) possibility of evaluating the calculation of route performance and operating results, (4) problems associated with the calculation of route performance and operating results, and (5) possible refinements of the calculation of route performance and operating results. The conclusions are: (1) the services offered and results achieved by public passenger transport undertakings should be calculated for each route. Forecasts should be compared with results over a period of time to assess the profitability and efficiency of the routes; and (2) electronic data processing permits the various interrelations of variables to be assessed rapidly and guarantees integration of all procedures.

34. DRAWBACKS INHERENT IN CURRENTLY USED MEASURES OF MASS TRANSIT PERFORMANCE

Barnum, DT; Gleason, JM

Nebraska University, Urban Mass Transportation Administration Spec. Report UMTA-NE-11-0002, May 1980, 19 p.

The paper examines weakness and biases inherent in certain measures of urban mass transit performance. The concepts of effectiveness and efficiency in transit are discussed, and the shortcomings of some currently used effectiveness ratios are examined. It is noted that many of the effectiveness measures should more properly be classified as efficiency measures. Weaknesses of certain efficiency measures are also examined. The performance measures examined are cost per passenger, passengers per vehicle hour, vehicle miles per operator, and cost per vehicle hour. Prepared in cooperation with Indiana Univ. Northwest, Gary.

AVAILABLE FROM: NTIS PB81-109308

35. EFFECTIVENESS AND EFFICIENCY: EVALUATING TRANSIT'S PERFORMANCE

Cox, W

Passenger Transport, Nov. 1979, pp. 6-7

This article was based on the premise that there are two primary elements in transit management: effectiveness (identifying and doing those things which best serve the community) and efficiency (doing what we do in the best way). Effectiveness, a political issue, includes the setting of service goals and standards which will be implemented by the transit system. A major subset of effectiveness is equity, i.e., defining the balance between serving transit needs and returnig to various communities some portion of the tax revenue. Transit management should do all that it can to encourage the policy board to make effectiveness decisions because the policy board is most expert at politics. Efficiency, service provided in the most efficient manner, should primarily be under management control and less dependent on politics than is effectiveness. It is important to keep issues of effectiveness and efficiency clearly separated since mixing of the two unnecessarily clouds the issue. Management performance can be measured through the use of performance indicators: number of boardings per passenger trip, subsidy contributed per subsidy expended, subsidy per revenue service hour, and passengers per service hour. Performance indicators should be used generally to identify the proper questions to ask to obtain better system performance. Effectiveness indicators compare the performance of the transit system to the goals set by the policy board and the performance this year and previous years. Efficiency indicators compare the performance of the agency to previous years and to other similar agencies. The transit industry must strive to (a) correct public concept of cost of public service, (b) address internal management controls and performance and (c) research further into management and performance. The author concludes that the most important issue which is going to face transit in the future is the issue of management and management performance.

AVAILABLE FROM: APTA

36. EFFECTIVENESS AND EFFICIENCY IN TRANSIT PERFORMANCE: A THEORETICAL PERSPECTIVE

Talley, WK; Anderson, PP

Transportation Research. Part A: General Vol. 15A No. 6, 1981, pp. 431-436

This article explores transit efficiency and effectiveness from the perspective of the firm itself and in terms of government objectives for transit service. These objectives are not mutually exclusive. From the point of view of the transit firm, effectiveness can be defined as the maximization of ridership within allowable deficit limits; a firm is said to be efficient if it minimizes the operating costs to be incurred in providing a given level of ridership. Effectiveness and efficiency performance criteria can be derived from an analysis of the variables which influence both demand (effectiveness) and cost (efficiency) functions and which can be manipulated by the firm. Performance standards are defined as those values of the performance criteria which will optimize the effectiveness and efficiency functions. Government objectives for transit can be defined as maximizing social well-being, economic development and environmental quality. Attainment of these objectives is predicated on the transit firm being both effective and efficient; if the firm is not effective and efficient, ridership and social benefit from ridership will be diminished. Since a transit firm must be both effective and efficient before a subsidy can be effective, and with the transit firm affecting the objectives of the government by the number of passenger trips provided, the authors conclude that transit systems should be evaluated from the perspective of the firm rather than that of the goverment.

AVAILABLE FROM: Pergamon Press Limited

37. THE EFFECTIVENESS AND EFFICIENCY OF TRANSIT SYSTEMS

Bennett, J; Helm, B

RTAC Forum Vol. 2 No. 3, 1978, pp. 39-44

Goals for the operation of transit services have shifted dramatically during recent years. Commercial "break-even" objectives have been displaced by broader considerations of community and social service. The role of the transit organization now includes the provision of all day area-wide services, the relief of peak period congestion, the carriage of handicapped, and the shaping of land-use development. To meet the costs of these broader policies of public service, provincial and municipal governments are providing financial assistance to supplement farebox revenues. Originally conceived as a blanket compensation for the continued operation of unremunerative services, the level of assistance now warrants the development of new and appropriate management information services through which to monitor "value for money". These management information systems are needed to increase efficiency in transit operations through the provision of timely data for use in internal management. These systems will also serve a role in the provision of external data to funding agencies concerned with accountability of their investments in transit services. The paper reviews some of the considerations which should be taken into account in the development of procedures for measuring and monitoring the effectiveness and efficiency of transit services, and for determining the cost effectiveness of individual operational and management activities. Examples are given of the kinds of information needed to judge how well a property is being run. The need for service-specific information is discussed together with associated problems of cost allocation. A distinction is drawn between the separate interests of management, in budgeting for and monitoring the day-to-day business, and municipal and provincial planning and funding agencies, in setting and monitoring overall targets.

AVAILABLE FROM: Roads and Transportation Association of Canada

38. EVALUATING INDIVIDUAL TRANSIT ROUTE PERFORMANCE

Glauthier, RE; Feren, JN

Transit Journal Vol. 5 No. 2, 1979, pp. 9-26

This investigation of the use of internal route evaluation techniques by transit properties, includes a discussion of the need for such evaluation schemes and their inherent weaknesses or problems, the development of route evaluation procedures, and the route evaluation techniques presently in use by three public transit properties in California and two transit properties outside of California. The developmental relationship between goals, objectives and performance indicators is emphasized. A major advantage in progressively developed goals, objectives and indicators is that conflict between the various elements is prevented. Clearly stated policy not only eases the problems of management in the public sector but provides for varying degrees of political control and input necessary in such a multi-governmental area such as transit. The utilization of well-defined evaluation processes similarly eases the task of public management administratively as well as politically. Route evaluation schemes provide a means for simplification of data analysis through predetermined performance indicators.

39. EVALUATING PUBLIC TRANSPORTATION FOR EFFECTIVE DECISION-MAKING

Hill, NE

Transportation Research Board Special Rpt. No. 155, 1975, p. 29

This paper views evaluation criteria in the transportation planning process from the operator's perspective. It is concluded that evaluation criteria for goals/objectives, and responsibilities must be designed to permit innovation in organization structure, facilities, operating procedures and practices, and service promotion, merchandising, and marketing. A table is presented showing evaluation criteria from the operator's perspective. It is organized according to the following three major areas of concern: organization, facilities, and operations.

AVAILABLE FROM: TRB Publications Office

40. EVALUATING THE SMALL SYSTEM

Dorfman, MJ

Passenger Transport Vol. 37 No. 32, Aug. 1979, p. 7

With funding from the Urban Mass Transportation Administration, the Montgomery Area Transit System (Montgomery, Ala.) has developed and applied a simplified route evaluation procedure appropriate for small transit systems with limited resources for ongoing service evaluation. This procedure relies upon four indicators of route performance: revenue per hour, passengers per mile, subsidy per passenger, and variable cost per hour. Quantitative standards were established for each of these measures. Data on the performance of each route in the system are collected monthly and analyzed quarterly using a small, programmable calculator. Based on this performance analysis, the routes are ranked on each indicator so that poor performing routes can be identified and analyzed for corrective action. Tangible operating cost savings ($27,500 in 10 months) were reported as a result of the application of this procedure to two routes in the MATS system. The author concludes by stressing the importance of scaling transit performance evaluation programs to the size and budget of the system being evaluated.

AVAILABLE FROM: APTA

41. EVALUATION MANUAL FOR MID-SIZE TRANSIT SYSTEMS IN THE STATE OF MICHIGAN

Peat, Marwick, Mitchell and Company, Michigan Department of Transportation, Aug. 1979, n.p.

This document describes the methodology for conducting an ongoing performance evaluation of mid-sized transit systems in the State of Michigan. This manual is supplemented by a companion data needs manual which identifies and defines the data and information needed to support the performance evaluation methodology. The manual includes an overview of the evaluation methodology, a brief discussion of industry concern over peer and time-series analysis, an introduction to the set of performance indicators developed for the program and their roles in the evaluation process, and step-by-step guidelines for conducting initial diagnostic and in-depth site visit evaluations. Appendices to the report include a summary analysis of transit performance evaluation programs in major U.S. transit properties and results of a pilot application of the Michigan methodology to the state's midsized properties.

AVAILABLE FROM: Peat, Marwick, Mitchell and Company

42. EVALUATION OF FIXED ROUTE TRANSIT PERFORMANCE: THE METHODOLOGY AND APPLICATION OF THE TRANSIT ROUTE EVALUATION PLANNING PACKAGE (TREPP)

Siegel, SM; Milione, V

Iowa University Institute of Urban and Regional Research, Dec. 1975, 66 p.

This manual complements a computerized simulation software package (TREPP) which was developed to organize and generate information needs required in transit planning projects. In this manual, the basis of TREPP analysis is set forth. An articulated impact taxonomy of transit service options based on a systems analysis paradigm is constructed. In addition, the terminology of TREPP analysis is defined, and the problem of transport systems analysis is placed within the TREPP context. The need for a disaggregate or behavioral based evaluation process is indicated, and the idea of a user-based construct which complements existing planning paradigms is forwarded. The output of the TREPP is presented, and an introductory overview of the TREPP algorithim is provided with special emphasis on data requirements. The manual also describes the application of TREPP; the measures generated by TREPP are operationalized in terms of efficiency, effectiveness, adequacy and equity indicators. TREPP's analytical framework begins by defining a study region in terms of (a) the transit network and operating policy, (b) the quantity and distribution of urban activities, and (c) its socio-economic profile. The evaluative framework of TREPP adopts a particular zone within the region. Its transit service is measured and evaluated in terms of the input and output dimensions of service, and the access of opportunity provided by the interaction of the transit service with the land distribution. Access opportunity is measured in terms of the cummulative number of ubran opportunities available within the specified impedance intervals.

43. EVALUATION OF PUBLIC TRANSIT SERVICES: THE LEVEL-OF-SERVICE CONCEPT (ABRIDGMENT)

Alter, CH

Transportation Research Board No. 606, 1976, pp. 37-40

There are two key independent combinations of factors that can be directly controlled by transit policy makers: transportation hygiene factors and indicators of the level of service. Of these two, only the LOS indicators can motivate potential riders; transportation hygiene factors can only discourage. The following parameters are used to define transit LOS: a composite of basic accessibility, travel time, reliability, directness of service, frequency of service and passenger density. The operationalism of the concept must be evaluated according to whether it is (a) user oriented, (b) operations oriented, (c) trip or link specific rather than area related, (d) quantifiable by an independent observer, (e) independent of an evaluation of efficiency measures and effects or impacts, and exclusive of any transportation hygiene factors. Conceptual indicators and operational definitions are discussed, alternative conceptual indicators are listed, and aggregation of the indicators is detailed. This model evaluation methodology appears to provide a useful framework for transit professionals and decision makers to evaluate public transit.

AVAILABLE FROM: TRB Publications Office

44. FIELD APPLICATION AND EVALUATION OF BUS TRANSIT PERFORMANCE INDICATORS. FINAL REPORT

Sinha, KC; Guenthner, RP

Purdue University School of Civil Engineering, Urban Mass Transportation Administration Report UMTA-IN-11-0005-81-2, Mar. 1981, 132 p.

This research study was performed in two parts: (1) field examination of the use of performance measures, and (2) use of the performance evaluation model. The first part of this research surveyed 19 bus transit operators in the five state area of Illinois, Indiana, Michigan, Ohio, and Wisconsin. The study revolved around operations data collection and the type and degree of performance evaluation in current use. An assessment of the adequacy of the indicators was performed. The current and potential uses of performance monitoring were evaluated especially in relation to the goals and objectives of the system. In general, the study concludes that about half of the transit systems visited collect enough operating data to inexpensively develop a comprehensive performance monitoring program. The second part of this study involved implementation of the Performance Evaluation Model developed that was basically designed to evaluate the effects on performance due to a short term change in fare, headway, or number of stops on a bus route. Several cities were selected. The actual operating statistics were compare to the model output. The model was also modified to provide for more ease of use, flexibility, and accuracy. The report states that the field tests for this model have indicated its reliable estimates of a variety of performance measures. This report contains a list of references, and includes a detailed user's manual describing the data preparation and program logic. See also PB81-209330.

AVAILABLE FROM: NTIS PB81-209348

45. FINANCING AND EVALUATING PUBLIC TRANSIT SYSTEMS IN CALIFORNIA: REPORT TO THE CALIFORNIA LEGISLATURE

Office of the Auditor General, Report 295, Jan. 1977, n.p.

This report reviews the factors underlying the declining performance of California's transit systems and suggests ways in which the state might encourage productivity improvements through modification to the subsidy allocation process. The report notes the inadequacy of the state's auditing procedures for transit operator performance and reviews a number of candidate evaluation techniques and indicators. It recommends that the state enact legislation requiring annual performance audits for transit systems receiving state operating assistance which would combine the analysis of selected indicators of financial and management performance with in-depth audits of the system's operational components. Recommended performance indicators are: operating cost/vehicle service hour; vehicle service hour/employee; operating cost/passenger; passengers/vehicle service hour and passengers/vehicle service mile.

AVAILABLE FROM: Office of the Auditor General, Joint Legislative Audit Committee, Sacramento, CA

46. FINDING A SUITABLE FRAMEWORK FOR PERFORMANCE INDICATORS

Dodge, SA

Passenger Transport, May 1979, n.p.

This article explores the external use of performance indicators by transit board members. The purpose is to show how well management is doing its job and to establish intermediate roles between transit and public. The most feasible framework to obtain these data include: goals, measurable objectives (performance indicators) and evaluation. Advantages and disadvantages of measurable objectives are discussed. The author concludes that performance indicators and objectives for external purposes and internal purposes are different, but the framework of goals and objectives would help determine what transit systems could and should do.

AVAILABLE FROM:: APTA

47. FLORIDA TRANSIT SYSTEM PERFORMANCE MEASURES AND STANDARDS

Post Buckley Schuh and Jernigan, Inc., Florida Department of Transportation, 1979, 144 p.

This report documents the results of a study designed to identify and select transit performance indicators and standards which would (1) assist the state's transit operators in the internal evaluation of routes, functional, and systemwide performance, and (2) assist the state in the allocation of financial resources to the state's transit properties.

The selection of measures, and the initial determination of the accessibility and reliability of data to support the indicators and standards, was based on input from site visits and questionnaire surveys of the state's transit operators. "Performance effectiveness" and "performance efficiency" were established as goals to guide transit property management and resource allocation. A set of eight operational objectives, intended to clearly define the selected goals, were adopted. Quantitative performance measures, and factors which influence performance on each of these measures, were then defined. To assist in comparative evaluation, standard value ranges for each performance measure were also derived. The report includes a complete listing of these measures, standard value ranges, and Section 15 reference locations.
Prepared in cooperaton with McDonald Transit Associates, Incorporated.

AVAILABLE FROM: Florida DOT

48. GENERAL AND PERFORMANCE SPECIFICATIONS FOR A SMALL URBAN TRANSIT BUS

RRC International, Inc., Urban Mass Transportation Administration Intrm. Report UMTA-IT-06-0074-77-5, Dec. 1976, 148 p.

The overall objective of the Small Bus Project is the development of a general and performance specification for an advanced small urban transit bus. It is a six-phase program designed to insure that final vehicle specifications would evolve from a comprehensive analysis of all aspects of the operating environment and thus have a broad applicability. The Small Bus Project is presented in six separate reports: (1) Operations of Small Buses in Urban Transit Service in the United States. This report investigates the operating environment of small buses in the U.S. and relates them to vehicle requirements; 2) Bus Characteristics Needed for Elderly and Handicapped in Urban Travel. Constraints imposed on bus design by the elderly and handicapped are outlined; 3) Operating Profiles and Small Bus Performance Requirements in Urban Transit Service. This report develops a set of operating profiles and service requirements as the basis for specifications for a new small urban transit bus to meet the identified operational needs; 4) Guidelines for the Design of Future Small Transit Buses and Bus Stops to Accommodate the Elderly and Handicapped. This report presents scenarios for the future uses and market of small buses, as well as the conceptual design for three vehicle configurations to assess the feasibility of meeting design requirements; 5) General and Performance Specifications for a Small Urban Transit Bus. Requirements for an advanced design coach which may be used for both demand-responsive and general service on urban arterial streets are presented; 6) Small Transit Bus Requirements Study. This report summarizes the findings presented in the five project reports. /FHWA/ Sponsored by the Urban Mass Transportation Administration, DOT.

AVAILABLE FROM: NTIS PB-269397

49. GUIDELINES FOR USING OPERATING CHARACTERISTICS IN THE EVALUATION OF PUBLIC TRANSIT SERVICE

Allen, WGJ; DiCesare, F

New York State Assembly Scientific Staff, National Science Foundation SS-504, NSF/RA/G-75/095, June 1975, 97 p.

This report is an introduction to transit service evaluation and its application to transit systems such as those of upstate New York. The intent of the report is to serve as a basis for legislative decision-making concerning public transit services. The concept of transit evaluation in terms of level of service is discussed in detail. The state of the art in research and practice is studied. The theory of transportation evaluation is examined along with several of the important issues involved such as transit operating subsidy. The main purpose of the report is to present and discuss a comprehensive set of service characteristics which should be considered in bus transit evaluation. The application of an evaluation methodology is discussed and an example is given to clarify the concepts. The report proposes guidelines which explain how the New York State Legislature and other agencies should become involved in the implementation of a transit evaluation system. Some of the difficult issues which may arise are mentioned as well as measures that could be taken to abate these problems.

Prepared in cooperation with Rensselaer Polytechnic Inst., Troy, NY. School of Engineering, and New York Sea Grant Inst., Albany.

AVAILABLE FROM: NTIS PB-301429/7ST

50. HANDBOOK FOR MANAGEMENT PERFORMANCE AUDITS: VOLUMES I AND II

Smerk, GM

Indiana University, Bloomington Institute for Urban Transportation, Urban Mass Transportation Administration Report UMTA-IN-11-0004-79-1 October 1979, 186 p.

This is a comprehensive examination and evaluation of a transit system's goals and objectives and the procedures it uses to accomplish these goals and objectives. The audit takes into account the resources with which the system has to work and constraints under which it must operate. A management performance audit has two purposes: 1) to improve the efficiency and effectiveness of the system by providing management with information to improve its practices and procedures and 2) to show how well public funds are being used by determining the efficiency of the operation. This Handbook introduces decision makers in transit properties, municipalities, Metropolitan Planning Organizations, and State Departments of Transportation to the concepts and techniques involved in management performance audits. The Handbook is comprised of two volumes. Volume I, describes the theory and technique of carrying out a management performance audit. The history and benefits of the audits are introduced: a description of the characteristics of a transit system including its social, political, and economic environment, its governing body, and its internal functions such as maintenance and transportation are addressed; and a discussion of the auditor's procedures from the planning of the audits to preparing the written report is presented. Volume I also gives background information for using Volume II. The appendix in Volume I provides a written report on an actual management performance audit. Volume II, is a field guide consisting of outlines are questionnaires used in conducting an audit. The outlines and questionnaires are provided for each characteristic of a transit system including its external environment, its governing body, and its internal functions such as maintenance, transportation, accounting, and finance. The outlines give the auditor a guide for collecting data by way of interviewing employees and other individuals involved with the transit system. The questions provide technical detail that an auditor must collect from each functional area. The report number for Volume II is: UMTA-IN-11-0004-79-2, PB80-117492.

AVAILABLE FROM: NTIS PB80-117484 & PB80-117492

51. IMPROVING SERVICE QUALITY AND EFFICIENCY THROUGH THE USE OF SERVICE STANDARDS

Tober, RJ

Transportation Research Board Special Report No. 172, 1977, pp. 86-91.

This paper describes the service policy of the Massachusetts Bay Transportation Authority for surface public transportation and its use in urban transportation system management. The establishment and use of a comprehensive statement of service policy are discussed in the context of TSM objectives. Such a service policy, which contains service goals and objectives, service standards and guidelines, and planning and evaluation procedures, provides the transit manager with a management control framework for monitoring service performance and identifying remedial actions that will improve the quality of service and the efficiency and effectiveness of resource allocation. The paper describes how MBTA uses the control framework embodied in its service policy to identify both general service improvements and some specific TSM service improvements such as reserved bus lanes on arterial streets. The paper concludes by discussing how the MBTA service policy through cooperative planning has begun to make local city and town policy makers more sensitive to transit operations, thereby enhancing the prospects for successful implementation of potentially controversial TSM projects. /Author/ From TRB Special Report No. 172, Transportation System Management, proceedings of a conference held November 7-10, 1976, conducted by the Transportation Research Board; and sponsored by the Urban Mass Transportation Administration and the Federal Highway Administration of the US DOT in cooperation with the Institute of Transportation Engineers.

AVAILABLE FROM: TRB Publications Office

52. IMPROVING USEFULNESS OF SECTION 15 DATA FOR PUBLIC TRANSIT

Holec, JM, Jr.

Transportation Research Board No. 835, 1981, pp. 9-15

The purpose of this paper is to accelerate the creative and insightful use of a new and powerful data base. The paper focuses on the use of Section 15 data as a surveillance and monitoring tool for statewide transportation planning and management. Use of Section 15 data for this purpose is receiving widespread attention and is advancing from initial consideration to development and implementation in many areas. This activity is likely to increase with the release of Section 15 data by the Urban Mass Transportation Administration. Two principal methods for improving the usefulness of Section 15 data are discussed in this paper. The first method involves improving the potential user's familiarity with the nature and quality of data. This familiarity will foster informed analysis and limit misrepresentation of a transit system's financial and operating performance. The second method involves enhancing the data base itself through editing and correcting the initial submissions of transit operators, clarifying reporting instructions (and thereby improving the quality of data submitted), modifying reporting forms, refining data-collection techniques, adding or deleting data elements, and/or augmenting the Section 15 data base with other available data. These methods are introduced by first providing a brief perspective on the type of information contained in the Section 15 data base, discussing specific shortcomings with the current data, and concluding with a summary of methods for improving the usefulness of the data base.

This paper appeared in Transportation Research Record No. 835, Transportation System Analysis.

AVAILABLE FROM: TRB Publications Office

53. INDICATORS: MEASURING PRODUCTIVITY

Passenger Transport Vol. 35 No. 44, Nov. 1977, 3 p.

This article summarizes the official position of the American Public Transit Association (APTA) concerning the development and application of transit performance indicators. APTA urges transit operators to take a leadership role in this area to insure that indicators are appropriately defined and applied. It endorses the use of performance indicators for measurement of progress toward internal goals and objectives, for evaluation of systemwide progress from year to year, for evaluation of individual service improvements, and for communication with government agencies. It cautions against the use of indicators for peer analysis because of the influence of external variables on transit performance. It argues that no single indicator can be used to assess system or managerial performance and that simplicity is necessary to insure that indicators are easily understood and applied. The article presents APTA's definitions of the concepts of efficiency and effectiveness and suggests useful indicators for development of a balanced and appropriate performance assessment program.

AVAILABLE FROM: APTA

54. INNOVATIVE TRANSIT SERVICE PLANNING MODEL THAT USES A MICROCOMPUTER

Turnquist, MA; Meyburg, AH; Ritchie, SG

Transportation Research Record No. 854, 1982, pp. 1-6

Transit service planning is the process of designing appropriate services, including considerations of area coverage, integration with other transit services, and the frequency of service that can be justified economically as well as socially and politically. A simple and usable analytic model to guide management in the search for, and evaluation of, operating strategies that meet local transit service objectives is described. This analysis system is intended primarily for use on single routes or in transit corridors that include a small number of parellel or serial routes. The model system includes as basic components models of supply (system performance), demand (mode and path choice), cost, and evaluation-measure prediction. The supply-and-demand components are linked in an explicit equilibration structure to include the important interactions between transit system performance and passenger volume. Design options that can be explored with the model system include fare and headway changes, scheduling changes such as turnbacks, etc. Two major aspects of this model system are that (a) it is designed to make maximum use of readily available data and (b) it has been implemented on a microcomputer (an Apple III) in order to minimize the investment in computer resources. This paper appeared in Transportation Research Record No. 854. Bus Services.

AVAILABLE FROM: TRB Publications Office

55. LEVEL OF SERVICE CONCEPT APPLIED TO PUBLIC TRANSPORTATION

Bullard, DL; Christiansen, DL

Texas Transportation Institute, Urban Mass Transportation Administration Final Report UMTA-TX-81-10671F, Aug. 1981, 71 p.

This research developed a preliminary level-of-service evaluation approach for fixed-route bus systems in Texas. Based on a review of existing LOS Models and interviews with Texas transit operators, eight indicators were identified and defined: Accessibility, travel time, directness of service, delay, frequency of service, reliability, passenger density, and passenger comfort. Quantitative values or standards corresponding to levels of service A through F were assigned to each indicator and, based on the preferences, a weighting technique was developed to determine the relative importance of each indicator. Passenger density, reliability and frequency of service received the highest ratings. The proposed LOS concept can be used to evaluate the entire transit system, a single route or run, or a segment of a specific route or run. Data collection techniques for each indicator are briefly outlined. The approach is illustrated with a sample evaluation of an inbound-outbound trip on one route of the Austin Transit System.

AVAILABLE FROM: NTIS

56. LEVEL-OF-SERVICE CONCEPT FOR EVALUATING PUBLIC TRANSPORT

Botzow, H

Transportation Research Record No. 519, 1974, pp. 73-84

A system of evaluating service variables common to all public transport modes is proposed so that an existing system may be managed or improved and a new system may be built on the basis of its ability to fulfill a desired level of service. The variables discussed are those directly perceived by the user regardless of mode: overall trip speed and en route delay and comfort factors associated with the vehicle including density, acceleration, jerk, temperature, air flow, and noise. Improving one or more of these measurable variables bears an associated cost and design requirement. Since better service is desirable in certain situations while average service is sufficient in others, levels of service A through F are adopted for each variable. In the proposed system, level of service is determined by the use of a weighted average of rankings assigned to individual factors. Within tolerable limits, 40 percent of the overall ranking should be based on speed and delay and 60 percent on comfort factors. When an individual comfort variable becomes intolerable, the entire ride is at service level F. Applicaton of the procedure results in reasonable comparisons of both systems and individual trips within a system.

Prepared for the 53rd Annual Meeting of the Highway Research Board.

AVAILABLE FROM: TRB Publications Office

57. LEVEL-OF-SERVICE CONCEPTS IN URBAN PUBLIC TRANSPORTATION

Taylor, W; Brogan, J

Highway Safety Research Institute, Michigan State Highway Commission UM-HSRI-78-50, Sept. 1978, 22 p.

The study examines the level-of-service concept as it might be applied to public transportation services. It describes proposed definitions of public tranpsortation level of service based on both system and rider attributes. The variation of public transportation quality as viewed by various user market segments is examined, and the sensitivity or demand elasticity to the various factors constituting 'level-of-service' is then made. Finally, a proposed study methodology to evaluate the increased level of service provided to user groups in line with their perceived measures of service quality is outlined.

Sponsored in part by Michigan State Highway Commission, Lansing.

AVAILABLE FROM: NTIS PB-298849/1st

58. MANAGEMENT INFORMATION SYSTEMS: A DIAGNOSTIC APPROACH

Prangley, RE

Transit Journal Vol. 6 No. 1, 1980 pp. 27-34

This article reviews the advantages of, and dangers inherent in, the use of transit management information systems. A well conceived MIS should monitor performance with basic, simple measurements which alert administrators to potential problems or trends in performance. The number of indicators is not as important as their effectiveness in conveying relevant information. The goal is to analyze trends, identify problem areas, and explain variations in performance so that well documented decisions can be made. The MIS should enable the manager to analyze problems that may cross inter-organizational boundaries. This is illustrated with a "decision tree" or diagnostic approach to isolating and identifying the cause of decline in on-time performance in a case study property.

AVAILABLE FROM: APTA

59. MANAGEMENT INFORMATION SYSTEMS: A TOP-DOWN APPROACH

Mundle, SR; Carter, DW

Booz-Allen and Hamilton, Inc., 1983, n.p.

In recent years, improvement of management information systems (MIS) has been the focus of significant concern in the transit industry. Operating in an era of declining public funding, transit managers are concentrating on productivity improvements as a means of preserving service integrity. A sound MIS is an important tool for realizing potential efficiencies through improved performance. Performance statistics and indicators provide diagnostic tools while presenting an overview of systems status. The historical approach to MIS development has been through use of extensive hardware and software systems programmed to capture and process detailed information pertaining to all aspects of operations. It might be described as a bottom-up approach. Although this technique provides an excellent data base, it does not necessarily fulfill the specialized information needs of top-level managers. This paper presents a different approach to MIS development, referred to here as a top-down approach. A case study of the Chicago Transit Authority's (CTA) development of a performance monitoring program, consisting of reports for the CTA Board, the Executive Director, and Department Managers is used to illustrate the concept. The approach used at the CTA merits consideration for two primary reasons. First, a top-down approach was used to ensure that management needs determine the structure of the reporting system and not current data availability or data-processing capabilities. Second, the program is not constrained by computer capacity, thus making the concept applicable to a wide variety of transit organizations.

AVAILABLE FROM: TRB Publications Office

60. MEASURES OF OPERATIONAL PERFORMANCE FOR URBAN BUS SERVICES

Silcock, DT

Traffic Engineering and Control Vol. 22 No. 12, Dec. 1981, pp. 645-648

The paper deals with the problem of measuring the effectiveness of the running of a bus service along a particular route to a predetermined schedule and set of fares. Potential performance measures are categorized as efficiency measures, which evaluate the quality of system management and operation, or effectiveness measures that determine the cost-effectiveness. The measure of service performance should reflect management objectives, should not require extensive and expensive data collection and should be capable of monitoring changes in conditions. The author reports on the indicators used by British bus operators and assesses the effectiveness of each measure. No single optimum measure is found, but those measures which relate most closely to the aspects of service most important to passengers (reliability, availability of a seat) require extensive data collection for valid statistical analysis. It is suggested that the extent of late running approaches is a 'cost-effective' measure in that it can be related to reliability and passenger waiting times, and it requires only moderate data collection. (TRRL)

AVAILABLE FROM: ESL

61. MEASURING THE EFFECTIVENESS OF LOCAL GOVERNMENT SERVICES: TRANSPORTATION

Winnie, RE; Hatry, HP

Urban Institute, U.S. Department of Housing and Urban Development Rpt. No. URI-16000

A consumer-oriented approach is made to assessing the quality of local transportation. The authors propose a system that local governments may use to estimate how well their transportation-related services are serving their citizens. Twelve specific measures of effectiveness, keyed to such broad goals as accessibility, convenience, travel time, safety, and maintenance of environmental quality, are proposed. Ways to collect and analyze the necessary data are indicated. Summary recommendations and cost estimates for carrying out the measurement system are provided. Library of Congress Catalog Card no. 72-95475.

AVAILABLE FROM: NITS PB-233390/4

62. MEASURING THE PERFORMANCE OF TRANSIT SYSTEMS

Dajani, JS; Gilbert, G

Transportation Planning and Technology Vol. 4 No. 2, Jan. 1978 pp. 97-103

This paper reviews the need for the development of transit performance measures, in the light of recent legislation and public subsidy issues for public transportation in the United States. An evaluation framework is presented, which defines and distinguishes between the efficiency, effectiveness and impact of public transit efforts. The application of this framework in evaluating public transit investments, and the use of the performance measures obtained through the application of this framework, in the allocation of funds among systems is then discussed. Research needs with respect to data collection requirements, cross-jurisdictional comparability, and the utility of the proposed performance measures for decision-making are finally discussed. /TRRL/

AVAILABLE FROM: ESL

63. MEASURING TRANSIT SERVICE. PROCEDURE MANUAL NO. 4A

Public Administration Service 1958, n.p.

This manual has two objectives: (1) to provide procedures for measuring and controlling the existing level of transit services so they may be operated on an efficient and economically sound basis and (2) to give guidance for gathering information by which transit management and public officials may integrate transit operations with overall community transportation policies. It discusses methods for the measurement of existing transit services in terms of routes and coverage, passenger loading, frequency and regularity of service, running time, and speed and delays. These procedures have been used for many years by transit operators. Data obtained from these measurements can be compared with the standards set forth in the Public Administration Service's Manual 8A ("Recommended Standards, Warrants and Objectives for Transit Services and Facilities") to determine what deficiencies, if any, exist and to furnish a background for any necessary improvement. The manual includes sample data collection forms.

AVAILABLE FROM: Public Administration Service, Chicago.

64. MEASURING TRANSIT SYSTEM PRODUCTIVITY AND PERFORMANCE

ITE Journal, Nov. 1982, pp. 24-27

This article summarizes the activities of the Institute of Transportation Engineer's Committee 6F-22 which undertook a study of performance indicators used by transit operators, local and regional planning agencies, and state and local governments. The specific objectives of the study were to: (1) identify performance measures of performance indicators considered most useful by the transit operators and state and provincial trasnportation agencies, (2) identify how the measures are utilized by different sectors of the transit community, and (3) identify the methods for assembling the required data. A field survey was undertaken of a group of operators and state and provincial transportation agencies in the U.S. and Canada. The survey uncovered a wide range of indicators currently in use and wide variance in the data collection and analysis capabilities of the agencies surveyed. Summary tables list those measures not commonly used by type of agency for the following uses: funding requirements, operations improvement, regulatory compliance, performance audits and capital planning.

AVAILABLE FROM: ITE

65\. METHOD FOR DEVELOPMENT OF A MASS TRANSIT EVALUATION MODEL BASED ON SOCIAL SYSTEM VALUES

Keller, WF

Highway Research Record No. 427 pp. 63-73

This paper describes a method in transportation systems engineering that provides a means of identifying the customers, or decision-makers, and their wants. The method was developed and applied to the hypothetical example of a peoplemover for downtown Los Angeles. The approach couples the methodology of systems engineering with utility theory and survey techniques. It includes steps to identify needs, characterize systems, establish performance criteria, identify decision-makers and their criteria, identify the implementation process, and generate the evaluation model. In the example, 4 basic groups of decision-makers were identified: government technicians, government managers and public officials, local businessmen, and potential riders. Questionnaires, tailored for each group, provided weightings of the decision-maker's influence, delegation of responsibility, criteria from the general down to the component level, and utility data points for all significant component criteria. Results were formulated into a composite value model that was used to generate both a tabular and a computerized evaluation model based on corresponding performance criteria and measures. The method provides identification of the social system decision-makers, their needs and influence, and a meaningful correlation and translation into technical criteria. The research shows the effectiveness of utility curves both as a quantitative measure of performance for a given criteria and as a means of combining worths of multidimensional criteria. /Author/

66\. METHODS OF PROMOTING EFFECTIVE AND EFFICIENT TRANSIT SERVICE

Institute of Transportation Engineers, 1978, pp. 65-70

This article briefly reviews concepts of transit efficiency and effectiveness; reviews and evaluates a number of common measures of transit system performance; and illustrates how established goals and objectives can be translated into a set of planning and operating standards and targets for remedial action. This process is illustrated with a case study of transit service planning in Tuscon, Arizona. Because of staffing limitations, this procedure was designed to rely on simple measures, readily covertable to computer processable form. Like many "sunbelt" cities, Tuscon has experienced unusually rapid population growth in major employment sites and adjacent suburban residential areas. To evaluate the cost-effectiveness of proposed transit routes to serve these areas, three factors were selected: (1) number of dense dwelling complexes, (2) population served, and (3) number of major transit trip generators, i.e., schools, medical centers and shopping complexes. Analysis was conducted using questionnaires distributed at major employment sites, geo-coding of residential locations of employees, and other techniques. Results of this analysis are briefly described.
Compendium of Technical Papers. Institute of Transportation Engineers 48th Annual Meeting.

AVAILABLE FROM: ITE

67. METROBUS PERFORMANCE MEASURES AND INDICATORS REPORT

Washington Metropolitan Area Transit Authority May 1974, n.p.

This report consists of the comparisons of performance for key efficiency, effectiveness, and financial indicators: (1) on time-trend basis; (2) in comparison with Fiscal Year 1978; and (3) in terms of selected management objectives. It provides a base for appraising performance and establishing management improvement objectives for: (1) operation; (2) equipment; (3) marketing; and (4) other bus transit services. Definitions are given of sources of measures and future performance measures. The management-by-objectives for Fiscal Year 1980 contains realistic improvement objectives.

AVAILABLE FROM: Washington Metropolitan Area Transit Authority, Office of Budget and Management Analysis

68. METROPOLITAN EVANSVILLE TRANSIT SYSTEM: MANAGEMENT PERFORAMNCE AUDIT

Dodge, SA; Leffers, DR

Indiana University, Bloomington Institute for Urban Transportation, Urban Mass Transportation Administration Report UMTA-IN-09-8004-79-2, Feb. 1979, 119 p.

This document is the management performance audit of the Metropolitan Evansville Transit System (METS), and it evaluates the transit system in the context of its goals and objectives and its resources and constraints. The scope of this performance evaluation report includes: 1) the resources and constraints of METS internal/external environment; 2) the organization's governing body--the Public Transit Department Board; and 3) the functional areas that define METS activities. This study of METS management of the transit system employs the use of statistical indicators, random samples, and interviews with key personnel to identify areas for detailed analysis. Resulting recommendations aim to assist METS management to improve the effectiveness and efficiency of the system. Among the major recommendations are: 1) that METS, Public Transit Department Board, and Evansville Urban Transportation Study's (EUTS) planners should jointly develop goals and objectives, and 2) that METS management and EUTS planners work more closely together.
The auditors also recommend that METS install a two-way radio system in the buses and hire a radio dispatcher to improve METS reliability. /UMTA/ Prepared in cooperation with Evansville Urban Transportation Study, Indiana and UMTA.

AVAILABLE FROM: NTIS PB-294958

69. METRO TRANSIT SERVICE EVALUATION CRITERIA: A REPORT ON SYSTEM AND ROUTE PERFORMANCE

Municipality of Metropolitan Seattle-METRO Mar. 1977, n.p.

This report documents the application of quantitative standards of performance to all rotues in the Seattle Metro system. Three areas of performance were defined: (1) route productivity (i.e., passenger carrying efficiency), (2) seat availability and (3) on-time performance. Feasibility of collecting data in a fourth area - directness of service - was also examined. Route productivity was defined in terms of two criteria: passengers/trip (relative to vehicle headways) and passengers/bus hour (relative to service area density). Standards for each of these measures were established for both peak and midday periods of operation. Routes which perform below the established standard are analyzed individually, in priority sequence, for possible modification. This report presents the results of the initial application of this methodology in October-November 1976. Tables, charts and graphs are used to illustrate individual and aggregate route performance.

AVAILABLE FROM: Municipality of Metropolitan Seattle-METRO, Transit Planning Division

70. THE MICHIGAN TRANSIT PERFORMANCE EVALUATION PROCESS: APPLICATION TO A U.S. SAMPLE

Anderson, SC

Richard B. Cross Company, Inc., 1980, pp. 94-103

This paper applied the performance evaluation scheme developed for the State of Michigan to historical data for fifty-seven U.S. transit properties. The comparative analysis shows the sensitivity of the Michigan program to the variables chosen as performance indicators as well as the results for sets of seven and twenty-seven performance indicators, and for a performance determination using factor analysis. This analysis was done to determine if the ease of handling a greatly reduced number of performance indicators is worth a deterioration in precision of performance comparison. The study concludes that a small performance indicator set can significantly reduce the cost and complexity of data analysis if an error of 11% to 26% in choice of high/low performance systems is acceptable. Evaluations similar to the Michigan program can realize cost savings by employing few well-chosen performance indicators.

Transportation Research Forum. Proceedings of the Twenty-First Annual Meeting.

AVAILABLE FROM: Richard B. Cross Company, Inc.

71. MONITORING AND SURVEILLANCE--SERVICE STANDARDS

Transit Authority of Northern Kentucky, Urban Mass Transportation Administration Report UMTA-IT-09-0080, Mar. 1980, n.p.

This report documents a program developed by the Transit Authority of Northern Kentucky for the collection and analysis of operating data. A series of performance standards for existing and proposed new route service has been identified. Standards have also been developed for other aspects of TANK's operations. Data collection procedures have been delineated for the purpose of providing the raw statistics to be evaluated. The complete collection and analysis program is designed to help TANK meet its primary goal of "providing the best public transportation service possible within the limits of its financial resources." This program will be reviewed on a periodic basis as part of TANK's Management by Objectives Program. The dynamic environment in which transit systems operate today demand that inappropriate or outmoded performance measures cannot be tolerated. (Author)

AVAILABLE FROM: NTIS

72. MONITORING THE EFFECTIVENESS OF STATE TRANSPORTATION SERVICES

Greiner, JM; Hall, JR, Jr; Hatry, HP; Schaenman, PS

Urban Institute, Report DOT-TPI-10-77-33, July 1977, 164 p.

This report discusses procedures that state governments might use to monitor the effectiveness of state transportation services on a regular (preferably annual) basis. Measurements procedures are discussed for assessing the outcomes of a variety of state transportation services, including highway planning, maintenance, mass transit, the division of motor vehicles, and highway emergency services. Measures of effectiveness and data collection procedures addressing the following state transportation concerns are described: rapid movement; access to important destinations; safety; travel convenience and comfort (including road rideability); environmental and aesthetic impacts; and provision of quality services to citizens in terms of courtesy, fairness, responsiveness, and equitability. The problems and limitations of the measurements are also discussed. A special section on measuring the effectiveness of local and intercity mass transit services is included. An illustrative citizen survey for obtaining information on a variety of state transportation effectiveness of local and intercity mass transit services is included. An illustrative citizen survey for obtaining information on a variety of state transportation effectiveness concerns is provided as an appendix. It is based on the results of statewide citizen surveys tested in North Carolina and Wisconsin as part of the project. Experiences regarding tests of a number of other measures by these and other states--including cost information--are also reported. /Author/

AVAIALABLE FROM: Office of the Secretary of Transportation

73. NATIONAL URBAN MASS TRANSPORTATION STATISTICS FIRST ANNUAL REPORT, SECTION 15 REPORTING SYSTEM

Morin, SJ

Transportation Systems Center, (UM-152, R-1777) Annual Rpt. UMTA-MA-06-0107-81-1, DOT-TSC-UMTA-81-18, May 1981, 386 p.

This report summarizes the financial and operating data submitted annually to the Urban Mass Transportation Administration (UMTA) by the nation's public transit operators, pursuant to Section 15 of UMTA Act of 1964, amended. The report consists of two sections: Section 1 contains industry aggregate statistics only, while Section 2 contains detailed financial and operating data on individual transit properties. The current edition contains transit industry statistics compiled from the Section 15 data submitted by the transit properties for fiscal years ending between July 1, 1978 and June 30, 1979, first year of operations of the Section 15 reporting system. (UMTA)

AVAILABLE FROM: GPO

74. NATIONAL URBAN MASS TRANSPORTATION STATISTICS SECOND ANNUAL REPORT, SECTION 15 REPORTING SYSTEM

Morin, SJ

Transportation Systems Center, (UM252, R2708) Annual Rpt. UMTA-MA-06-0107-82-1 June 1982, 398 p.

This report summarizes the financial and operating data submitted annually to the Urban Mass Transportation Administration (UMTA) by the nation's public transit operators, pursuant to Section 15 of the UMTA Act of 1964, as amended. The report consists of two sections: Section 1 contains industry aggregate statistics only, while Section 2 contains detailed financial and operating data on individual transit agencies. The current edition contains transit industry statistics compiled from the Section 15 data submitted by the transit agencies for fiscal years ending between July 1, 1979 and June 30, 1980, the second year of operation of the Section 15 reporting system.

AVAILABLE FROM: GPO

75. NATIONAL URBAN MASS TRANSPORTATION STATISTICS, 1981 SECTION 15 REPORT

Jacobs, M

Transportation Systems Center, (UM352, R3685) Annual Rpt. UMTA-MA-06-0107-83-1, Nov. 1982, 384 p.

This report summarizes the financial and operating data submitted annually to the Urban Mass Transportation Administration (UMTA) by the nation's public transit operators, pursuant to Section 15 of the UMTA Act of 1964, as amended. The report consists of two sections: Section 1 contains industry aggregate statistics only, while Section 2 contains detailed financial and operating data on individual transit agencies. The current edition contains transit industry statistics compiled from the Section 15 data submitted by the transit agencies for fiscal years ending between July 1, 1980 and June 30, 1981, the third year of operation of the Section 15 reporting system. It is important to note that, due to reporting inconsistencies, commuter rail data is not included in this document.

AVAILABLE FROM: GPO

76. **THE NATIONAL URBAN TRANSPORTATION REPORTING SYSTEM**

Sale, JE

Urban Mass Transportation Administration, Feb. 1976, n.p.

This document provides a brief overview of early efforts to develop and implement a national urban transportation reporting system. It describes the program's purpose, legislative mandate, development of indicators and supporting data elements, sources of data, and proposed program administration. Separate appendices outline proposed data elements to be collection from transnit operators, metropolitan planning organizations, state departments of transportation and national and metropolitan travel surveys.

AVAILABLE FROM: NTIS

77. **THE NEED FOR AND USE OF PERFORMANCE INDICATORS IN URBAN TRANSIT**

Stokes, BR

Transit Journal, 1979, pp. 3-10

Basic efficiency indicators relate units of cost or work by employees or vehicles to units of service or other types of input. However, it is noted that no one indicator will reveal the relative or absolute performance of a system's management. In order to respond to changing priorities, all levels of government have become aware of the need to develop uniform indicators of transit performance. Such indicators can assist in the establishment and evaluation of public policy with regard to transit. This article reviews the current state of transit performance, and discusses the transit communities role in developing performance indicators.

78. **THE NEED FOR EVALUATION**

Heathington, KW

Transportation Research Board Special Reports No. 155, 1975, pp. 3-5

The basic steps involved in the urban transportation planning process are reviewed, along with past efforts which to date have proved unsuccessful in establishing a viable public transportation system. From this review, the necessity for a meaningful evaluation of public transportation at all levels of government is apparent. For this purpose a conference was organized. Its objectives, as stated in this introduction to the proceedings, were as follows: (1) to provide all attendees with a better understanding of the perspectives and needs of the users, transit authority boards, planners, operators, and grantors; (2) to identify current approaches being used by each of these groups to evaluate performance; (3) to identify steps that need to be taken to provide information necessary to plan, design, operate, finance, and effectively evaluate public transportation; and (4) to identify research projects, complete with work statements, that are needed to increase the effectiveness of each of the groups as they interact to fulfill their respective roles.

AVAILABLE FROM: TRB Publication Office

79. NEW FOCUS ON/IN PERFORMANCE STANDARDS

Debo, CS

Transitions, 1981, pp. 1-21

The public transit industry is entering a very difficult era when extensive federal cutbacks in transit operating assistance and increased competition from other public service programs for local tax assistance pose a serious challenge to the survival of transit systems across the nation. Transit managers must prepare to meet that challenge. To maintain fiscal integrity and increase service productivity, they must set and meet high standards for performance. The purpose of this article is to recommend a methodology by which the transit manager may make the most of reduced funding resources. It suggests a method for analyzing the performance of each category of transportation service provided by the system, selection of specific performance indicators for use in service evaluation, a strategy for establishing appropriate and attainable service standards and criteria for deciding which services should be retained and which should be cut back.

AVAILABLE FROM: ATE Management and Service Co., Inc.

80. OBSTACLES TO COMPARATIVE EVALUATION OF TRANSIT PERFORMANCE

Fielding, GJ; Glauthier, RE

California University, Irvine Institute of Transportation Studies, Rpt. ITS-I-SP-77-1, April 1977, 10 p.

The studies encountered and the issues raised in efforts to collect reliable and uniform operating and financial data from transit operators in California are detailed. The data was collected in an attempt to test the usefulness of performance indicators which were specified for criteria for evaluating public transit performance. The problems discussed include those relating to why the data is not reported, the meaning of the data, and if the data is outdated. It is recommended that data requirements and data reporting channels be simplified. The required data items must be specified. It is noted that the area of data requirements, collection, and use, needs the combined and cooperative attention of the transit industry, government, and the research community. This paper was prepared for presentation at the National Planning Conference of the American Society of Planning Officials, San Diego, California, April 23-28, 1977. It was sponsored by DOT, Urban Mass Transportation Administration.

81. OPERATING GUIDELINES AND STANDARDS FOR THE MASS TRANSPORTATION ASSISTANCE PROGRAM

Pennsylvania Department of Transportation Jan. 1973, 25 p.

In 1973, the State of Pennsylvania established operating guidelines to assist in its Mass Transportation Assistance Program. This document outlines these guidelines, including a definition of desirable characteristics and standards for transit service and operations, a questionnaire for data required for this analysis, and a discussion of the relationship of these standards to state financial assistance made available to transit agencies. The guidelines contained in this manual are intended to accomplish the following: (1) To determine the required quantity and quality of public transportation service in various urban areas; (2) To evaluate the efficiency of transit operations; (3) To analyze the effectiveness of transit management in implementing the policies, objectives and procedures established for the administration and operation of the transit system; (4) To identify areas in which improvements could or should be made in the management and operation of the transit systems; (5) To provide a mechanism by which transit authorities and agencies can evaluate and analyze their operations; (6) To form the basis upon which the state could allocate financial assistance to its operators; and (7) To assist transit agencies in defining their own needs for capital improvements.

AVAILABLE FROM: Pennsylvania DOT, Bureau of Mass Transit Systems

82. OPERATING PROFILES AND SMALL BUS PERFORMANCE REQUIREMENTS IN URBAN TRANSIT SERVICE

RCC International, Inc., Urban Mass Transportation Administration Intrm Report UMTA-IT-06-0074-73-3, Dec. 1976, 41 p.

The overall objective of the Small Bus Project is the development of a general and performance specification for an advanced small urban transit bus. It is a six-phase program designed to insure that final vehicle specifications would evolve from a comprehensive analysis of all aspects of the operating environment and thus have a broad applicability. The Small Bus Project is presented in six separate reports: 1) Operations of Small Buses in Urban Transit Service in the United States. This report investigates the operating environment of small buses in the U.S. and relates them to vehicle requirements; 2) Bus Characteristics Needed for Elderly Handicapped in Urban Travel. Constraints imposed on bus design by the elderly and handicapped are outlined; 3) Operating Profiles and Small Bus Performance Requirements in Urban Transit Service. This report develops a set of operating profiles and service requirements as the basis for specifications for a new small urban transit bus to meet the identified operational needs; 4) Guidelines for the Design of Future Small Transit Buses and Bus Stops to Accommodate the Elderly and Handicapped. This report presents scenarios for the future uses and market of small buses, as well as the conceptual design for three vehicle configurations to assess the feasibility of meeting design requirements; 5) General and Performance Specifications for a Small Urban Transit Bus. Requirements for an advanced design coach which may be used for both demand-responsive and general service on urban arterial streets are presented; 6) Small Transit Bus Requirements Study. This report summarizes the findings presented in the five project reports. /FHWA/

AVAILABE FROM: NTIS PB-269395

83. ORGANIZATION THEORY AND THE STRUCTURE AND PERFORMANCE OF TRANSIT AGENCIES. ABRIDGMENTS

Fielding, GJ; Porter, LW; Dalton, DR; Spendolini, MJ; Tudor, WD

Transportation Research Record No. 761, 1980, pp. 17-20

Relationships between structural and performance variables were studies in 16 public transit organizations in California. Data were collected from archives, personal interviews, management surveys, and on-site observations. Statistical analyses focus on associations between structural variables and organizational efficiency, effectiveness, and employee commitment. Organization size, span of control, centralization, and length of managerial tenure were all associated with higher levels of organizational performance. Specialization and formalization were found to be associated with lower levels of performance on certain efficiency and effectiveness indicators. (Author) This paper appeared in Transportation Research Record No. 761, Public Transportation Planning.

AVAILABLE FROM: TRB Publications

84. PERFORMANCE-BASED FUNDING-ALLOCATION GUIDELINES FOR TRANSIT OPERATORS IN LOS ANGELES COUNTY

Fielding, GJ; Mundle, SR; Misner, J

Transportation Research Record No. 857, 1982, pp. 14-18

During the last five years, transit performance indicators have been widely used in transit industry. California and New York have used performance indicators to determine eligibility for funding. In Pennsylvania, transit performance measures have been used to provide incentive payments for superior performance, and in Michigan a detailed analysis of transit operations provides the basis for state managerial assistance. In Los Angeles County, nine transit operators, including Southern California Rapid Transit District, provide fixed-route transit service. Between 1977 and 1980, operating cost per vehicle hour increased from $28.52 to $38.76, a rate higher than the consumer price index for the Los Angeles area. In response to state legislation designed to maximize utilization of public subsidies for transit, Los Angeles County Transportation Commission undertook the development of performance-based guidelines for allocating transit subsidies. The performance guidelines developed in cooperation with the local transit operators are presented here. In this program, service is classified into local and express categories. Seven indicators were chosen to monitor transit performance on a periodic basis. Three indicators were selected to establish standards to be achieved by all fixed-route service operators in Los Angeles County. Compliance with these standards will determine eligibility for discretionary funds (representing 5 percent of operating assistance) in the future. The methodology for quantifying loss of subsidy funds if an operator falls below the established standards is also described . The performance guidelines merit consideration for two reasons. First, they represent an attempt by a large transit metropolitan area to control transit costs, and second they initiate performance-based funding allocation rather than funding based on demographic characteristics or operating deficits. Both reasons are substantial advancements in the theory and application of performance-based guidelines to transit-financing issues. This paper appeared in Transportation Research Record No. 857, Bus Operations and Performance.

AVAILABLE FROM: TRB Publications Office

85. PERFORMANCE EVALUATION FOR DISCRETIONARY GRANT TRANSIT PROGRAMS. DISCUSSION AND CLOSURE

Fielding, GJ; Lyons, WM; Gray, G

Transportation Research Record No. 797, 1981, pp. 34-40

Discretionary grant programs have been popular with state legislatures as a mechanism for extending the benefits of transit programs to small cities and rural areas as well as for stimulating innovations in urban areas. This article analyzes state discretionary grant transit programs in California and Minnesota by using the criterion of effective administration. The purpose is to develop a framework for understanding administrative problems that result when state discretionary transit programs do not have adequate objectives. Without explicit objectives, selection, monitoring evaluation, and overall management are weak. Project performance is reduced and scarce public funds are wasted. Recommendations include the following: (a) discretionary programs, (b) administrative agencies should define measurable objectives and administrative guidelines, and (c) local grant recipients should be granted funds only after specific objectives and performance standards have been presented. (Author) This paper appeared in Transportation Research Record No. 797, Transit Planning and Management.

AVAILABLE FROM: TRB Publications Office

86. PERFORMANCE INDICATORS: A NECESSARY MANAGEMENT TOOL?

Underwood, WC

Transit Journal, 1979, pp. 11-16

The article notes the need for the measurement and evaluation of transit performance within policy and financial constraints, and discussed the Pennsylvania Department of Transportation's efforts to improve transit service and to increase operating efficiencies in return for the public tax dollars committed for transit. These efforts included: the adoption of operating guidelines that specify elements of service such as speed, reliability, etc.; financial guidelines to compare the financial data of individual properties; a standardized reporting system for operating and financial data; a methodology for determining service changes based upon performance criteria and financial criteria; and a new formula grant allocation methodology. Some of the key data that might be developed and used as part of performance evaluation programs are listed.

87. PERFORMANCE INDICATORS FOR TRANSIT MANAGEMENT

Fielding, GJ; Glauthier, RE; Lave, CA

Transportation Vol. 7 No. 4, Dec. 1978, pp. 365-379

Transit performance can be evaluated through quantitative indicators. As the provision of efficient and effective transit service are appropriate goals to be encouraged by federal and state governments, these goals are used to develop performance indicators. Three efficiency and four effectiveness indicators are described, together with two overall indicators. These nine indicators are analyzed for comparability utilizing operating and financial data collected from public transit agencies in California. Performance indicators selected for this study should not be viewed as final. Twenty-one performance indicators proposed by previous studies were reviewed. Theoretical considerations and unavailability or unreliability of data caused omission of several useful measures like passenger-miles. Circumstances such as improved data, emphasis upon goals other than efficiency and effectiveness, and local conditions might warrant the inclusion of indicators deleted from this research. /Author/TRRL/

88. PERFORMANCE MEASUREMENT AS A TECHNIQUE FOR IMPROVING MAINTENANCE MANAGEMENT

Doolittle, JT

California University, Irvine, May 1980, pp. 65-72

This paper describes the characteristics of an optimal performance measurement system and applies these concepts to the evaluation of the bus maintenance function. A maintenance performance evaluation system should consist of three categories of measurements: (1) environmental indicators, which measure the basic conditions under which the maintenance function is performed, (2) effectiveness indicators, which measure the ability of the system to provide reliable service, and (3) efficiency indicators which relate labor and other inputs to overall cost and performance. Recommended indicators are provided for each category. Each indicator should be linked to a specific policy objective, a plan to achieve that objective, and a method for monitoring progress toward that objective. The frequency of measurement should be related to the role that the specific measure plays in the overall management plans of a system. Indicators can be used to measure the performance of the maintenance system against historical trends, against specific policy objectives, against peer group of similar systems and against industry standards. The author stresses the importance of using the maintenance performance system to affect positive changes in resource allocation or policy, rather than as a punitive device.

In Fielding, GJ (Pete), and Holliden, Al, Proceedings of the Conference on Improving Transit Performance.

AVAILABLE FROM: Institute of Transportation Studies, California University, Irvine

89. PERFORMANCE MEASUREMENT: EXTERNAL AND INTERNAL

Mauro, JT

Transit Journal Vol. 6 No. 2, 1980, p. 57

In an effort to make the countywide transit system produce the most useful service at the lowest cost to the consumer and taxpayer, the San Mateo County Transit (SamTrans system) district is trying out a new system of evaluating bus services. The program consists of the collection and analysis of key ridership and economic data which measure the performance of each route in the SamTrans system. Five measurable factors (average number of passengers carried daily on each route, passengers per vehicle mile, passengers per scheduled trip, net cost per passenger and percent of operating costs recovered from fares) were identified. The combination of economic and ridership data has enabled SamTrans to redflag the least efficient and least effective service, establish priorities for remedial action, measure and record the impact of route and schedule adjustments, identify and serve growth opportunities essentially with miles and hours salvaged from less productive routes, and achieve productivity by addressing one route or a related group of routes at a time.

AVAILABLE FROM: APTA

90. PERFORMANCE MEASURES FOR PUBLIC TRANSIT SERVICE

Fuller, E

California Department of Transportation, Mass Transportation Division, Urban Mass Transportation Administration Final Rpt. UMTA-CA-09-8001-79-1, Dec. 1978, 115 p.

This report which evaluates existing and proposed transit systems identifies definitional, institutional, and technical difficulties associated with developing Transit Peformance Measures (TPM's) for the use in evaluating public transit service. A survey is made of contemporary evaluation process and their purposes. The procedures used by the Division of Mass Transportation of the California Department of Transportation in developing its list of TPM's and methods for developing peformance standards are described. The necessity for linking TPM's to funding strategies are also discussed. The report recommended that further refinement and verification of the research methodology used in this research project is needed. It is pointed out that if public transit service evaluation can be developed effectively, it will greatly enhance the efficiency and effectiveness of public transit service. Sponsored by Department of Transportation, Urban Mass Transportation Administration.

AVAILABLE FROM: NTIS

91. A PLANNING PERSPECTIVE ON EVALUATING URBAN PUBLIC TRANSPORTATION

Heathington, KW

Transportation Research Board Special Report No. 155, 1975, pp. 14-23

The first part of this paper outlines some of the basic differences between highway and transit planning which should be recognized and accounted for if successful public transportation operations are to be achieved. In the second part of the paper, several steps to be followed for achieving a meaningful evaluation of public transportation systems are discussed. These steps are as follows: (1) establish specific and quantifiable goals and objectives for public transportation; (2) select alternative means of accomplishing the objectives; (3) define the criteria that will be used to evaluate an alternative in terms of meeting the objectives; (4) firmly establish the constraints under which the objectives are to be accomplished; and (5) develop the methodologies to be used in evaluation of each alternative. It is pointed out that these steps are applicable at all levels of government.

AVAILABLE FROM: TRB Publications Office

92. THE POTENTIAL FOR TRANSIT STANDARDS

Deen, TB

Traffic Quarterly Vol. 31 No. 1, Jan. 1977, pp. 119-137

This article presents a conceptual framework for the establishment of transit standards. The author identifies five groups of individuals impacted by transit service - passengers, operating personnel, transit agencies, equipment manufacturers, and the general public - and specifies a set of objectives important to each group. Quantitative standards, termed "output measures", can be developed for each objective to assess the degree of satisfaction. Achievement of a desired level of output requires a number of managerial decisions or actions, termed "controlled attributes", because they are the direct result of the system's management. These controlled attributes can be grouped into five categories: (1) performance (i.e. speed, deceleration), (2) physical (i.e. dimensions, weights), (3) input (i.e. labor materials), (4) control (i.e. automatic, pneumatic), and (5) operational (i.e. schedules, fares). Standards for each controlled attribute, termed "input standards", can be developed to evaluate the overall results of system operation. The relationship between controlled attributes and user satisfaction can also be quantitatively assessed. Transit standards can also be classified according to activity (i.e. planning, design, construction, maintenance) and by mode. The author illustrates his evaluation framework with a matrix which incorporates the dimensions of impact group, activity, and modal grouping. The article concludes with a discussion of standardization of transit vehicles and facilities.

AVAILABLE FROM: Eno Foundation for Transportation, Inc.

93. POTENTIAL IMPACTS OF TRANSIT SERVICE CHANGES BASED ON ANALYTICAL SERVICE STANDARDS

Kocur, G

Transportation Research Record No. 854, 1982, pp. 60-67

The results of a hypothetical case study of the Hartford, Connecticut, bus transit system in which service and fares are redesigned based on service standards derived from an analytical optimization model are presented. The key variables in the analysis are route spacing, headway, fare, and route length for both local and express routes. Three different sets of possible local objectives are treated, which place varying emphasis on profit (or deficit) and user benefits. Comparisons of the results with the existing system are made, and several policy issues are addressed. The analysis concludes that major increases in productivity are technically possible, based in large part on route restructuring and the introduction of substantial express service. Because relatively large changes from current operations are entailled, equity and political feasibility may be large issues in making the proposed changes. This paper appeared in Transportation Research Record No. 854, Bus Services.

AVAILABLE FROM: TRB Publications

94. PRELIMINARY DESIGN AND EVALUATION OF COORDINATED PUBLIC TRANSPORTATION SERVICES

Cottrell, BH, Jr; Demetsky, MJ

Traffic Quarterly Vol. 35 No. 1, Jan. 1981, pp. 143-162

An integrated system of coordinated transit services described is shown to offer potential improvements in the productivity and efficiency of transit operations in low density urban areas. The recommended method allows for a formal evaluation of feasible alternatives relative to the established system objectives, and the results of the evaluation can be interpreted to show how systems that provide minimal service levels can be implemented to evolve into a system with higher levels of service. Scheduling and transfer considerations are developed in a subsequent detailed design phase of the planning process.

AVAILABLE FROM: ESL

95. PROCEEDINGS OF THE CONFERENCE ON IMPROVING TRANSIT PERFORMANCE

Fielding, GJ; Hollinden, A

California University, Irvine May 1980, n.p.

This document contains formal papers and transit industry respondent papers presented at in invitational conference held in February 1980. The papers are grouped into seven categories: (1) the use of performance measures to improve transit performance, (2) improving internal management, (3) managing labor relations, (4) marketing strategies to improve transit effectiveness, (5) maintenance management, (6) the cost of labor work rules, and (7) route evaluation strategies.

AVAILABLE FROM: California University, Irvine, Institute of Transportation Studies.

96. PROCEEDINGS OF THE FIRST NATIONAL CONFERENCE ON TRANSIT PERFORMANCE

Public Technology, Inc., Urban Mass Transportation Administration Conf. Paper UMTA-DC-06-0184-78-1, Jan. 1978, 167 p.

The first National Conference on Transit Performance was held in Norfolk, Virginia, September 18-21, 1977. This Conference reflects a major effort aimed at clarifying the issues to transit performance and developing recommendations for actions which could be taken to improve transit performance. Two hundred persons broadly representative of local government, transit management and labor, city and regional planning organizations, educational institutions, transportation consulting firms, and State and Federal agencies met in Norfolk to exchange ideas on transit performance. This document contains the proceedings of the conference, namely: the addresses, the issue and resource papers, and summaries of the problems and recommendations developed in workshop sessions. Subject papers include: Trends in Transit Performance; Concepts and Indicators; Revenue Policy and Pricing; Service Characteristics; Labor-Management Relations; Internal Management; Transit Performance Indicators; Case Studes of New York City, Southern California Rapid Transit District, and Seattle Metro; and Effects of Fare Changes. This report also contains an annotated bibliography and list of conferees, members of the planning group, and technical advisors. /UMTA/ The Norfolk Conference was sponsored by the Urban Mass Transportation Administration, the American Public Transit Association, and Public Technology, Incorporated acting as secretariat for Urban Consortium of Technology Initiatives. Conference Proceedings, September 18-21, 1977.

AVAILABLE FROM: NTIS PB-291032

97. PRODUCTIVITY, EFFICIENCY, AND QUALITY IN URBAN TRANSPORTATION SYSTEMS

Tomazinis, AR

Heath Lexington Books, (0-669-00142-2) 1975, 256 p.

This study developed a theoretical framework for the evaluation of transit system performance based on previous work conducted for the U.S. Dept. of Transportation. It explores transit productivity from the point of view of the system user, system operator, government, and society. The urban transportation system is divided into the network, primary services, and support functions; detailed lists of performance measures are proposed for each. The use of input-output analysis is discussed at length. The book concludes with a discussion of the problems inherent in transportation performance evaluation and suggestions for further research.

98. PROTOTYPE BUS SERVICE EVALUATION SYSTEM

Becker, AJ; Talley, W; Krumke, J; Anderson, P

Tidewater Transportation District Commission, Urban Mass Transportation Administration Final Rpt. UMTA-VA-09-7001-81, Apr. 1981, 67 p.

Many transit operators have a critical need for a service evaluation system which can measure existing service performance. To assist these operators, the Office of Planning Assistance of the Urban Mass Transportation Administration, through its Special Studies Program, initiated operator prototype studies in Boston and Norfolk. The purpose of these studies is to develop and test systems for bus service evaluation. The emphasis of these studies is on how local operators can use existing planning techniques to meet their evaluation needs. This report describes the development and testing of a prototype bus service evaluation system in Norfolk, Virginia. The project has two objectives: (1) to develop a service evaluation system utilizing existing techniques and (2) to test and verify that such a service evaluation system is a practical and effective method for service evaluation.

AVAILABLE FROM: NTIS PB82-117763

99. PUBLIC TRANSIT PERFORMANCE EVALUATION: APPLICATION TO SECTION 15 DATA

Anderson, SC; Fielding, GJ (California University, Irvine)

California State University, Northridge 1983, n.p.

Peformance indicators are the quantitative measures that enable managers and policymakers to determine the current position of an agency and outline strategies to improve performance. But public services typically have many different dimensions of performance, giving rise to large numbers of performance indicators. In this paper, a conceptual model is used to help select a few performance indicators that represent all the important performance concepts. Data came from a national sample of 311 urban bus transit systems, obtained in the first year of data reported under Section 15 of the Urban Mass Transportation Act. This method reduces both data-collection and analysis requirements. The steps in the performance evaluation procedure involve defining a conceptual model of performance and designing a balanced set of performance

indicators that represent all performance concepts. Then factor analysis is used to select the indicators that best represent all dimensions of performance. This small, representative set of performance indicators is then used to analyze performance and to establish peer group rankings.
Prepared for the 62nd Annual Meeting of the Transportation Research Board, January 17-21, 1983. In Press.

AVAILABLE FROM: TRB Publications Office

100. PUBLIC TRANSPORTATION OPERATING STANDARDS

Krambles, G

Transportation Research Board Special Reports Proceeding No. 144, 1974, pp. 76-79

Some of the standards employed by the Chicago Transit Authority (CTA) are discussed here. Practically every aspect of transit service is codified with standards, most of them unwritten, but no less effective. A review of such standards serves to emphasize the need for flexibility over rigidity. At operating levels, standards are applied to employee selection, training and performance. Design standards relating to maximum number of passengers per vehicle, and the schedule policy which establishes a range for the selection of service frequencies or the reciprocal, headways are discussed. The maximum service is determined from the allowable crowding standard for passengers per vehicle, and the base or minimum service is determined from the headway so that the time between trips will meet the policy criteria for the transit system involved. The maximum workable length of a bus route, a standard relating to Chicago, is also discussed. Maximum fleet requirements constitute a common control on service standards, as do the vehicle characteristics: length, width, door width, and seating and standing vehicle capacity. The gridiron route pattern and some radial routes ensures that most of the population is within 0.375 mile of more than one CTA service. Policy standards are followed to provide the broadest possible period of service for those who need it at night. Some of the security measures adopted by the CTA (such as the exact fare procedure etc.) are outlined. Fare collection, which in a rapid transit system, can involve as much as 16 percent of the operating costs, is reviewed. Standards are essential in planning route changes, extensions or cutbacks. The use of aerial surveys, the problem of the terminal, physical and geometric characteristics of pavements, potential traffic and questionnaire surveys of industries along the route are all aspects to be considered in planning route changes.
Appeared in Issues in Public Transportation, proceedings of a conference held by the Highway Research Board at Henniker, New Hampshire, July 9-14, 1972.

AVAILABLE FROM: TRB Publications Office

101. PUBLIC TRANSPORTATION OPERATING STANDARDS (INTRODUCTORY REMARKS)

Echols, JC

Transportation Research Board Special Reports No. 144, 1974, p. 63

Clear statements of transit service operating standards would be helpful both to industry and to government agencies in making judgements on the relative merits of transit operations, and in the measurement and comparison of the performance of individual systems. They could help set performance levels for transit services. Four papers are presented here which present different views of operating standards. The views are presented of a manager of an all-bus transit system in a medium-sized metropolitan area. A private consultant and the manager of a regional transit authority that acquired a privately owned bus company present their views. A multimodal transit operator from a large metropolitan area also presents his views. The reasons are listed why transportation system managers view operating standards with skepticism: (1) the managers are concerned that any service standard that is explicitly adopted will be too rigidly applied; (2) different operation standards apply to different modes and to different-sized metropolitan areas; (3) transit operating standards that are currently being used were determined by the society of another period; (4) the concentrated city of a few years ago is now a suburbanized metropolitan complex. Appeared in Issues in Public Transportation, proceedings of a conference held by the Highway Research Board at Henniker, New Hampshire, July 9-14, 1972.

AVAILABLE FROM: TRB Publications Office

102. RELIABILITY AND AVAILABILITY ASSESSMENT CRITERIA, DATA INPUTS AND ANALYSIS METHODS FOR MASS TRANSIT SYSTEMS

Welker, EL

Institute of Electrical and Electronics Engineers, 1976 Proc. Paper

The availability and reliability of a mass transit system is analyzed and assessed, and a fairly complete list of criteria for judging these characteristics of a mass transit system is presented. A discussion is also included of the analysis and data reduction methods involved and an interpretation is given of the resulting numerics noting the particular aspect of reliability or availability addressed by each within the context of previously determined management goals. Presented at the Annual Reliab. Maintainability Symp., Las Vegas, Nev., Jan. 20-22, 1976 sponsored by ASME and IEEE.

AVAILABLE FROM: ESL

103. SEMINAR ON SYSTEMS ATTRIBUTES AND PERFORMANCE

Brand, D; Solomon, RJ; Heathington, KW; Bauer, HJ; Curd, HN; Ketola, HN; Schwartz, A; Morrill, DD; Ventura, FL

Highway Research Board Special Reports No. 127, 1971, pp. 69-87

The discussion is concentrated in two areas: the impact of system attributes and performance on (1) nonusers and (2) users. In addition, an M.I.T. History on innovative transit is reviewed briefly. The nonusers considered were operators, government, the community, and related systems. It is noted that operators will not consider demand-activated systems an enhancement of public transit but as competition. That they will be supported by courts in this misconception is manifested by a decision that forbade minibuses in northern New Jersey from operating in a car-pool fashion; the requirement to operate in defined corridors forced the operator to discontinue the service because of the financial loss incurred. Existing regulations and regulatory agencies also inhibit flexible and innovative public transportation. The acceptability of buses in neighborhoods is determined largely by their exterior design, environmental impact (noise, exhaust emissions), and safe operation (especially in residential neighborhoods that do not now experience much through transportation). Finally, the impact on highway congestion, land value, and land development is discussed. Under user impact, two topics are discussed: attributes of system operation affecting (1) usage and (2) demand. Most of the comments on demand relate to the tradeoff between fares and time.

104. SERVICE-SENSITIVE INDICATORS FOR SHORT-TERM BUS-ROUTE PLANNING (ABRIDGMENT)

Horowitz, AJ

Transportation Research Record No. 798, 1981, pp. 36-39

Transit performance indicators are useful means of monitoring existing systems and planning for future systems. The development of one type of transit performance indicator, a service-sensitive indicator, is discussed. The purpose of the service-sensitive indicator is to succinctly summarize the effectiveness and fairness of short-term route changes. Included in the indicator are considerations of the important performance variables perceived by riders: in-vehicle time, transfer time, walking time, waiting time, requirements to wait, and requirements to transfer. The service-sensitive indicator is applied to a case study - the improvement of transit service to the Milwaukee County Institutions Grounds, where major public medical care facilities are located. Because questions of equity are of greatest importance, the indicator is separately calculated for each of the potential rider groups. It is shown that the indicator measures the impacts of route alignment and route extensions on relevant population groups and does so without the need for extensive travel survey data. (Author) This paper appeared in Transportation Reseach Record No. 798, Bus Planning and Operations.

AVAILABLE FROM: TRB Publications Office

105. SERVICE STANDARDS AND OPERATING CRITERIA IN NASHVILLE, TENNESSEE

Buckley, RL; Ward, PE

Transit Journal Vol. 4 No. 3, 1978, pp. 41-46

This article describes the service standards and operating criteria adopted by the Metropolitan Transit Authority of Nashville in January 1976. These standards were keyed to the authority's goal of providing socially acceptable service within the limits of its financial resources. Adequacy of service is judged by a variety of measures including loading standards, on-time performance, ridership, and cost. Measurements are taken and reported monthly and presented periodically with formal financial reports showing budget vs. actual revenues and expenses. In this way, management is made aware of those services which most adversely affect the financial security of MTA. Established service standards are also used to plan new routes or extensions.

AVAILABLE FROM: APTA

106. SIMPLIFIED AIDS FOR TRANSPORTATION ANALYSIS: TRANSIT ROUTE EVALUATION. VOLUME 4

Peat, Marwick, Mitchell and Company, Urban Mass Transportation Administration Final Rpt. UMTA-IT-06-9020-79-4, Jan. 1979, 35 p.

This is one of a series of six reports describing simplified aids to improve transportation decisions without resorting to computers or extensive data collection. The analytical aid presented in this report provides one method for evaluating individual transit routes for a fixed-route, fixed-schedule urban transit system. Individual transit system routes are evaluated semiannually, based on a comparison of nine performance factors with established route standards set for each factor. Input data used in the evaluation are recorded on a semiannual basis, and scores are computed for each of the nine performance factors for each route according to an evaluation score algorithm. Scores are then added for each route, and routes are ranked by their total evaluation score. The results of the evaluation are used as the basis for route refinement and modification decisions. The report points out that the evaluation procedure is best applied in systems whose overall ridership is growing. Stable or declining ridership conditions would not be satisfactorily treated by this procedure. Also, because the intent of this report is to provide a simplified analysis aid, modifications, embellishments, and improvements to the suggested procedure are encouraged if local data or previous analyses suggest more appropriate methods. (UMTA)

AVAILABLE FROM: NTIS PB-299983/AS

107. A SINGLE MEASURE FOR EVALUATING PUBLIC TRANSIT SYSTEMS

Talley, WK; Becker, AJ

Transportation Quarterly Vol. 36 No. 3, July 1982, pp. 423-431

This article proposes a public transit evaluation measure that can satisfy four criteria: Measurement of positive contributions rather than minimum standards; allowance for weighting of different kinds of passenger trips to accommodate special equity and externality considerations; permits assessment of a range of potential improvement actions - not just route extensions or cutbacks; and allows comparison of a new proposal with the best available alternative. The evaluation measure is transit deficit per passenger. Specifically, the transit route deficits per passenger is consistent with evaluating a transit system from the standpoint of effectiveness and efficiency.

AVAILABLE FROM: Eno Foundation for Transportation, Inc.

108. SOUTHWEST OHIO REGIONAL TRANSIT AUTHORITY PLANNING PROCEDURES MANUAL

Southwest Ohio Regional Transit Authority UMTA-IT-09-0080, Jan. 1979, 48 p.

This report provides an overview of the processes used by the Southwestern Ohio Regional Transit Authority (SORTA) to measure transit system performance and plan for or implement operational changes. The report provides an overview of SORTA as an organization, outlines the type of performance data collected, documents SORTA's performance standards and route review procedures, and outlines SORTA's preventive maintenance program. Appendices to the report include detailed listings of performance measures, service standards, and sub-organizational units responsible for data input/compilation.

AVAILABLE FROM: Southwest Ohio Regional Transit Authority, Dept. of Research and Planning

109. STATEWIDE TRANSIT EVALUATION IN MICHIGAN

Holec, JM; Schwager, DS

Peat, Marwick, Mitchell and Company, Urban Mass Transportation Administration Tech. Rpt. UMTA-MI-09-8004-81-1, July 1981, 79 p.

The objective of this report is to share the experience gained during the development of a performance evaluation methodology for public transportation in the State of Michigan. This report documents the process through which an evaluation methodology was developed including a review of project objectives, milestones, meetings, and products. Two major lessons learned during the development of the evaluation methodology for mid-size transit systems in Michigan are (1) that there is a need to establish the groundwork for conducting performance evaluation; and (2) the concerns and perspectives of public transportation systems regarding performance evaluation must be addressed and integrated into the development and implementation of the evaluation program. Although the paper is based on the experience of one state government agency, the findings and conclusions are generally applicable to other organizations that may evaluate public transportation performance, especially those that provide/administer funding.

AVAILABLE FROM: NTIS PB82-115999

110. STATISTICAL ANALYSIS OF TRANSIT PERFORMANCE

Lave, CA; Pozdena, RJ

California University, Irvine UCI-ITS-SP-77-2, Dec. 1977, n.p.

This study attempted to apply two multivariate statistical techniques - Farrell efficiency analysis and multiple regression analysis - to financial and operating data from forty-seven California transit properties collected in 1976-77. These analyses were conducted to explore the relationship between variables characterizing transit's external environment (geography, demography, organizational structure, economic and labor conditions, etc.) on transit operating performance. Results of both analyses were disappointing. This was attributed to inadequacies of the California data set as well as the relatively small sample size.

AVAILABLE FROM: California University, Irvine, Institute of Transportation Studies

111. STRATIFICATION APPROACH TO EVALUATION OF URBAN TRANSIT PERFORMANCE

Sinha, KC; Jukins, DP; Bevilacqua, OM

Transportation Research Record No. 761, 1980, pp. 20-27

In a period of growing transit operating deficits, increasing attention and concern is being directed at both the general and the broad differences in measured service performance compiled for various transit systems. In making these performance assessments, analyses have commonly relied on highly aggregated industrywide data and have not given adequate consideration to the changing and unique operational context within which individual transit systems must function. This paper presents a stratification approach to the evaluation of urban bus transit system performance. The stratification scheme was used on the premise that there exists many environmental and policy factors outside the control of the transit operator that constrain the performance of the transit system. Factors such as area population, population density, union work rules, system configurations, fleet age, and operational forms have strong influences on the productivity and efficiency levels of an individual transit service. By implementing the stratification procedure and compiling temporal data pertaining to both environmental and policy influences and system performance, the possible bias in making assessments and comparisons of existing transit systems can be controlled and changes in performance levels of a system in response to both external changes and operational improvements can be predicted. (Author)

AVAILABLE FROM: TRB Publications Office

112. A STUDY OF EFFICIENCY INDICATORS OF URBAN PUBLIC TRANSPORTATION SYSTEMS

Tomazinis, AR

Pennsylvania University, Philadelphia Final Rpt. DOT-TST-77-47, Jan. 1977, 299 p.

This report presents the efforts of a research project on efficiency problems of urban public transportation systems (UPTS). Three test regions were selected in an effort to discover, clarify, and understand the efficiency relationships with UPTS. The test regions vary from a small one-mode region to a large multimode region. The UPTS are first divided into three major system components, i.e. primary services, support functions, and the network. Then each system is divided by mode, and each component by each distinct function carried within the system component. The inputs to the system are also divided by type, i.e. labor, capital, and energy, and according to the contributor, i.e. the operator, the direct user, the society at large, and the government at all levels. Input units are also traced in terms of many costs (Fiscal Inputs Matrix) and physical units (Physical Inputs Matrix). System outputs are also separated by the receiver and the nature of the outputs. Efficiency analysis is then explored in a hierarchial manner exploring three types of relationships, i.e. system inputs vs. system outputs; component inputs vs. component inputs; component outputs vs. component outputs. Efficiency indicators are then discussed as to the type of useful service they may offer in various types of efficiency analysis problems. /Author/

Sponsored by the Office of the Secretary, Department of Transportation.

AVAILABLE FROM: NTIS PB-270940/OST

113. SURVEILLANCE AND MONITORING OF A BUS SYSTEM

Sheskin, IM

Transportation Research Record No. 862, 1982, pp. 9-15

Most transit operators occasionally conduct an on-board survey of riders. Based on experiences in Washtenaw County (Ann Arbor) Michigan, Dade County (Miami) Florida, and Honolulu, Hawaii, this paper examines three aspects of such surveys. First, a survey instrument is described that permits considerably more information to be collected than is possible from the traditional postcard type of on-board survey. Descriptions of the types of data needed to be collected on the participatory self/administered survey of riders for both systemwide surveillance and individual route monitoring are provided. In addition, it is recommended that the survey personnel record observable information (e.g., passenger volumes) on bus operations. Second, procedures are described for reducing nonresponse bias for collecting at least some information from a subgroup of riders who would otherwise be nonrespondents. Third, sampling strategies (including the necessary sample sizes) are described both for systemwide surveillance and individual route monitoring.

This paper appeared in Transportation Research Record No. 862, Short-Range Transit Operations Planning and Development.

AVAILABLE FROM: TRB Publications Office

114. TIMETABLES: WHAT MAKES THEM EFFECTIVE?

Everett, PB

Transportation Research Board Unpublished Report No. 12, Nov. 1979, pp. 31-38

This paper discusses the timetable, a pocket-sized pamphlet that displays both a timetable and a route map for one or a small number of routes. The evaluation of the effectiveness of the timetable is also discussed. Research that delineates the effectiveness attributes of timetables is minimal. A few such studies are briefly reviewed. It is noted that before research on timetable design and distribution, there should be an investigation of the timetable within a comprehensive information system. This paper appeared in TRB Unpublished Report No. 12, Information Aids for Transit Consumers: Conference Proceedings

AVAILABLE FROM: TRB Publications Office

115. TOWARD VALID MEASURES OF PUBLIC SECTOR PRODUCTIVITY-PERFORMANCE MEASURES IN URBAN TRANSIT

Gleason, JM; Barnum, DT

Management Science Vol. 28 No. 4, Apr. 1982, pp. 379-386

This study examines weaknesses and biases inherent in commonly used measures of urban mass transit performance. It is shown that measures of efficiency, such as cost per passenger, are being incorrectly used as measures of effectiveness and that various traditional measures of efficiency, such as those which incorporate mileage, can be misleading when applied in decision making. Suggestions are made for developing valid performance indicators and for developing safeguards that will avoid present shortcomings.

AVAILABLE FROM: ESL

116. TRANSIT ACTIONS: TECHNIQUES FOR IMPROVING PRODUCTIVITY AND PERFORMANCE

Public Technology, Inc., Department of Transportation Rpt. DOT-I-79-18, October 1979, 259 p.

The workbook contains actions which cut the cost of providing transit services or improve system operating efficiency and effectiveness. The three perspectives presented in the beginning of this workbook emphasize the need to improve productivity and performance. The remainder of the workbook is divided into five areas: Service Level, Transit Financing Policies, Internal Management, Labor-Management Relations, and Performance Measures.

AVAILABLE FROM: NTIS PB82-154535

117. TRANSIT PERFORMANCE EVALUATION MODEL

Guenthner, RP; Sinha, KC

ASCE Journal of Transportation Engineering Vol. 108 No. TE4, July 1982, pp. 343-361

An analytical methodology, known as the Transit Performance Evaluation Model, has been extended and applied. The model is used to evaluate the effect on transit performance from short term policy changes including: fares, service frequencies, route coverage, and route alignment. Long term trends in ridership due to a shift in the demand function caused by factors beyond the control of transit operators were also considered. The model was intended for use by bus operators in small to medium sized cities. Model tests were performed in several small midwestern cities using a variety of policy changes.

AVAILABLE FROM: ESL

118. TRANSIT PERFORMANCE IN NEW YORK STATE

Barbour, LC; Zerrillo, RJ

Transportation Research Record No. 857, 1982, pp. 18-25

Over the past two years, the New York State Department of Transportation has developed a program to monitor the performance of transit operations that receive state operating assistance. The initial performance evaluation methodology has been revised to better meet a change in Department emphasis to monitor individual operator performance and encourage improvement. Past efforts are expanded by examining (a) the grouping of transit operators on the basis of mode, service type, and vehicle fleet size; (b) the relative performance of each group of operators over time; (c) the performance levels of public and private bus operators; and (d) the advantages and disadvantages of the proposed change in methodology. The results in this analysis show that grouping operators into peer groups yields more meaningful internal group comparisons and, in most cases, should help identify operators that are performing poorly. The overall change in performance between 1978-1979 and 1979-1980 seems to indicate that operator efficiency is improving while effectiveness is declining. Many of the differences seen in performance measures are found to be attributable to vehicle speed. As expected, private operators report higher levels of operating efficiency than public operators and also seem to be holding the line on rising costs better than the public operators. Future years efforts will need to include expanded time-series analysis of the state's large operators coupled with a more in-depth review of the use of measures of transit service quality. This paper appeared in Transportation Research Record No. 857, Bus Operations and Performance.

AVAILABLE FROM: TRB Publications Office

119. TRANSIT PERFORMANCE MEASURES AND LOCAL OBJECTIVES: STATE-LEVEL POLICY CONSIDERATIONS (ABRIDGMENT)

Forkenbrock, DJ

Transportation Research Record No. 813, 1981, pp. 23-26

With increased involvement by the states in financing pubic transportaton, the issue has arisen whether states should determine the standards by which the equality of transit service is measured. Either the performance measures on which these standards are based can be used to define a minimum quality level to qualify for state funds or they may actually constitute the basis for distributing state assistance. In this study, several possible criteria for distributing assistance at the state level are contemplated. Some of them are in conflict; it would not be possible to apply all of them simultaneously. The purpose of this analysis is to explicate the policy implications of alternative allocation criteria. (Author) This paper appeared in Transportation Research Record No. 813, Finance Issues: County Highways and Public Transit.

AVAILABLE FROM: TRB Publications Office

120. TRANSIT SYSTEM PERFORMANCE EVALUATION AND SERVICE CHANGE MANUAL

Booz-Allen and Hamilton, Inc., Simpson and Curtis Division, Urban Mass Transportation Administration Tech. Rpt. UMTA-PA-09-8003-82, Feb. 1981, n.p.

This manual is a guide to help Pennsyslvania transit system managers make better use of limited physical and financial resources. It details a process for setting objectives, evaluating performance, and implementing service and fare changes. The stress is on aiding transit governing boards and management to decide the level of performance they should meet and making appropriate changes to achieve that performance. Many different performance objectives and service alternatives are described. The manual is organized in five sections: Formulation of system objectives; Evaluation methodology; Types of service changes available; Fare related changes and effects on revenues and ridership.

AVAILABLE FROM: NTIS

121. TRANSIT SYSTEM PERFORMANCE INDICATORS: AN ASSESSMENT OF CURRENT U.S. PRACTICE

Peat, Marwick, Mitchell and Company, Urban Mass Transportatoin Administration Oct. 1978, n.p.

This report provides an inventory and assessment of performance indicators currently utilized by U.S. transit systems and discusses the relevance of these indicators to the various user groups. Indicators are categorized as those for external reporting purposes and those for internal evaluation and are summarized in a tabular format. Two case studies - the Santa Clara County Transit and the Washington Metropolitan Area Transit Authority - are developed to illustrate performance evaluation in a medium sized bus firm and a large multi-modal operator, respectively. The report concludes with a set of recommended indicators appropriate for the performance evaluation of a given type of public transit system, for comparing given types of systems, and for measurement of the performance multi-mode systems. The authors stress that transit performance in the U.S. in an embryonic stage and that more research should be done, particularly in the areas of system comparability and the interrelationships between public policies and transit performance.

AVAILABLE FROM: Peat, Marwick, Mitchell and Company

122. TRANSIT SYSTEM PRODUCTIVITY

Public Technology, Inc., Department of Transportation, Office of the Secretary, July 1978, 57 p.

This bulletin explores the subjects of transit productivity mesurement and potential for productivity improvement. The following are discussed: (1) The concept of productivity; (2) Varying institutional perspectives; (3) Productivity indicators; (4) Labor productivity; (5) Service characteristics and pricing; and (6) Maintenance, organization, and procurement. There is a case study--Seattle's used by part-time bus drivers--which describes the potential of part-time labor for productivity improvement. A list of contacts and current programs is also included. Sponsored in part by Department of Transportation, Washington, DC, Office of the Secretary.

AVAILABLE FROM: NTIS PB82-148990

123. UNIFORM DATA MANAGEMENT SYSTEM: SYSTEM DEVELOPMENT AND TESTING

Iowa Department of Transportation, RPT-3715(001)-93-52, DOT-I-81-2, Oct. 1980, 20 p.

The Uniform Data Management System (UDMS) was initiated to acquire appropriate accounting information and operating data on Iowa's 33 transit properties. Initially a computer software program was developed to accumulate the state-wide data. The UDMS project is based on the UMTA Section 15 Uniform System of Accounts and Records and Reporting Systems. It defined transit activities and recording procedures in a uniform manner and would allow Iowa data to be compared with other transit information around the country. A special problem was adopting this system to Iowa's 16 rural transit systems. The UDMS program was designed in two separate, but related, elements - financial element and nonfinancial element. Following testing of the computer software in Phase I, there follows implementation of the system of additional properties, development of a UDMS user's manual, and development of performance standards with implementation of performance audits.

AVAILABLE FROM: Iowa DOT

124. URBAN MASS TRANSPORTATION INDUSTRY UNIFORM SYSTEM OF ACCOUNTS AND RECORDS AND REPORTING SYSTEM. VOLUME I. GENERAL DESCRIPTION

Andersen (Arthur) and Company, Urban Mass Transportation Administration, UMTA-IT-06-0094-77-1, Jan. 1977, 64 p.

The purpose of the report is to present and document the detailed features of the uniform system of accounts and records and reporting system required by Section 15 of the Urban Mass Transportation Act of 1964, as amended. This report is presented in four volumes: Volume 1 presents an overview of the systems, and an identification of the analytical potential provided by comparative data generated by the systems. Also available in set of 4 reports PC E11, PB-264 876-SET.

AVAILABLE FROM: NTIS PB-264877/2ST

125. URBAN MASS TRANSPORTATION INDUSTRY UNIFORM SYSTEM OF ACCOUNTS AND RECORDS AND REPORTING SYSTEM. VOLUME II. UNIFORM SYSTEM OF ACCOUNTS AND RECORDS

Andersen (Arthur) and Company, Urban Mass Transportation Administration, UMTA-IT-06-0094-77-2, Jan. 1977, 268 p.

The purpose of the report is to present and document the detailed features of the uniform system of accounts and records and reporting system required by Section 15 of the Urban Mass Transportation Act of 1964, as amended. Volume 2 contains the definitions for the uniform systems of accounts and records. Modes of transit service subject to this Section 15 system are also defined in this Volume.
See also Volume I, B-264 877. Also available in set of 4 reports PC E11, PB-264 876-SET.

AVAILABLE FROM: NTIS PB-264878/0ST

126. URBAN MASS TRANSPORTATION INDUSTRY UNIFORM SYSTEM OF ACCOUNTS AND RECORDS AND REPORTING SYSTEM, VOLUME III. REPORTING SYSTEM FORMS AND INSTRUCTIONS-REQUIRED

Andersen (Arthur) and Company, Urban Mass Transportation Administration, UMTA-IT-06-0094-77-3, Jan. 1977, 60 p.

The purpose of the report is to present and document the detailed features of the uniform system of accounts and records and reporting system required by Section 15 of the Urban Mass Transportation Act of 1964, as amended. Volume 3 contains illustrative forms for each of the reports required to be submitted under Section 15 and instructions for completing these forms.
See also Volume 2, PB-264 878. Also available in set of 4 reports PC E11, PB-264 876-SET.

AVAILABLE FROM: NTIS PB-264879/8ST

127. **URBAN MASS TRANSPORTATION INDUSTRY UNIFORM SYSTEM OF ACCOUNTS AND RECORDS AND REPORTING SYSTEM, VOLUME IV. REPORTING SYSTEM FORMS AND INSTRUCTIONS-VOLUNTARY**

Andersen (Arthur) and Company, Urban Mass Transportation Administration, UMTA-IT-06-0094-77-4, Jan. 1977, 112 p.

The purpose of the report is to present and document the detailed features of the uniform system of accounts and records and reporting system required by Section 15 of the Urban Mass Transportation Act of 1964, as amended. Volume 4 contains illustrative forms and instructions for optional revenue and expense reporting.

See also Volume 3, PB-264 879. Also available in set of 4 reports PC E11, PB-264 876-SET.

AVAILABLE FROM: NTIS PB-264880/6ST

128. **URBAN PUBLIC TRANSPORT: EVALUATION OF PERFORMANCE**

Organization for Economic Cooperation and Development, Monograph 1980, 76 p.

This report identifies approaches for evaluating public transport service through the use of performance indicators. Chapter 1 introduces various concepts of transport performance and relates them to different users and purposes. Chapter 2 discusses the various specialized groups (public transport managers, municipal managers, policy board, regional planners, street traffic system managers, central, national and state government, public transport users and research community), and their perceived needs for performance measures. Chapter 3 deals with data collection while chapter 4 examines the various functions fulfilled by performance indicators (cost, service production, service reliability, engineering, accidents, revenue, patronage, effectiveness indicators). Chapter 5 describes the design of performance indicators for service planning, internal assessment over time, comparisons between different operating areas, and comparisons between different operations. Chapter 6 outlines the research needs in system performance. An appendix summarizes selected case studies of approaches used by some member countries in their performance evaluation. (TRRL)

AVAILABLE FROM: Organization for Economic Cooperation and Development

129. **USE OF FEDERAL SECTION 15 DATA IN TRANSIT PERFORMANCE EVALUATION: MICHIGAN PROGRAM (ABRIDGMENT)**

Holec, JM, Jr; Schwager, DS; Fandialan, A

Transportation Research Record No. 746, 1980, pp. 36-38

In the first application of its kind, the reporting system of Section 15 of the Urban Mass Transportation Act, as amended, is being used to

support the development of a straightforward, routine, and comprehensive transit performance evaluation program in the state of Michigan. The methodology developed for Michigan satisfies the complementary needs to account for public funds invested in transit operation and development and to promote the efficient and effective use of these funds in the delivery of transit services. At the same time, the methodology avoids placing an additional burden of record keeping and reporting on individual transit operators. In the rapidly developing field of transit performance evaluation, these features are essential for state and local funding agencies to consider as part of any plans to develop a continuing evaluation program. In this paper, the Michigan program is described, and the features of the program that have general applicability for other areas concerned with transit performance measurement and evaluation are highlighted. (Author) This paper appeared in TRB Record No. 746, Bus Transit Managment and Peformance.

AVAILABLE FROM: TRB Publications Office

130. USE OF SERVICE EVALUATION PLANS TO ANALYZE NEW YORK STATE TRANSIT SYSTEMS (ABRIDGMENT)

Zerrillo, RJ

Transportation Research Record No. 797, 1981, pp. 58-61

Recent state legislature mandated that the New York State Department of Transportation develop a transit service evaluation plan reporting requirement to be used along with transit performance measures in the evaluation of the state's major transit systems. This paper describes the development of the service plan submission and summarizes the results of the plan submittals for the first year. The results of the two reporting groups of transit systems (public authorities and county sponsors) are compared on each of four topics (use of goals and objectives, operating performance evaluation, service coordination, and service problems and needs). It is concluded that the service plans provide a basis for relating transit system performance to local service objectives and operating conditions and also for improving the performance monitoring of New York State's major transit systems. (Author) This paper appeared in Transportation Research Record No. 797, Transit Planning and Management.

AVAILABLE FROM: TRB Publications Office

131. UTILIZATION OF SECTION 15 DATA BY STATE GOVERNMENTS

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AVAILABLE FROM: NTIS PB-264880/6ST

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Organization for Economic Cooperation and Development, Monograph 1980, 76 p.

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AVAILABLE FROM: Organization for Economic Cooperation and Development

129. USE OF FEDERAL SECTION 15 DATA IN TRANSIT PERFORMANCE EVALUATION: MICHIGAN PROGRAM (ABRIDGMENT)

Holec, JM, Jr; Schwager, DS; Fandialan, A

Transportation Research Record No. 746, 1980, pp. 36-38

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support the development of a straightforward, routine, and comprehensive transit performance evaluation program in the state of Michigan. The methodology developed for Michigan satisfies the complementary needs to account for public funds invested in transit operation and development and to promote the efficient and effective use of these funds in the delivery of transit services. At the same time, the methodology avoids placing an additional burden of record keeping and reporting on individual transit operators. In the rapidly developing field of transit performance evaluation, these features are essential for state and local funding agencies to consider as part of any plans to develop a continuing evaluation program. In this paper, the Michigan program is described, and the features of the program that have general applicability for other areas concerned with transit performance measurement and evaluation are highlighted. (Author) This paper appeared in TRB Record No. 746, Bus Transit Managment and Peformance.

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130. USE OF SERVICE EVALUATION PLANS TO ANALYZE NEW YORK STATE TRANSIT SYSTEMS (ABRIDGMENT)

Zerrillo, RJ

Transportation Research Record No. 797, 1981, pp. 58-61

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This paper describes the Florida Department of Transportation's Transit Management Assistance Program, which relies heavily on data from the

Section 15 reporting system. The Florida program involves determination of operations and management needs of transit systems, development of goals and objectives, information dissemination and data development, annual evaluation of needs and services, and application of performance measures to determine system efficiency and effectiveness and upon which expenditures of state funds are based. Use of Section 15 replaced a previous data collection effort which had placed undue burden upon the operators. To facilitate data reporting and analysis, the state has provided a specially programmed desk top computer to each operator. This enables the operators to generate reports on vehicle maintenance, ridership, safety and Section 15 financial and operating data. Data in eleven performance areas, compatible with the Section 15 system, are provided annually to the state and are used as the basis of system evaluation, short and long range planning efforts, and allocation of state operating assistance. A number of positive benefits derived from the use of the Section 15 system are enumerated and discussed.
Prepared for the 62nd Annual Meeting of the Transportation Research Board, Washington, D.C. January 22, 1980.

AVAILABLE FROM: TRB Publications Office

132. A VITAL PHASE OF TRANSIT EVOLUTION: MANAGEMENT INFORMATION SYSTEMS

Knautz, DD

Transportation Research Board Special Report No. 187, 1980, pp. 33-35

Passage of the Urban Mass Transportation Act of 1964 signaled a new era for the transit industry by facilitating the public acquisition of private operations as well as capital purchases of equipment. In 1974, operating assistance was provided under the National Mass Transportation Act. The increase in federal funding, however, has resulted in significant increases in federal regulations and reporting requirements. This has caused an intensive effort to provide sound system management and internal controls at the local level. To give transit managers the information essential to fully utilize available funds, management information systems have been developed. Successful management information systems are based on, first, the identificaton of the particular information needs of a transit system and, second, the development of performance criteria from and in-depth statistical analysis of the management provided. Although the management information systems are continually being updated, the performance criteria are still in the formative stages. Yet it is these performance criteria, based on sound management information, that will help transit to become more cost-effective and to provide better service. (Author) This paper appeared in TRB Special Report 187, Transportation Planning for Small and Medium-Sized Communities, Proceedings of a Workshop sponsored by UMTA and FHWA, conducted by TRB, Sarasota, Florida, 3-6 December 1978.

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APPENDIX B

APPENDIX B

The data presented in the section entitled "Surveys of Park-and-Ride Users and Nonusers" was obtained through either on-board (user) surveys performed at 8 Houston park-and-ride lots or from telephone interviews conducted in the market areas for the North Shepherd and Addicks Park-and-Ride lots. Survey instruments were used for both the on-board and home telephone surveys. While there were slight differences in survey forms between different lots and different market areas, the survey instruments used were all generally similar. Representative user and nonuser surveys are included at the end of this appendix. Specific lot locations for the on-board surveys and target market areas for the telephone surveys are illustrated in Figures B-1 through B-3. The sample selection procedures utilized for these survey efforts are discussed in Research Report 205-11.

On-Board Survey

The on-board surveys were conducted on approximately 30% of the buses departing each park-and-ride lot during the morning peak period. Of those buses surveyed, each rider was given a questionnaire and asked to return the completed form to the survey taker before leaving the bus. At all lots surveyed, between 96% and 99% of the riders chose to participate by answering the questionnaire. The number of surveys completed by lot is presented below:

Kuykendahl	400
North Shepherd	269
Spring	260
Seton Lake	213
Addicks	98
Westwood	281
Alief	131
Southwest Freeway	70
Total	1722

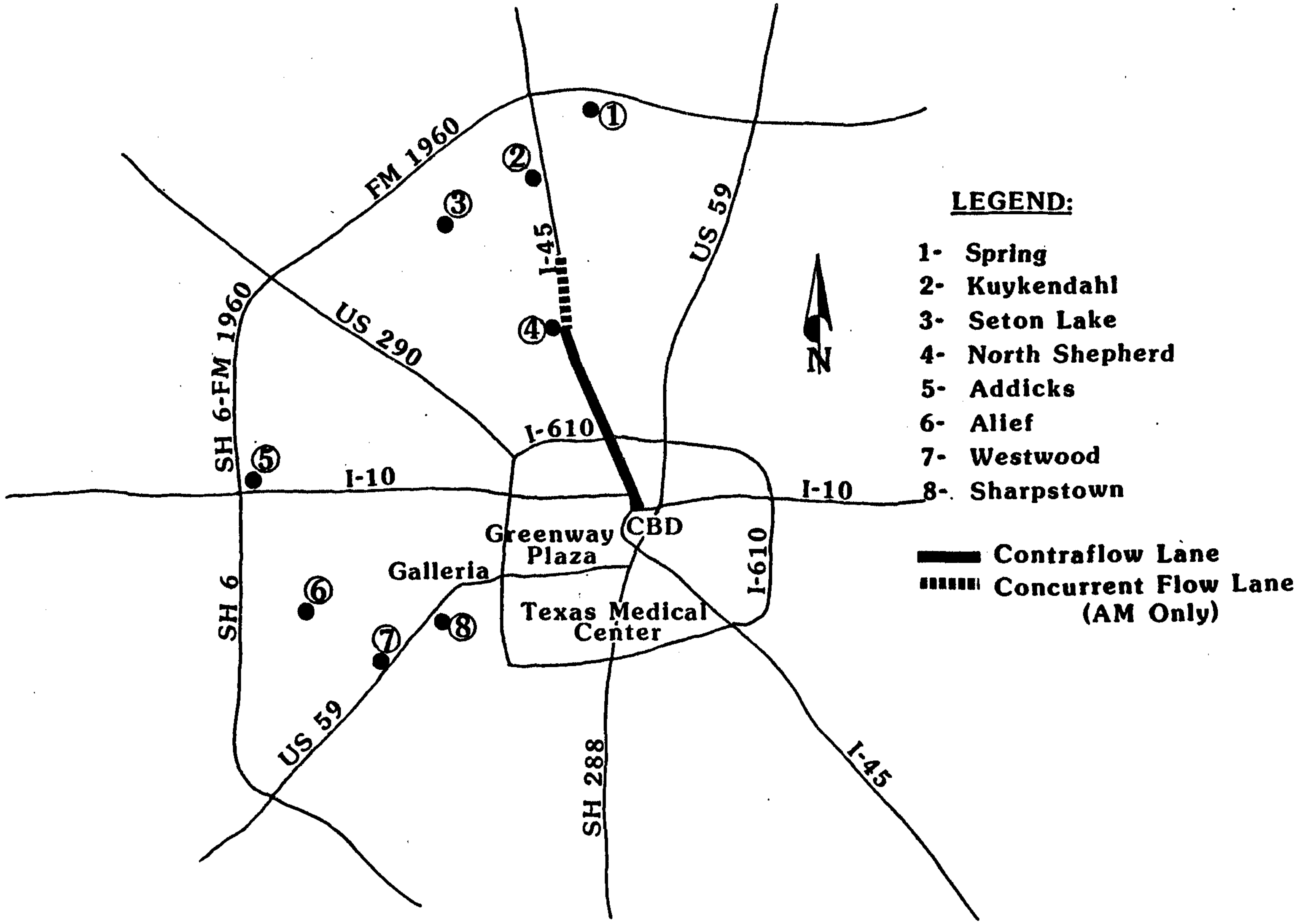

Figure B-1: Location of the Park-and-Ride Lots Included in the On-Board Survey

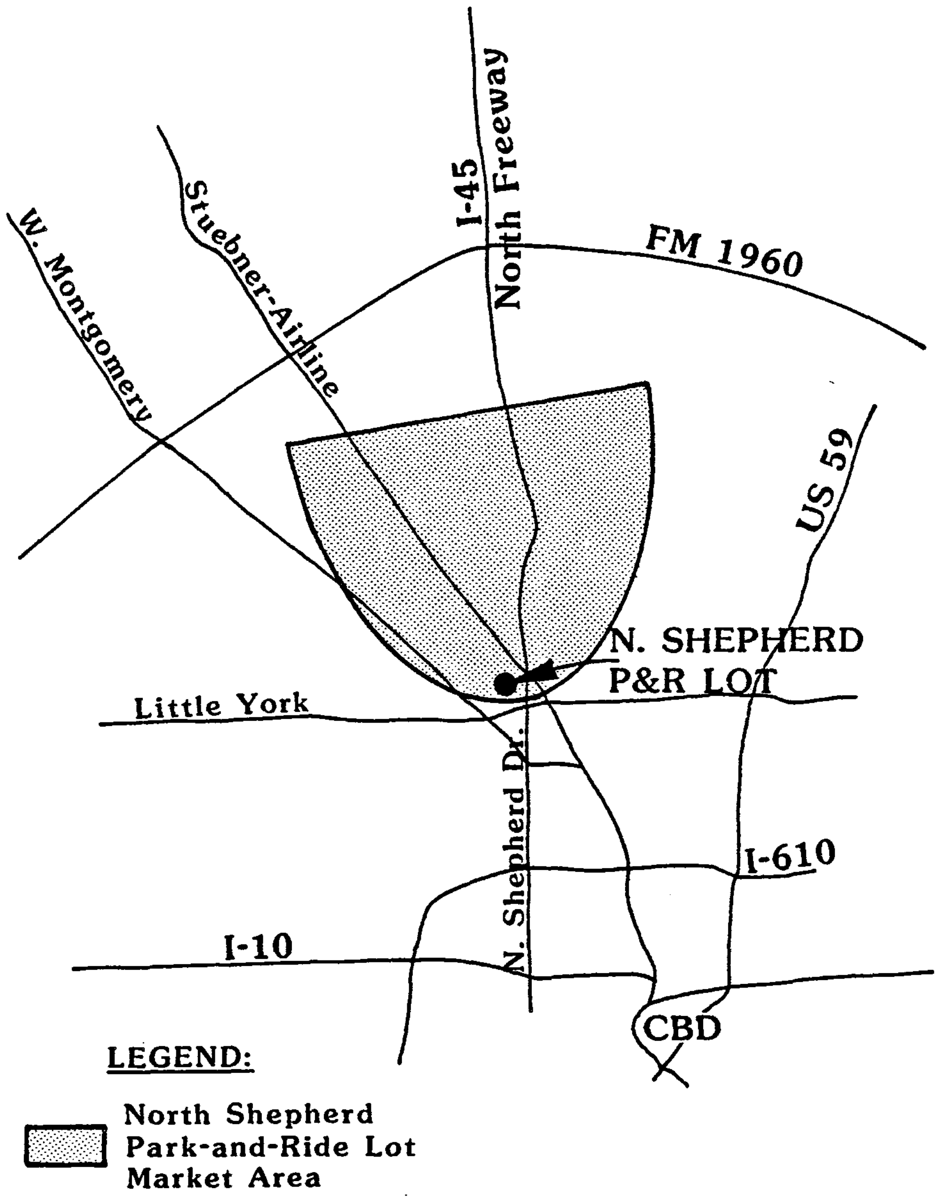

Figure B-2: North Shepherd Park-and-Ride Lot Market Area for the Home Telephone Survey

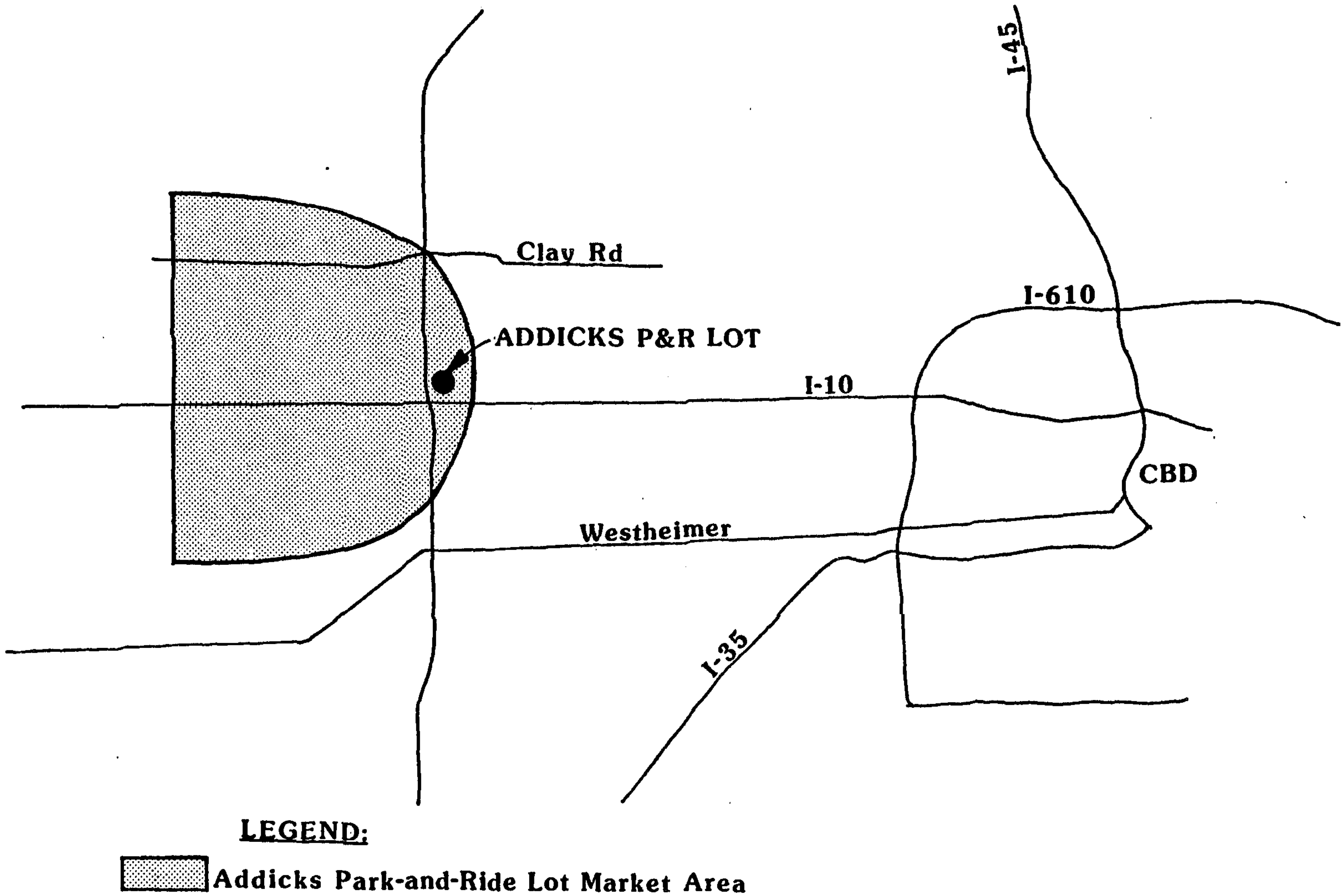

Figure B-3: Addicks Park-and-Ride Lot Market Area for the Home Telephone Survey

Home Telephone Survey

Target market areas for the North Shepherd and Addicks Park-and-Ride lots were identified and related to the trade zones shown in Cole's Directory, and approximately 2400 names and telephone numbers were selected at random from each market area. These names and telephone numbers formed the basis for the home telephone survey. Allowing for disconnected numbers, busy numbers and persons who were not home, a goal of approximately 600 willing participants per market area was established and attained. A total of 521 (87%) of the North Shepard area participants and 507 (84%) of the Addicks area participants indicated that they did not work in the activity centers served by park-and-ride; their interviews were subsequently concluded. An additional 25 (4%) of the North Shepherd area participants and 15 (3%) of the Addicks area participants indicated that they were regular users of park-and-ride service and their interviews were also concluded. This left 52 participants from the North Shepherd area and 82 from the Addicks area (who were considered potential users of park-and-ride) who completed the entire survey form.

PARK & RIDE USER SURVEY

Undertaken by the Texas Transportation Institute, The Texas A&M University System,
in cooperation with the Texas State Department of Highways and Public Transportation,
the Metropolitan Transit Authority, and the U.S. Department of Transportation

1. Before you began using the Park & Ride service, how did you normally make this trip?
   ______Drove self ______Vanpool ______Did not make trip
   ______Carpool ______Regular route bus ______Other

2. How did you reach the Park & Ride lot this morning?
   (a) I walked ______ blocks
   (b) I drove ______ miles and parked
   (c) I was driven ______ miles
   (d) Other ______________________

3. How did you pay your fare for this bus ride?
   ______Cash ______Token ______Ticket ______Monthly pass ______Other

4. What is your final destination on this trip?______________________________
   (name of bldg. and address)

5. How long have you used the Park & Ride service? ______________________________

6. In your decision to use Park & Ride, how important is the availability of the Contraflow Lane?
   ______Not important ______Not a factor ______Very important

7. Would you use Park & Ride if the Contraflow Lane did not exist?
   ______Yes ______No ______Not sure

8. The Contraflow Lane began operation in August 1979. Have you changed job locations since that date?
   ______Yes ______No

   If "yes," was the Contraflow Lane and the availability of Park & Ride service to your work site a factor in your decision to accept the job? ______Yes ______No

9. Have you changed residential locations since August 1979? ______Yes ______No

   If "yes," was the Contraflow Lane and the availability of Park & Ride service nearby a factor in your decision to move to that neighborhood? ______Yes ______No

10. Do you save time using the Park & Ride service rather than driving?
    ______Yes / If "yes," how many minutes do you save one-way? ______________minutes
    ______No / If "no," how many minutes do you lose one-way? ______________minutes

11. Do you save money using the Park & Ride service rather than driving?
    ______Yes / If "yes," how much do you save? $______________per month
    ______No / If "no," how much do you lose? $______________per month

12. What is the primary reason you chose to use Park & Ride?______________________________

13. In your opinion, has the Contraflow Lane been successful in achieving its goals of:

    Increasing transit ridership? ______Yes ______No ______Not sure
    Reducing travel times for transit users? ______Yes ______No ______Not sure
    Reducing traffic congestion on I-45N? ______Yes ______No ______Not sure
    Reducing auto parking requirements downtown? ______Yes ______No ______Not sure

14. What is your... Age?__________ Sex?______________ Occupation?______________________

15. What is the highest level of school you have completed?______________________________

Please use the back of this form for additional comments. Thank you for your cooperation!

PARK & RIDE USER SURVEY

Undertaken by the Texas Transportation Institute, The Texas A&M University System, in cooperation with the Texas State Department of Highways and Public Transportation, the Metropolitan Transit Authority, and the U.S. Department of Transportation

1. Before you began using the Park & Ride service, how did you normally make this trip?
   ______Drove self ______Vanpool ______Did not make trip
   ______Carpool ______Regular route bus ______Other

2. How did you reach the Park & Ride lot this morning?
   (a) I walked ______ blocks (c) I was driven ______ miles
   (b) I drove ______ miles and parked (d) Other ______________________

3. How did you pay your fare for this bus ride?
   ______Cash ______Token ______Ticket ______Monthly pass ______Other

4. What is your final destination on this trip?______________________________________
   (name of bldg. and address)

5. How long have you used the Park & Ride service?______________________________________

6. METRO began offering Park & Ride service from the ______________________ lot in ______________.
   Have you changed job locations since that date? ______Yes ______No

   If "yes," was the availability of Park & Ride service to your work site a factor in your decision to accept the job? ______Yes ______No

7. Have you changed residential locations since ______________? ______Yes ______No

   If "yes," was the availability of Park & Ride service nearby a factor in your decision to move to that neighborhood? ______Yes ______No

8. Do you save time using the Park & Ride service rather than driving?
   ______Yes / If "yes," how many minutes do you save one-way? ______________________minutes
   ______No / If "no," how many minutes do you lose one-way? ______________________minutes

9. Do you save money using the Park & Ride service rather than driving?
   ______Yes / If "yes," how much do you save? $______________________per month
   ______No / If "no," how much do you lose? $______________________per month

10. What is the primary reason you chose to use Park & Ride?______________________________________

11. Based on your knowledge of the Contraflow Lane operation along I-45N (North Freeway), do you think that the Contraflow Lane had been successful in achieving its goals of:

    Increasing transit ridership? ______Yes ______No ______Not sure
    Reducing travel times for transit users? ______Yes ______No ______Not sure
    Reducing traffic congestion on I-45N? ______Yes ______No ______Not sure
    Reducing auto parking requirements downtown? ______Yes ______No ______Not sure

12. Are you in favor of the transitway (for use by buses and carpools) currently being constructed along the Katy Freeway? ______Yes ______No ______Not sure

13. What is your... Age?__________ Sex?______________ Occupation?______________________

14. What is the highest level of school you have completed?______________________________________

Please use the back of this form for additional comments. Thank you for your cooperation!

PARK & RIDE USER SURVEY

Undertaken by the Texas Transportation Institute, The Texas A&M University System,
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the Metropolitan Transit Authority, and the U.S. Department of Transportation

1. Before you began using the Park & Ride service, how did you normally make this trip?
   ______Drove self ______Vanpool ______Did not make trip
   ______Carpool ______Regular route bus ______Other

2. How did you reach the Park & Ride lot this morning?
   (a) I walked ______ blocks (c) I was driven ______ miles
   (b) I drove ______ miles and parked (d) Other ____________________

3. How did you pay your fare for this bus ride?
   ______Cash ______Token ______Ticket ______Monthly pass ______Other

4. What is your final destination on this trip?______________________________
   (name of bldg. and address)

5. How long have you used the Park & Ride service?______________________________

6. METRO began offering Park & Ride service from the ____________________ lot in ______________.
   Have you changed job locations since that date? ______Yes ______No

   If "yes," was the availability of Park & Ride service to your work site a factor in your decision to accept the job? ______Yes ______No

7. Have you changed residential locations since ______________? ______Yes ______No

   If "yes," was the availability of Park & Ride service nearby a factor in your decision to move to that neighborhood? ______Yes ______No

8. Do you save time using the Park & Ride service rather than driving?
   ______Yes / If "yes," how many minutes do you save one-way? ____________________minutes
   ______No / If "no," how many minutes do you lose one-way? ____________________minutes

9. Do you save money using the Park & Ride service rather than driving?
   ______Yes / If "yes," how much do you save? $____________________per month
   ______No / If "no," how much do you lose? $____________________per month

10. What is the primary reason you chose to use Park & Ride?______________________________

11. Based on your knowledge of the Contraflow Lane operation along I-45N (North Freeway), do you think that the Contraflow Lane had been successful in achieving its goals of:

Increasing transit ridership?	______Yes	______No	______Not sure
Reducing travel times for transit users?	______Yes	______No	______Not sure
Reducing traffic congestion on I-45N?	______Yes	______No	______Not sure
Reducing auto parking requirements downtown?	______Yes	______No	______Not sure

12. Would you be in favor of a reserved lane for buses and vanpools along the Southwest Freeway corridor?
    ______Yes ______No ______Not sure

13. What is your... Age?__________ Sex?______________ Occupation?______________________

14. What is the highest level of school you have completed?______________________________

Please use the back of this form for additional comments. Thank you for your cooperation !

NORTH FREEWAY SURVEY OF NON PARK-AND-RIDE USERS

1. **Do you, or any other household members, work in downtown Houston or, the Texas Medical Center?**

   ____1. Yes

   (If "yes," ask to speak with the person who works at one of those locations and go on to Question 2.)

   ____2. No

   (If "no," the survey is concluded.)

2. **Are you a regular user of the METRO Park-and-Ride service currently provided along the North Freeway?**

   ____1. Yes

   (If "yes," the survey is concluded.)

   ____2. No

   (If "no," continue with the rest of the survey.)

3. **At which location do you work?**

   ____1. Downtown Houston
   ____2. Texas Medical Center
   ____3. Other (specify below)
   ____

4. **How do you travel to your work location?**

   ____1. Drive alone
   ____2. Carpool
   ____3. Vanpool
   ____4. METRO local bus
   ____5. Other (specify below)
   ____

5. **How often do you ride a METRO bus?**

   ____1. Almost every day
   ____2. About once a week
   ____3. Seldom
   ____4. Never

6. **Have you ever used the METRO Park-and-Ride bus service which operates along the North Freeway?**

   ____1. Yes

   (If "yes," go to Question 9.)

   ____2. No

   (If "no," go on to Question 7.)

7. **Do you know the location of the Park-and-Ride lot nearest your home?**

   ____1. Yes ____2. No ____3. Not sure

8. **Do you know enough about the Park-and-Ride service provided by METRO to confidently begin using it tomorrow?**

____1. Yes ____2. No ____3. Not sure

9. **Does your job require that you have a car available during the day?**

____1. Yes ____2. No

The next few questions concern your opinion about the operation of the North Freeway contraflow lane.

10. **In your opinion, has the contraflow lane encouraged more people to ride buses?**

____1. Yes ____2. No ____3. Not sure

11. **Do you think the contraflow lane has reduced the time it takes for bus and vanpool users to travel to and from work?**

____1. Yes ____2. No ____3. Not sure

12. **Has the contraflow lane reduced traffic congestion on the North Freeway?**

____1. Yes ____2. No ____3. Not sure

13. **Do you think the use of the contraflow lane by Park-and-Ride users has reduced the demand for auto parking spaces downtown?**

____1. Yes ____2. No ____3. Not sure

14. **Does your employer pay for "all" or "part" of your parking expense?**

____1. Yes (pays all)
____2. Yes (pays part)
____3. No

15. **Does your employer pay for "all" or "part" of your bus pass expense?**

____1. Yes (pays all)
____2. Yes (pays part)
____3. No
____4. Don't know

16. **What is the primary reason you do not regularly use Park-and-Ride to travel to and from work?**

____

____

17. **What, if anything, would encourage you to use Park-and-Ride to travel to and from work?**

____

____

18. **In which of the following age groups do you belong?**

____1. Less than 18
____2. 18-21
____3. 22-31
____4. 32-41
____5. 42-51
____6. 52-61
____7. 62 or older

19. **Sex?** ____1. Male ____2. Female

20. **What is your current job?**____________________________

21. **What is the last level of school that you have completed?**

____1. Less than high school
____2. High school graduate
____3. Some college
____4. College graduate
____5. More than college

KATY FREEWAY SURVEY OF NON PARK-AND-RIDE USERS

1. **Do you, or any other household members, work in downtown Houston?**

____1. Yes

(If "yes," ask to speak with the person who works at one of those locations and go on to Question 2.)

____2. No

(If "no," the survey is concluded.)

2. **Are you a regular user of the METRO Park-and-Ride service currently provided along the Katy Freeway?**

____1. Yes

(If "yes," the survey is concluded.)

____2. No

(If "no," continue with the rest of the survey.)

3. **How do you travel to your work location?**

____1. Drive alone
____2. Carpool
____3. Vanpool
____4. METRO local bus
____5. Other (specify below)
____

4. **How often do you ride a METRO bus?**

____1. Almost every day
____2. About once a week
____3. Seldom
____4. Never

5. **Have you ever used the METRO Park-and-Ride bus service which operates along the Katy Freeway?**

____1. Yes

(If "yes," go to Question 8.)

____2. No

(If "no," go on to Question 6.)

6. **Do you know the location of the Park-and-Ride lot nearest your home?**

____1. Yes ____2. No ____3. Not sure

7. **Do you know enough about the Park-and-Ride service provided by METRO to confidently begin using it tommorrow?**

____1. Yes ____2. No ____3. Not sure

8. Does your job require that you have a car available during the day?

____1. Yes ____2. No

The next few questions concern your opinion about the operation of the North Freeway contraflow lane. We realize that because you live in west Houston, you may not have had many occasions to observe the contraflow lane in operation. We would nevertheless like you to answer the following questions based on what knowledge you do have concerning the contraflow lane.

9. In your opinion, has the North Freeway contraflow lane encouraged more people to ride buses?

____1. Yes ____2. No ____3. Not sure

10. Do you think the North Freeway contraflow lane has reduced the time it takes for bus and vanpool users to travel to and from work?

____1. Yes ____2. No ____3. Not sure

11. Has the North Freeway contraflow lane reduced traffic congestion on the North Freeway?

____1. Yes ____2. No ____3. Not sure

12. Do you think the use of the North Freeway contraflow lane by Park-and-Ride users has reduced the demand for auto parking spaces downtown?

____1. Yes ____2. No ____3. Not sure

13. Are you in favor of the transitway for use by buses and vanpools currently being constructed along the Katy Freeway?

____1. Yes ____2. No ____3. Not sure

14. Will you be able to use the Katy Transitway when completed?

____1. Yes ____2. No ____3. Not sure

15. Does your employer pay for "all" or "part" of your parking expense?

____1. Yes (pays all)
____2. Yes (pays part)
____3. No

16. Does your employer pay for "all" or "part" of your bus pass expense?

____1. Yes (pays all)
____2. Yes (pays part)
____3. No
____4. Don't know

17. What is the primary reason you do not regularly use Park-and-Ride to travel to and from work?

____

____

18. What, if anything, would encourage you to use Park-and-Ride to travel to and from work?

____

____

19. In which of the following age groups do you belong?

____1. Less than 18
____2. 18-21
____3. 22-31
____4. 32-41
____5. 42-51
____6. 52-61
____7. 62 or older

20. Sex? ____1. Male ____2. Female

21. What is your current job?______________________________

22. What is the last level of school that you have completed?

____1. Less than high school
____2. High school graduate
____3. Some college
____4. College graduate
____5. More than college