To the Graduate Council:

I am submitting herewith a dissertation written by Carlos Rafael Bonilla entitled "Jitneys: A Complement to Public Transportation." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Civil Engineering.

Frederick J. Wegmann, Major Professor

We have read this dissertation
and recommend its acceptance:

Accepted for the Council:

Vice Chancellor
Graduate Studies and Research

JITNEYS: A COMPLEMENT TO PUBLIC TRANSPORTATION

A Dissertation

Presented for the

Doctor of Philosophy

Degree

The University of Tennessee, Knoxville

Carlos Rafael Bonilla

December 1980

3046912

To my wife Elsie and my father Jose Angel

ACKNOWLEDGMENTS

The author recognizes the guidance provided by Dr. Frederick J. Wegmann who served as dissertation committee chairman and who provided advice and encouragement during his years at The University of Tennessee.

In addition the author is very grateful to Dr. Kenneth W. Heathington, Director of the Transportation Center of The University of Tennessee for his encouragement and financial support through a research assistantship. The author wishes to thank Mrs. Bette Huber and other Transportation Center staff who cooperated in the preparation of the drafts and drawings that made this dissertation possible.

With great appreciation, the author recognizes the cooperation, information and advice of Mr. Joaquin Montesino Colon, President of the Puerto Rico Federation of Publico Drivers, Mr. William E. Lee, President of the Chattanooga Cruising Cab Association, and Mr. William Greenberg, President of the Atlantic City Jitneymen Association.

ABSTRACT

The growing inability to pay for the quality of transit service desired is encouraging many cities to pursue paratransit alternatives. Yet, no other mode is equivalent to public transit which provides extensive and continuous service while charging low fares. Jitneys seem capable of complementing transit by substituting for some transit functions, by serving some markets unreached by transit and by helping to improve transit's efficiency.

This study reviews past and present regulations that have hindered the jitney role in public transportation. These include outright prohibitions or regulations that preclude management options to increase profits regardless of service. Regulations drawn in the past to protect private interests still prevail, and these regulations may compromise some community goals such as improving the citizen's mobility. Regulation of private transportation modes should be flexible to allow for the efficient utilization of manpower and equipment and to promote the provision of all forms of transportation services.

As part of this study, ten jitney routes that provide corridor service were visited, and their organization and operating characteristics were investigated. On-board and roadside surveys provided information to evaluate performance measures from the points of view of the operator and of the user. Relationships were found between passengers per vehicle-mile, passenger-miles per vehicle-mile, passenger-miles per seat-mile and speed related to vehicular trip distance. Disaggregate cost data were collected for automobile, jitney and bus

modes and were associated with causal factors such as vehicle-miles, vehicle-hours and number of vehicles. Bus transit costs associated with peak and off-peak periods of operation were determined.

The information obtained from the field studies and the analysis of observed data was used to develop a simulation procedure to plan for jitney operation. The procedure relied on a computer program to simulate and analyze operating service, quality of service, economic viability and fuel efficiency. The computer program simulated jitney and bus transit corridor operations. Manual computations were possible, but they were more time consuming and less flexible. Scenario analysis was used to demonstrate applications of the procedure and to show expected results of bus and jitney comparisons.

Other planning considerations to implement jitney services are introduced. These include opportunities for service implementation, desirable regulation and suggested approaches for establishing jitney operations.

Jitney opportunities are limited mostly by regulation rather than by their capabilities. It is strongly recommended that jitneys should be privately owned and operated. A profit incentive is necessary for jitneys if they are to remain efficient and effective.

TABLE OF CONTENTS

CHAPTER		PAGE
1.	INTRODUCTION	1
	Transportation Goals and Costs	1
	Jitney Potential for Public Transportation	3
	Study Goal and Objectives	7
2.	REGULATORY ENVIRONMENT: ORIGINS AND CURRENT STATUS	9
	Background	9
	Emergence of Jitneys and Regulation	9
	Present Status	12
	What Lies Ahead?	21
3.	CHARACTERISTICS OF SELECTED SYSTEMS	23
	Jitneys: What Are They Like?	23
	Organization	23
	Vehicle Types	28
	Route Operations	35
	User Characteristics and Trip Purposes	50
	Understanding Jitney Services	51
4.	PERFORMANCE OF SELECTED ROUTES	53
	Introduction	53
	Field Procedures	54
	Productivity Measures	56
	Trip Time Measures	71
	Assessment of Findings	93
5.	ENERGY, COST AND AIR POLLUTANT EMISSIONS	95
	Measurements	95
	Data Collection	97
	Energy Consumption	98
	Cost of Services	107
	Findings and Information Usage	111
6.	SIMULATION OF JITNEY OPERATIONS: PLANNING PROCEDURES	113
	Introduction	113
	Simulation of Route Operations	115
	Planning Procedures	123
	Scenarios	129
	Review	150

CHAPTER PAGE

7. IMPLEMENTING JITNEY SERVICES 151

Planner Concerns 151
Opportunities for Service Implementation 152
Desirable Regulation 164
A Suggested Approach Toward Jitney Operations . . . 169
Synopsis 177

8. FINDINGS, CONCLUSIONS AND RECOMMENDATIONS 179

General Findings 179
Conclusions 181
A Planning Procedure and Scenario Analysis Findings 182
General Recommendations 183

LIST OF REFERENCES 186

APPENDICES 193

APPENDIX A. CORRIDOR CHARACTERISTICS AND ROUTE DESCRIPTIONS 194

APPENDIX B. FORMS USED IN FIELD SURVEYS 213

APPENDIX C. AIR POLLUTANT EMISSIONS 217

APPENDIX D. PROGRAM CORRIDOR 222

APPENDIX E. OFF-PEAK TO PEAK RATIO 247

APPENDIX F. MANUAL PROCEDURE FOR ESTIMATING JITNEY COSTS . . 252

VITA 257

LIST OF TABLES

TABLE		PAGE
3-1	Route Operating Characteristics	36
4-1	Jitney Productivity By Trip	58
4-2	Cruising Cab and Transit Bus Average Productivities	64
4-3	Jitney Route Headways for Peak and Off-Peak Period (Minutes)	75
4-4	Jitney Trip One-Way Distance and Average Speed	80
4-5	Average Passenger Trip Length to Route Length Ratio by Service Mode	86
4-6	Bus Running Time and Speed for Peak and Off-Peak Periods (Minutes)	91
5-1	Jitney Speed and Gasoline Mileage	100
5-2	Fuel Mileage Rates for Auto and Light Duty Vehicles	102
5-3	Fuel Consumption Rates by Speed (Gallons/Vehicle-Mile)	105
5-4	Typical Major Item Costs (1978 Dollars)	109
6-1	Daily Emissions and Fuel Consumption	142
6-2	Emission and Fuel Productivity Indices	144
6-3	Quality of Service (Time in Minutes)	149
A-1	Corridor Characteristics	195
C-1	Modal Emission Rates (1978)	220

LIST OF FIGURES

FIGURE		PAGE
3-1	Modified Delivery Panel Trucks Used for Jitney Service in Atlantic City, New Jersey	30
3-2	Cruising Taxicabs Serving in Chattanooga, Tennessee	32
3-3	Sedans and Checker Vehicles Used in Publico Service in San Juan, Puerto Rico	33
3-4	Vans Used in Publico Service in San Juan, Puerto Rico	34
3-5	Atlantic City Jitneymen Association Shift Schedule	47
4-1	Jitney Van Passengers per Vehicle-Mile	62
4-2	Jitney Van Passenger-Miles per Vehicle-Mile	66
4-3	Jitney Van Passenger-Miles per Seat-Mile	68
4-4	Jitney Van Speed (10-15 Seat Vans)	82
5-1	Gasoline Mileage Rates by Speed	103
6-1	Route Operations Simulation Procedure	116
6-2	Typical Parameter Input Provided with Corridor Program	120
6-3	Typical Corridor Program Output	121
6-4	Net Income Analysis	125
6-5	Jacksonville Transit Route 30 and Hypothetical Jitney Route	130
6-6	Jacksonville Scenario Corridor Program Output for Peak Period	134
6-7	Jacksonville Scenario Corridor Program Output for Off-Peak Period	135
6-8	Map of Atlantic City Jitney and Bus Routes	147
7-1	Jitney and Bus Transit Spatial Coordination	161
7-2	Suggested Procedure to Implement Jitney Service	170
A-1	Caguas to Villa Blanca Jitney Route	197

FIGURE		PAGE
A-2	Chattanooga's Cruising Cab Route	199
A-3	Atlantic City Jitney Route	200
A-4	Bayamon to Regional Hospital Jitney Route	202
A-5	Bayamon to Sabana Seca Jitney Route	204
A-6	Rio Piedras to Campo Rico Jitney Route	205
A-7	Bayamon to Riverview Jitney Route	207
A-8	Rio Piedras to Caimito Bajo and to Caimito Alto Jitney Routes	209
A-9	Jitney Routes from Rio Piedras to Canovanas and from Rio Piedras to Caguas	210
D-1	Corridor Program General Flow Chart	223
D-2	Corridor Program	231
D-3	Card Type 1: Title Card	240
D-4	Card Type 2: Service Time for Vehicle Types	241
D-5	Card Type 3: General Vehicle Data	242
D-6	Card Type 4: Cost Rates	243
D-7	Card Type 5: Cost-Related Ratios	244
D-8	Card Type 6: Speed Type of Roadway	245
D-9	Card Type 7: Route Designation	246
E-1	Full-Time Workers with Split Shifts Permitted	248
E-2	Time Versus Vehicle Requirements	251

CHAPTER 1

INTRODUCTION

Transportation Goals and Costs

Recently transportation goals of improving mobility, reducing air pollution, conserving energy and increasing economic and social opportunities for all citizens are being jeopardized by the growing inability of cities to pay for transit deficits. With the increasing costs of operating conventional transit, several communities are curtailing the frequency and hours of service and/or are discontinuing service in less patronized areas. It is evident that a need exists to search for more effective and efficient means for delivering public transportation services in those areas or corridors which conventional transit cannot or will not serve.

Decentralization of residential and business activities brought about by the advent of the private auto has resulted in lower urban densities and in diffused travel patterns. This trend has reduced the potential to provide efficient and economical public transportation services along fixed routes with large capacity vehicles. From 1945 to 1972, transit ridership declined by 72%, while vehicle-miles of service were reduced by only 46% (1). Thus, over that period there was a noticeable reduction in the passenger productivity of fixed-route transit systems. Since 1973, that trend has been reversed, and transit ridership now is increasing slowly. Yet, increased ridership has been achieved largely by service expansion that adds vehicle miles

at a higher rate than ridership, leading to further reductions in productivity.

During the 1970 to 1976 period, transit costs increased much faster than income. Thus, transit deficits increased by more than 800% as a result of the growing gap between costs and revenues. Higher costs have been principally attributed to inflation, higher labor wages and the cost of employing more operators to provide increased peak-period services (2). Cost increases also have occurred in the private sectors of transportation, but these have been partially offset with concurrent growth in productivity (3).

In the search for solutions to the mobility versus cost dilemma paratransit options such as dial-a-ride or vanpools have received increased attention as alternatives to some conventional transit services. Of the paratransit options, only a few can provide continuous service to the general public throughout the day, taxi and dial-a-ride being the most frequently considered.

Most paratransit options are poor substitutes for bus transit services and cannot provide coverage of an entire urbanized area 18 hours a day, 365 days a year. Dial-a-ride operations attempting to deliver high levels of service by minimizing waiting time cannot economically provide the peak period capacity available through bus transit. Also, the area coverage of dial-a-ride will be limited for any system catering to the general public due to the difficulty of managing a large fleet with current technology. Except for a few shared-ride taxi operators, dial-a-ride cost per passenger exceeds revenue per ride and is generally higher than bus transit cost per

passenger (4). Conventional taxi service provided exclusively to one party at a time is too expensive for most people and is generally limited to trips within central areas. Also, taxi availability during peak periods of the day is low. Vehicular pools such as vanpools and subscription buses are associated with long commuter trips to work and should not be viewed as general alternatives to bus transit. Bus transit serves shopping, medical, school and other trips throughout the day, charges low fares and does not require advance reservations. In general, the paratransit options currently available in most American cities provide limited public transportation services.

Jitney Potential for Public Transportation

Jitneys frequently are overlooked as a public transportation option because they are illegal in most cities and there is only a limited understanding of this mode. Jitneys are privately-owned public transportation that engage in shared-ride services along an authorized semi-fixed route and operate without fixed schedules. They can be considered an intermediate mode between taxi and bus transit. Potential passengers can hail the driver for a ride anywhere on the route. Once on board, passengers pay a very low fare (5) and can disembark at any other point along the route. Jitneys can make minor route deviations while serving passengers having origins and destinations within a designated corridor. Unlike shared-ride taxis, jitneys incur little deadhead mileage by serving principal travel corridors and picking up and delivering passengers who walk to and from their route.

Jitneys have the potential to complement public transportation by operating either in coordination with existing transit or independently. Jitneys can share corridor service with bus transit by traveling the same route, segments of a bus transit route or separate but parallel routes. Thus, jitneys can increase spatial and temporal coverage of a bus transit corridor by widening the corridor service area or by increasing peak period passenger handling capacity (6). Jitneys can serve sectors where transit cannot reach economically or physically, thus extending spatial coverage such as to low density neighborhoods or hilly corridors.

Jitneys also can serve markets not being served properly by existing public transportation modes. They can provide mobility to riders who cannot afford to pay a taxi fare but whose needs are not satisfied by infrequent bus schedules or fixed-route service. Most jitney vehicles are easier for elderly or handicapped persons to enter and exit than a full-size bus, and passengers always ride seated. Most importantly, jitney service operating with very short headways is extremely attractive because it allows for close to instantaneous service by providing multiple trip opportunities. As an illustration, a passenger walking to such a route may leisurely watch a jitney go by as he/she arrives at the curb, disregarding that trip opportunity to catch a second jitney coming by within the next minute.

Frequent service potentially can divert some auto users with a consequential reduction in traffic congestion, energy consumption and air pollutant emissions. For example, in Atlantic City where average jitney headways are very short (below 2.5 minutes), it probably takes

less time to wait for a jitney than to park at any downtown location. Service at very short headways make users much less conscious of waiting time and unconcerned with service schedules.

Low fares are possible as a result of efficient operations combined with the use of inexpensive vehicles, less skilled labor, part-time labor and small administrative overhead. Efficient service is achieved by flexible allocation of vehicles to meet fluctuating market demand, by ridesharing and by the use of small vehicles that mix well with auto traffic. For example, in Atlantic City jitneys have been reported to produce more passenger-miles per seat-mile than buses or private autos (5). Limited control of work periods allows operators to work as many hours as they wish or can, depending on economic needs and physical conditions of each driver. Most drivers own the vehicles which they operate, provide periodic vehicle maintenance and incur very little administrative cost.

Thus, frequent jitney service (six or more trips per hour) can operate with a profit where demand would barely justify two bus transit trips per hour. Saltzman and Solomon express that (7):

> In most low density areas present transportation systems either operate unprofitable routes or provide no service at all. Many bus routes have been discontinued where there was still sufficient demand along these routes to support jitney operations. . . . Jitneys need lower revenues per mile than buses to cover costs and make a profit. . . .

Jitneymen are unconcerned with the cost (or deficit) versus mobility dilemma facing transit and public officials today. Jitney operators adjust their service to make a profit at the authorized fare level--they are private enterprises.

Jitneys have the potential to improve the mobility of captive and noncaptive riders, to conserve energy, to reduce air pollutant emissions, to provide employment opportunities for less skilled labor and to require no public capital or operating subsidies. This will be demonstrated later. Jitneys provide high quality service, attracting passengers more effectively than conventional transit, taxi or dial-a-ride services. For example, a 1957 transportation study for St. Louis indicates that on the routes on which streetcars competed with service cars (local name for jitneys), the latter carried about 70% of the total public passenger load during mid day and around 50% during rush hours (8). Saltzman and Solomon (7) suggest that the presence of "gypsy" taxis and illegal jitney operations in low income ghettos all over the United States is further evidence of the demand for this type of service.

However, for jitneys again to operate in the United States as a complement to public transportation, regulatory constraints that previously ruined and currently restrict this service need to be abolished or modified substantially. Permissive jitney regulation and coordination with other modes can help to provide more extensive and intensive transportation services to the general public while improving the economic posture of bus transit.

Being realistic, documentation of all benefits and costs of any public transportation service is required to ascertain the viability of jitneys and other modes. Yet, there is a need to understand the

jitney mode in depth, to assess its impacts, to plan for its implementation and, more important, to convince planners that changes in existing regulations can be beneficial to all sectors of the community.

Study Goal and Objectives

It is the contention of this research that jitneys are a viable option to provide attractive and efficient public transportation service. This study intends to provide planners with an understanding of the role of jitneys in public transportation and to develop some tools for analysis and planning. To fulfill this goal the following study objectives have been set:

1. To review the current regulatory environment in light of jitney emergence and initial regulation;
2. To identify characteristics of selected systems concerning organization, vehicles used, corridor operations and riders;
3. To analyze quantitatively actual operations to investigate quality of service, productivity measures, cost and fuel consumption;
4. To develop service and economic analysis procedures; and
5. To introduce additional planning considerations identifying conditions favorable for jitney service, proposing desirable regulation and suggesting a service implementation procedure.

Documenting the regulatory and operating environment in which jitneys operate can provide a better understanding of the role of jitneys. Documenting jitney performance and proposing planning procedures and other planning considerations can provide the basic tools to plan for jitney services and to foster changes in ordinances and regulations currently inhibiting the efficient and effective provisions of all privately-owned public transportation services.

CHAPTER 2

REGULATORY ENVIRONMENT: ORIGINS AND CURRENT STATUS

Background

The key issue confronting jitney service is the regulating environment carried over from the early jitney days which has precluded or severely restricted jitney operations in most United States cities. This chapter reviews the emergence of jitney service and ensuing regulation and briefly presents the regulatory environment under which jitneys currently operate--fares, service patterns, service entry and exit, financial responsibilities and safety. Special attention is given to identifying case examples in cities where jitneys currently operate within the constraints of various regulations. Before expanding on characteristics of selected systems that provide corridor service it is important to understand the scope of jitney regulation.

Emergence of Jitneys and Regulation

The initial growth of jitneys throughout the United States occurred between 1914 and 1916. The term "jitney" (for five cent fare) seems to have been coined in Los Angeles by mid-1914 (9); by 1915, jitney service was used widely by urban dwellers across the country. Jitney entry into the passenger transportation market was quickly followed by regulation. A few case studies highlight the situation.

Atlantic City

During a trolley car strike in 1915, owners of private autos started serving passengers along the trolley route on Atlantic Avenue (10). Two passenger touring cars started the service, and by the time the strike was over in 1916, there were about 400 vehicles of various types covering the route.

Early attempts to control jitneys failed in Atlantic City as there were no laws to regulate jitneys' unique method of operation (10). City ordinances were passed in 1915 requiring mercantile licenses for jitney vehicles and establishing a route along the same avenue that the trolley operated. In 1916, New Jersey passed legislation covering jitney operations, but by then the trolley strike was over. However, the competition provided by jitney operations was already so strong that the trolley company went into receivership. Soon after, as a result of legal action, a local ordinance banned jitneys from operating along Atlantic Avenue (10). Jitneys then moved to Pacific Avenue which runs parallel to Atlantic Avenue and remain there to this day. Subsequent amendments to the jitney ordinance now regulate route alignment, entry, fare and some aspects of operations.

Chattanooga

In February 1915, jitney bus operations were reported along Market Street in Chattanooga (11). However, opposition by streetcar companies came very soon. Arguments on behalf of the streetcar operators were that they had to pave the streets as a condition for franchising and now jitneys were skimming the cream of the market by

traveling only along profitable routes. Nevertheless, public sentiment seemed to differ from streetcar management as editorialized in a local paper (12): "If jitneys can render a better service than streetcars, then the jitney will be preferred as a popular favorite."

A week after jitneys were operating on Chattanooga streets, the Mayor insisted that an ordinance regulating such traffic was necessary (13). Yet, by the time local regulations were being studied, a Tennessee state law declared that jitneys were to be considered common carriers and required a minimum bond of $5,000 per car, thus effectively driving the first jitneys out of business (14). Restrictions did not discourage all operators, and many remained serving passengers illegally thereafter. In 1921, with the country entering a recession, men who found themselves out of work but with an auto available went into the jitney service. That year the first "black jitney" began operation (15). These survive in Chattanooga to this date.

Puerto Rico

As early as 1916, jitneys or "publicos," as they are known throughout Puerto Rico, were officially recognized as a separate form of transportation (16). In 1917, the Public Service Commission was authorized to regulate all forms of for-hire transportation (17), but this had negligible effect on jitney operations since regulations and administrative action came about very slowly. It was in 1926 when an established bus company requested action to enforce the 1917 law that the commission was compelled to move against jitneys (18). But by this time jitneys had spread throughout the Island and the commission's

weak delegated powers could not keep the number of jitneys from increasing. The successful growth of jitneys was attributed largely to little governmental control and lack of strong opposition from rail companies.

Direct licensing of jitneys as public service automobiles was used in Puerto Rico between 1940 and 1949. No entry or route controls were exercised. It was not until 1949 that pressure from the passenger transportation industry brought about legislation to regulate entry, routing and other aspects of jitney service (19).

Other Operations

During the early jitney years (1914 through 1916), the same general pattern of rapid growth occurred across the United States. Jitney operations in Paterson, New Jersey; Bridgeport, Connecticut; and Detroit, Michigan, attracted as many as 50% of the streetcar passengers during peak periods and even more during off-peak hours (7). These developments created a series of legal battles that finally brought about the demise of jitneys. The streetcar enterprises lobbied intensely at all levels of government to ban jitneys from streets. Except for a few locations where jitneys had organized early or where anti-jitney regulation was not pursued effectively, jitneys succumbed to streetcar interests.

Present Status

Of the countless jitney systems that existed in the past, only two of any significant size and sanctioned by law remain operational

within the continental United States. These are operating on Pacific Avenue in Atlantic City and on Mission Street in San Francisco. Chattanooga's cruising cabs serving the corridor between Orchard Knob and the central business district provide typical jitney service but are registered as taxicabs, thus avoiding bonding and franchising requirements of common carriers. Smaller or extra-legal operations remain in Pittsburgh, New York, Chicago, Cleveland, Miami and other cities, but little information is available on them.

In Puerto Rico, a commonwealth in permanent association with the United States, jitneys have been established legally as a principal public transportation mode since 1916. Puerto Rico provides a unique setting where this mode operates extensively and successfully under the legal and economic system of the United States. Hundreds of routes provide urban, rural and intercity service. There are about 11,000 designated jitney vehicles (20).

Within the United States, the principal constraint to more extensive jitney service is inflexible regulations that prohibit or make it virtually impossible for a prospective jitney operator to obtain legal permits. Even where jitneys exist, vehicle licenses or permits are limited strictly by ordinance or actual practice, and competitors still try to eliminate jitneys. As recently as 1973, attempts were made to eliminate some of the remaining systems such as in Chattanooga by refusing to transfer permits when an operator would die or retire from service (15).

In general, jitney services are regulated in fares, service patterns, service entry and exit and financial and safety responsibilities.

The following sections introduce current jitney regulations, principally based on discussions of systems visited in Chattanooga, Atlantic City, San Juan and Caguas (see Appendix A).

Fares

Regulatory bodies commonly wait for operators to request fare review before taking any action on this regard. The primary basis for approval or rejection of a fare is the rate of return or equivalent salary received by the service provider. A field study may or may not be conducted to determine costs and revenues depending on the reason for the request. For example, a petition claiming higher operating costs due to increasing traffic congestion may be investigated carefully, while another asking for fare increases based on the higher cost of gasoline may be approved without much analysis. Jitney operators may be required to post proposed fare changes and mechanisms for appealing the rate increases to the regulatory agency.

A single fare may be set for the entire length of a route, or fares may be set for different segments or zones along longer routes. In principle, all persons should receive more or less equal service for the same fare (21). Thus, shorter routes usually operate with a single fare, while longer routes are subdivided into zones.

Service Patterns

Spatial and temporal characteristics which are easy to identify or peculiar to certain operations usually become subject to regulation. Specific aspects most commonly regulated are service area, route alignment, travel method, service availability, vehicle capacity and special services.

Jitneys may be required to operate within a service area such as designated corridors or specified political boundaries. In the past, jitney conflicts with transit routes has resulted in the former being forced to move to other streets or areas. Atlantic City jitneys were moved from Atlantic Avenue to Pacific Avenue, and San Francisco jitneys transferred from the main shopping street to Mission Street (22). In San Juan, jitneys were removed from the bus service area by legislation disallowing free entry routes within designated boundaries (23). New Jersey and California do not allow jitneys to operate in more than one political subdivision unless they obtain a certificate of public convenience and necessity.

Route alignment commonly is controlled by specifying roadways to be traversed and terminal points to be reached. Strict control of the roadways served commonly is regulated to prevent route or point deviations. Strict control of terminal points to be reached by each jitney run eliminates turn-backs in the middle of the route. Route deviations are of concern to regulators because some operators will intrude into other markets such as bus transit corridors or more profitable jitney routes when these exist. Terminal points to be reached are of concern to regulators because end points otherwise may be served improperly. Both controls help regulatory bodies in the supervision of route service. In addition, it is alleged that route deviations penalize most riders by lengthening their travel time and increasing the uncertainty of arriving on time at their destination (24). However, minor route deviations provide a more attractive service to some passengers, and the jitney driver's consultation with other passengers avoids major inconveniences to anyone in particular. In Chattanooga,

there is no officially recognized route for jitneys, but they adhere to their traditional corridor to avoid conflicts with the transit operator.

Travel method refers to the manner in which jitneys are required to serve a given route. As previously mentioned, jitneys in Atlantic City, Chattanooga and San Francisco are required to cruise continuously and to stop or stand only at designated locations. In contrast, several states prohibit cruising altogether. Another traveling method consists of departing from a stand when a minimum selected passenger load is on board and then allowing passengers to alight at any point along the route. Additional passengers are picked up along the route as long as empty seats are available. In general, cruising, waiting at collection points, route deviations, adjustments in route length or shared-riding may be prohibited, permitted or required.

Service availability refers to antidiscriminatory, temporal and spatial regulations. Common to all services are antidiscriminatory clauses to prevent service refusal to individuals because of characteristics such as race, sex or religion. Temporal requirements refer to service during specified periods of the day, week or season. Spatial requirements refer to service coverage of a route and usually are tied to the number of vehicles required to be in service. Temporal and spatial regulation, when required in combination, in essence demand posting schedules; this requirement has been used in the past to drive jitneys out of business. In Atlantic City, a regulation evidently associated with past requirements of service availability demands that passengers on board at the end of the route must get off. Thus,

passengers willing to continue the trip must get off and walk across the street to board the same vehicle on the way back. This is a nuisance to patrons who could wait for service under shelter on one side of the street but, in order to be served, must walk across the street regardless of weather conditions. This is a significant inconvenience to elderly or partially handicapped patrons.

Jitney vehicle capacity and/or passenger loading methods are extensively regulated and enforced. In New Jersey, vehicle capacity is limited by law to 5 passengers except for coastal cities where the maximum is 10. Thus, jitney operators in Atlantic City use several new vehicles with capacity for 13 passengers but which are equipped only with seats for 10. Chattanooga's jitneys use five-passenger sedans since they are licensed as taxicabs. In San Francisco, police regulations limit the number of passengers to 12, matching the seating capacity of the vehicles used (6). In Puerto Rico, legislation recognizing the asset of jitney services in furthering transportation goals allows for the use of any vehicle up to a 14-passenger capacity (25). In all systems studied, loading more passengers than the authorized seating capacity is prohibited, thus optimum efficiency with vehicles that are physically capable of handling more seated passengers or standees cannot be attained.

Special services refer to those services rendered away from the designated route or corridor. The most evident case may be the taxi mode assumed by Chattanooga jitneys when they receive a radio call. If they wish to answer a call and revert to the taxi mode, a jitney

must first serve any passengers on board before leaving the jitney corridor. After serving in the taxi mode, they are free to return to jitney service. Charter service can also be provided by Chattanooga jitney operators under the taxi mode, in which case the fare may be charged on an hourly basis or as a negotiated fee.

In Puerto Rico, jitney operators are authorized to provide two special services. One is the emergency trip in which case an operator may take a passenger or passengers under hardship anywhere necessary (26,27). The term emergency is defined loosely in the regulation, but it is generally understood to be any significant personal problem such as a medical emergency. Another special service allowed under regulation is charter trips. This is an exclusive service rendered to one or more persons with the same destination and where the amount to be paid is a mutual agreement between the operator and the prospective user(s) (27). This service may be contracted to go anyplace at anytime. For example, during field surveys, this service was observed to be very valuable to teachers working in a small rural school where no transit service was available.

Service Entry and Exit

These controls are designed to protect existing providers of public transportation from competition and to prevent discontinuance of service on less profitable routes. Three methods have been used to control or restrict the number of jitney vehicles and providers. These are direct licensing, certificate of public convenience and

necessity and franchise. Direct licensing of jitney vehicles, without any written restrictions, has been used in the past but is unknown at this time.

A certificate of public convenience and necessity traditionally has been required by public service commissions from common carriers willing to provide transportation services for a fee. To receive such a certificate, the transportation provider must prove to the regulatory agency that there is a public need for the service and that the provider can service that need adequately.

For an individual operator to enter a route already served by others, those serving the route must agree to accept another route member and/or the regulator may conduct a route study to ascertain the need for additional service. Once a jitney operator is serving a route, the operator is expected to provide continuous service; but this is seldom investigated or enforced by the regulator. Route members or an association of route members sometimes pressure a lazy operator to work more or else to get out. If an operator wants to move to another route, the operator must go through the regulatory agency once more and must prove the public necessity and convenience of such a move for each of the two routes involved (24,26). Nevertheless, in Puerto Rico, the Public Service Commission provides that single owner/ operators who want to get out of jitney service completely may do so by surrendering their operating permits to the commission (28).

Jitneys may be franchised by local governments when this is not preempted by the state public service commission. A franchise may be used instead of a certificate of public convenience and necessity.

A franchise has the same provisions and requirements of a certificate and allows operation of as many vehicles as can be justified. However, the total number of franchises usually is limited by local ordinance to some predetermined number of vehicles (29). San Francisco jitneys are limited by ordinance from the City and County Boards of Supervisors to 700 licenses, although in practice no more than 120 are allowed to operate (22). Chattanooga will not distribute more licenses than the 85 already issued, and the Atlantic City jitney ordinance sets a ceiling of 190.

Financial and Safety Responsibilities

These are the oldest and most common of jitney regulations. In principle, they are designed to protect the public, but at times have been used to eliminate "undesirable" services such as jitneys.

Financial responsibility is directed to require adequate insurance to compensate victims of jitney accidents for personal or physical damages. This commonly is regulated by specifying minimum limits of insurance coverage. Public liability rates have seen a drastic increase during recent years, particularly those charged to independent or less organized operators who cannot get collective insurance. For example, according to Lee (30), basic premiums for a cruising cab in Chattanooga were increased from $1,035 to $1,325 per year between 1977 and 1978. Atlantic City jitney insurance premiums have been estimated at $540 per year per vehicle (10), but these are group rates. Another obstacle to obtaining jitney insurance is availability since many insurance companies lack information about jitneys and prefer not to get involved. A unique approach to these problems has been taken by

the Administration for Compensation in Automobile Accidents in Puerto Rico whereby $35 a year provides limited insurance to compensate victims of vehicular accidents (28).

Safety requirements are related to the physical and operating conditions of the vehicle and driver qualifications. Vehicles may be required to pass a periodic inspection, or only vehicles that meet certain specifications such as for warning lights, number of doors and adherence to federal safety standards may be authorized to operate (31). Drivers may be required to obtain a chauffeur's license, to show evidence of good conduct and to have an acceptable driving record. In addition, a physical examination including mental tests of capability to perform duties may be required.

What Lies Ahead?

Jitneys have the potential to complement public transportation. Early jitneys proved to be extremely attractive to users in most cities across the United States. However, in many cases these operations succumbed to regulation brought about to protect streetcars. The present status of public transportation is very different to that in which the jitney competed directly with private enterprise. Most transit systems now are publicly owned in order to preserve community interests. However, regulations drawn in the past to protect private interests still prevail, and some community goals have been compromised.

Regulation of transportation modes should be flexible to allow efficient utilization of manpower and equipment and to promote the provision of all forms of privately-owned transportation services in coordination with other modes. Otherwise, viable options such as

jitneys may never be allowed to become effective providers of urban transportation services.

CHAPTER 3

CHARACTERISTICS OF SELECTED SYSTEMS

Jitneys: What Are They Like?

Jitneys have been proposed as a potential public transportation mode to serve urban areas (7,32,6), but few people understand this mode. Only a few jitney systems operate within the United States, and in those locations, only a small segment of the population has access to them. Few planners understand how they operate. Attempts to define jitneys in a few sentences do not explain the concept adequately. A description of existing jitney systems can provide a better picture of their characteristics and their operations.

Like urban transportation modes such as bus transit or autos, jitneys are sometimes characterized by their organization and the vehicles used. However, jitneys are not just a single mode but rather are various service modes defined by the way they adjust travel method to serve actual market needs. The travel method may change in time and location depending on corridor served, operating hours and even fare structure. This chapter discusses jitney organizations, vehicles used, route operations and user characteristics identified from selected jitney routes.

Organization

Private Ownership and Operation

Typically, every driver engaged in jitney service is an independent entrepreneur who assumes the risks and enjoys the benefits of his

economic venture. Most drivers are the owners of the vehicles driven; the remainder are lessors. However, both owners and lessors operate to transport as many passengers as they can within time and regulatory constraints to increase their income.

Atlantic City jitneymen are owners of their vehicles, retain all passenger revenues and work at their convenience within the constraints of shift schedules prepared by the Jitneymen Association. In Chattanooga, where about 72% of the cruising cabs are owner operated (15) and all work at their convenience, less than 50% elect to operate the jitney mode on a full-time basis. In San Francisco, each vehicle has one operator, the owner (22). In Puerto Rico, about 66% of the publico vehicles are owner operated (33). However, publicos commonly operate as family enterprises where one or more vehicles are driven by the owners and other members of their families. Thus, each publico driver has a personal commitment to the vehicle (20).

Associations and Other Groups

Like other business enterprises, jitney organizations are created for different purposes and under varying regulatory constraints. Some operators prefer to remain independent, but the majority elect to associate with some kind of organization. Such organizations exist to serve members rather than to make a profit. An "association" can range from the highly organized Atlantic City Jitneymen Association (which operates with some delegated powers from the City Commissioner of Revenue and Finance) to loose associations created for the sake of sharing a common name and a stand. The level of organization of any route depends on membership objectives.

The Atlantic City Jitneymen Association regulates general operations and shift schedules. It also represents members as a body (10). Five officers are responsible for day-to-day operations--one president, two vice-presidents, one secretary and one treasurer. The executive board, composed of 15 elected members, is responsible for drafting rules and regulations which are then submitted to the general members for approval. The executive board is also responsible for selecting and appointing seven members to a traffic committee. The traffic committee receives complaints, makes charges and determines penalties in cases of infractions of the association's rules. A member found guilty of violating internal regulations may be assessed a cash penalty or may be forced into "time off" (10). Appeals may be made to the executive board and ultimately to the Commissioner of Revenue and Finance.

The Jitneymen Association has its headquarters in a residential sector of Atlantic Avenue, and many jitney operators begin or end their shift at this location. Within this facility jitneymen get coin change for operations, share impressions, fuel their vehicles and make minor unscheduled repairs. Gasoline and oil are debited to each driver's account, from which the association's operating expenses also are deducted. Any surplus over the association's operating expenses are distributed yearly to jitney operators. There are no seniority rules to differentiate between members.

In San Francisco, the Mission Street Jitney Owners' Association brings together about 90% of the drivers serving Mission Street (5). The association develops working rules for its members. Each driver

may work up to 10 hours per day, but one weekday of each week he is not allowed to work between 9:00 a.m. and 4:00 p.m. Unlike Atlantic City, the city government does not delegate any enforcement responsibilities nor specify or enforce a minimum service level. However, any driver who does not work for a period of 10 consecutive days should obtain permission to be absent from the city commissioner of police (5).

Headways on Mission Street are not regulated during peak hours, but an association employed starter dispatches vehicles at 3.5 minute intervals between 9:00 a.m. and 4:00 p.m. (5). Association rules also provide for making short route runs as follows. On even-numbered days, even-numbered vehicles can make a short run while going south by turning-back at 29th street instead of traveling an extra 3.2 miles to the southern terminal; odd-numbered jitneys may do the same on odd-numbered days.

In Puerto Rico, various types of organizations exist. They are defined by the Public Service Commission in the following way (27):

1. "Cooperative"--any society or group organized under the Law of Cooperatives;
2. "Association"--any entity made up in voluntary agreement between a group of owners of lower capacity vehicles and organized to operate as a public vehicle enterprise making use of common facilities, business name and badge; and
3. "Union"--a group of operators of lower capacity vehicles with the purpose, among others, to establish

> regulations that control the personal behavior of its members (note that this is not a union definition as recognized by a department of labor).

Out of about 11,000 publicos that operate on the island, only about 34% are still independent (33). In San Juan, most of the 2,000 publicos seem to belong to some form of association.

In Puerto Rico the difference between associations and unions may be less than as suggested by the Public Service Commission definition since it is up to the owner-operators to decide the degree of internal regulation they wish to have. From observations, it seems evident that both organizations control personal behavior to some extent. The organization's president, elected by majority vote of route members, is considered like a big brother who provides advice and help to members and serves as a judge to settle minor disputes. Members have no seniority status; all help each other with personal problems or emergencies; and they usually buy repair parts, tires and other items wholesale to get lower prices. A study of San Juan jitney operators found the majority to feel very satisfied with their job (34) and to view each other as close friends or even as members of the same family.

Publico cooperatives are more formal organizations which, in addition to following common practices of associations, pool the economic resources of their members to create employee benefit programs, to pay wages to night-shift drivers and to establish garages and service stations for the operators (20). Overall, they tend to provide more extensive service to passengers than conventional associations. They also may secure an exclusive franchise to operate a

route or place of operation such as from the San Juan International Airport, thus preventing competition. Working capital is obtained from shares sold to members of the cooperative. Except for monetary dividends, all members have the same rights and privileges regardless of number of shares owned.

In Chattanooga, the Cruising Cab Association is the organization representing all jitney operators to protect this mode from other forces that may seek to drive jitneys out of business (15). Members pay dues to the association, and the association maintains a lawyer to handle all legal problems. A five-member board constitutes the association's directive body.

In Chattanooga, most jitneys also are affiliated with small taxicab companies. The primary service rendered to jitney operators by these companies is to dispatch in the taxi mode those vehicles provided with two-way radios (15). Wholesale purchases of tires and accessories allows lower cost to members. The taxi stand and terminal is also a driver's office and is used as a place to relax and forge friendship with other drivers. Affiliation with these companies costs drivers as much as $15 per week.

Vehicle Types

Vehicles used to provide jitney services range in capacity from 5-passenger sedans to 14-passenger vans, excluding the driver. Under permissive regulation, operators select the vehicles they believe will be most suitable to attract their customers, least expensive to buy

and most economical to operate. However, local or state regulations may restrict selection by specifying maximum capacity and vehicle characteristics.

In Atlantic City, old Metro buses (manufactured by International Harvester before 1966) constitute about 80% (22) of the vehicles now in use, while the rest are modified delivery trucks built by various manufacturers. Figure 3-1 shows pictures of an old jitney bus and of a newer one, as modified to carry passengers. All are equipped with 10 seats facing forward, although newer vehicles could be fitted with up to 13 seats (state law limits capacity to 10 seated passengers). Unlike vans, the ample headroom of these vehicles allows for easy access; thereby minimum time is lost at each stop. The estimated cost of new vehicles is about $13,000 (35), including modifications to accommodate passengers. Useful life of vehicles has been estimated in the range of 8 to 12 years. New vehicles have a more powerful V-8 engine, consume as much gas as old vehicles (8 to 9 miles per gallon), have a smoother ride, provide better heat distribution, have more interior space and require less maintenance. The jitney buses also are equipped with emergency radios to contact police and a fare box resembling those used by transit buses.

Chattanooga cruising cabs are standard five-passenger sedans of all makes. Most are used vehicles, probably exceeding five years of age, with an estimated 1976 average value of $2,900 (15). Because of the similarity of service and equipment, they consume about as much gas as conventional taxis, traveling about 10 to 12 miles on a gallon





FIGURE 3-1

MODIFIED DELIVERY PANEL TRUCKS USED FOR JITNEY SERVICE IN ATLANTIC CITY, NEW JERSEY

of gas. It is uncertain how vehicle capacity is regulated, but because of their double role as taxis, it is doubtful if larger vehicles would be suitable. Figure 3-2 shows typical cruising cabs in operation.

Publicos in Puerto Rico have been operating under a different, much more permissive regulatory environment. For example, jitney capacity, which is controlled by legislation, has been increased successively to take advantage of larger vehicles thus reducing operating costs and helping to avoid road congestion. In 1941, maximum passenger seating capacity was restricted to 8 (36). Maximum capacity was increased to 10 in 1962, then amended to 12 (37). Since 1974, the maximum has been 14 (25). In high demand corridors, 11- and 14-passenger vans are common, while lower demand and/or longer routes are served by sedans and Checker vehicles. Some routes are served with vans during the day and with sedans during evening hours. Less traveled routes are served by sedans or Checker vehicles during the day and have little or no service at night. Figures 3-3 and 3-4 show typical vehicles used in publico service.

The majority of publico vehicles are equipped with V-8 engines, automatic transmissions and power steering. Vehicles serving shorter routes along highly traveled corridors are sometimes equipped with air conditioning units. In 1974, over 80% of all publico vehicles operating throughout the island were under 6 years old with an average age of 4.1 years (33). No estimate exists for average cost of those vehicles. However, in 1977, the average price of new publico vehicles was estimated by the Public Service Commission to range from $5,356 for a Checker vehicle (sedans were slightly higher) to $7,591 for a





FIGURE 3-2

CRUISING TAXICABS SERVING IN CHATTANOOGA, TENNESSEE

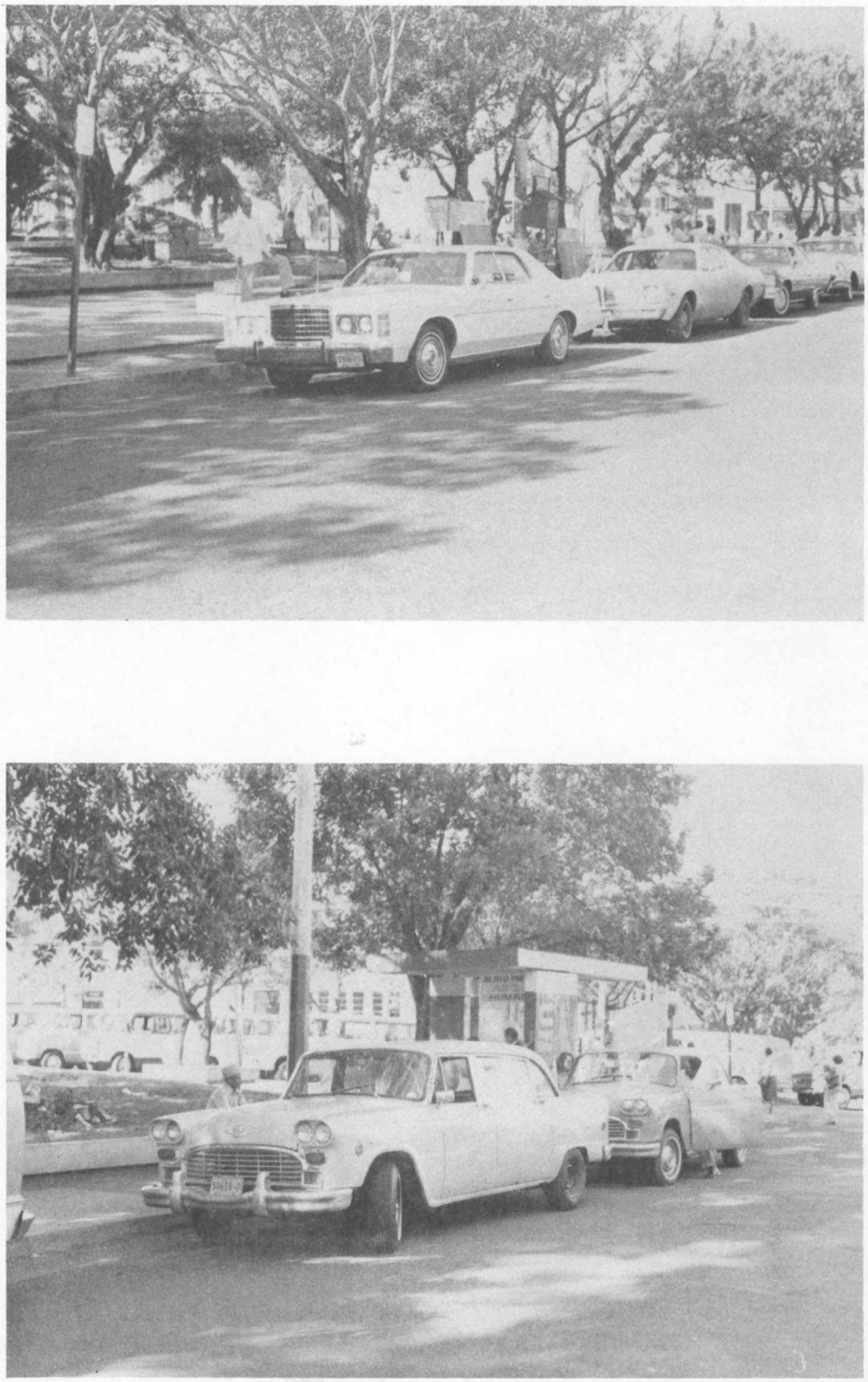


FIGURE 3-3

SEDANS AND CHECKER VEHICLES USED FOR PUBLICO SERVICE
IN SAN JUAN, PUERTO RICO





FIGURE 3-4

VANS USED IN PUBLICO SERVICE IN SAN JUAN, PUERTO RICO

14-seat van (38). Fuel consumption rates have been estimated to range from a low of 8 mpg for a large van serving a short route to over 15 mpg for a sedan traveling on a long route where expressway speeds can be maintained.

Route Operations

Jitney service along corridors joining multiple activity centers and residential areas seem very attractive, efficient and lucrative to jitney operators. Jitneys take advantage of their flexibility to provide expeditious and inexpensive service.

Each jitney route operates under rules set up by its own members that define the service mode. Since it is not possible to review all jitney operations in detail, a sample of 10 routes was selected by route length. These routes are located in Atlantic City, Chattanooga and two urbanized areas in Puerto Rico.[1] Route operating characteristics can be specified in terms of travel method, access to route service, hours of service and fares. Table 3-1 outlines characteristics of the routes visited.

Travel Methods

Travel method refers to how jitneys traverse a given corridor as a function of time and place. For example, jitneys may cruise continuously during early morning hours and operate from a stand the rest of the day. Some jitneys may traverse the whole length of an authorized route, while others make shorter runs. The method of serving the

---

[1]Appendix A provides a physical description of each route and the corridor served.

TABLE 3-1

ROUTE OPERATING CHARACTERISTICS

	Route	Length (Miles)	Service Period	Travel Method	Fixed Access Points	Fare (Cents)	Comments
1.	Caguas to Villa Blanca Dev., Puerto Rico	2.2	6 am - 6 pm Sunday-1 veh.	Cruising	Downtown stand	25	Shorter and longer route, other route deviations, indep. school loop
2.	Patten to Citico, Chattanooga Tennessee	3.3	6 am - 6 pm	Cruising	None official but downtown and residential ends recognized by users	45	Route deviations and extended quasi-taxi service
3.	Caspian to Jackson, Atlantic City, New Jersey	4.1	6 am - 6 pm Sunday Schedule	Cruising scheduled shifts	Designated stops at every block along the route	35	Shorter segment runs made no route deviations permitted
4.	Bayamon thru Lomas Verdes Dev. to Bayamon Regional Hospital, Puerto Rico	4.3	6 am - 9 pm	Semi-cruising (dispatched every 3 minutes	Downtown terminal and hospital stand	35	This loop runs vehicles in opposing directions with every dispatch
5.	Bayamon to Sabana Seca, Puerto Rico	4.3	6 am -10 pm Sunday day-5 veh. night-2 veh.	Cruising 9 am, thereafter dispatched	Downtown terminal adjacent to bus terminal	35	Shorter runs and semi-independent longer route runs made
6.	Rio Piedras to Hondo Rico Dev., Puerto Rico	5.6	6 am - 6 pm Sunday 1 veh.	Cruising until 9 am, thereafter dispatched	Downtown stand	25	Shorter runs made

TABLE 3-1 (Continued)

Route	Length (Miles)	Service Period	Travel Method	Fixed Access Points	Fare (Cents)	Comments
7. Bayamon to Riverview and Rio Hondo Dev., Puerto Rico	6.4	6 am - 8 pm Sat. & Sun - 3 veh.	Cruising until 9 am, thereafter dispatched	Downtown terminal by bus terminal	30	Shorter segment 4.2 miles has more service
8. Rio Piedras to Camimito Bajo and Caimito Alto, Puerto Rico	9.4	6 am - 6 pm	Cruising until 9 am, thereafter dispatched	Downtown stand	30	Shorter segment 7.2 miles has more service
9. Rio Piedras to Canovanas via Carolina, Puerto Rico	10.8	6 am - 6 pm	Dispatched at each end; some cruise	Downtown stand at both ends	60	Carolina sometimes by-passed
10. Rio Piedras to Caguas, Puerto Rico	15.1	6 am - 6 pm	Dispatched at each end; some cruise	Downtown stand with shelter at both ends	50	Via divided highway or via freeway

route is a collective decision of route drivers (unless otherwise regulated) and is greatly influenced by each member's desire to maximize revenues. Frequently, drivers of shorter routes (under five miles) opt for the cruising mode, while those serving longer routes (over five miles) are dispatched from a stand or terminal.

Cruising involves traveling continuously along the authorized route or corridor to serve customers having trip origins and destinations dispersed throughout the corridor. Jitneys are frequently stopping on the roadway to pick up and drop off passengers at the curb side. They may operate from a downtown stand, but this is not necessary since prospective passengers usually are distributed along the route. However, lack of a downtown stand encourages further passenger dispersion and increases the number of stops required.

Stand-dispatched jitneys (noncruising) depart from a downtown stand after a desired passenger load has been reached. People frequently walk to the stand to board the first departing vehicle, thus avoiding the uncertainty of waiting for another vehicle. A downtown stand reduces the inconvenience to customers and the number of stops within the downtown area. Longer routes, usually operated from a stand, make greater use of principal highways, are more likely to depart fully loaded and make fewer stops on the way. Headways are not necessarily uniform, but operators try to spread trips during off-peak periods. Table 3-1 shows length and travel method of each route studied.

Actually, many routes classified as "stand-dispatched" operate with all vehicles cruising during morning peak hours as exemplified by Routes 5 through 8 included in Table 3-1. These routes have in common

high trip generation at the residential end. On Route 4, vehicles cruise during the morning peak, but afterwards operate in a semicruising mode in which vehicles are dispatched every three minutes. On Routes 1, 2 and 3, vehicles cruise continuously.

Vehicle departures from a stand usually follow a first-come, first-served rule. Passengers arriving at a stand are shown the way to the first vehicle in the line by a dispatcher, a procedure commonly found in taxi operations. Upon arriving at a terminal, drivers get in the waiting line until their time to load passengers comes. Some drivers select not to wait in the line and turn to cruising but, according to route regulations, they must bypass passengers waiting at the stand.

Once on the road, jitneys move as fast as possible within safety and legal limitations. Overall speed is barely lower than speed attained by private autos following the same route as reported by Garcia Pacheco (28) and as observed by this author.

A "starter" or dispatcher usually is assigned the task of organizing the vehicle queue and, on some routes, to control headways. Starters keep tab of arriving vehicles in the queue and advise drivers when it is time to load. Starters keep a chart of arrivals and departures, but it is the driver's responsibility to make sure the starter has picked them up in his tally. A starter is also looking for prospective passengers and usually announces his route to approaching pedestrians. He shows passengers to the boarding vehicle and helps some board. For this service, each driver usually pays the starter from 50 cents to 1 dollar per day. Starter dispatched services are common in Puerto Rico and in San Francisco.

Peak period passenger demand is directional along most routes with more people going downtown in the morning and more people returning to residential areas during early evening hours. However, peak demand seems much less pronounced for jitneys than for regular transit. To satisfy customers, fleet capacity is matched to peak directional demand at any segment of the route. Unlike bus transit, peak passenger loads are not necessarily concentrated during peak periods of highway traffic, e.g., Chattanooga jitney passenger peaks occur between 10:00 a.m. and 11:00 a.m. and between 3:00 p.m. and 4:00 p.m. (15). Where regulations allow for some vehicle selection, the highest capacity vehicle is commonly used except where this implies very long headways (as a rule of thumb, longer than 15 minutes). Since small vehicles are used, frequency of service is always higher than possible with bus transit.

Perhaps more important, jitneys operate with enough vehicles on the road to allow each driver a reasonable return on investment and a low but livable income, thus ensuring efficiency in the process. When too many vehicles are operating for a given level of demand, some jitneys may run empty. Then it is usually observed that some drivers take time off to rest or conduct other chores, allowing others to remain in profitable service. A large number of operators serving a route, entering and leaving at random, ensures that, if a few drivers go out-of-service, enough remain to provide continuity of service. If for some reason demand is higher than usual at any one location, drivers who become aware of the imbalance tell other route members, and in a few minutes more vehicles proceed to that point. The ability

of jitneys to adjust to fluctuations in demand and to maintain high levels of utilization seems unsurpassed by any other existing transportation mode.

Flexible operations allow further efficiency by adjusting vehicle trip length to demand for service. Intermediate points for turnbacks before reaching the end of the route are very common even though regulatory agencies generally prohibit this practice by specifying terminal points for jitney routes. Intermediate points tend to coincide with locations where different levels of demand occur. For example, a route going past a medical center may operate with half of the vehicles coming from downtown turning back at this point while the rest continue to serve the residential end of the route. If a vehicle headed to the residential area gets fully loaded with passengers going downtown (the reverse direction) before the jitney reaches the residential end, the jitney driver's response is to turn back as soon as he becomes aware of this condition. Most systems operate shorter and longer runs on the same route whether authorized or not. All this is possible on routes served by many jitneys because the high frequency of service greatly reduces the probability of passengers being left stranded in the residential area due to vehicles turning back.

Route deviations are an acknowledged trait of jitney flexibility. Route deviations allow personalized service such as required by the elderly, partially handicapped persons, mothers with babies in arms, young school children or persons with packages. Deviations in routes operated with small vehicles allow for coverage of fairly wide corridors. Drivers of larger jitney vehicles are more constrained on

deviations since many persons asking for deviations would increase travel time substantially. Deviations are made to avoid traffic congestion and to take shorter routes when no on-board passengers are affected. Most jitney regulations restrict or forbid this practice, but on some routes they are seldom enforced.

Access to Route Service

Jitneys commonly operate along fixed routes which people access by walking. People are picked up at street stands (or terminals), at any point along the route or at designated stops. The corridor served by jitneys can be defined as the area encompassed by a maximum walking distance perpendicular to the route, usually slightly over 0.5 mile. High-frequency service (particularly headways under 10 minutes) tends to make people more willing to walk longer distances to access a route. This results from increasing the reliability of arriving on time to a final destination. Thus, with flexible operations and greater frequency of service, jitneys enjoy a wider service corridor than possible with fixed-route services.

Atlantic City jitneys operate along an L-shaped route, 4.2 miles long. The longest segment of this route, about 2.7 miles, is along Pacific Avenue (a major arterial bound by major hotels, restaurants, night clubs, schools and shops). Officially designated jitney stops at most intersections along the route provide virtually continuous access points. No shelters are available for jitney users to protect themselves from inclement weather or to obtain service information, but buildings bordering Pacific Avenue allow some weather protection.

Once on Pacific Avenue, jitney service is easy to identify by the peculiar vehicles, as shown in Figure 3-1 (p. 30), and by stop signs posted along the route.

The Chattanooga cruising cab route is 3.3 miles long and is completely devoid of passenger information or facilities. Prospective customers need to know in advance about their operations to use jitneys effectively. Sedans carrying a jitney sign behind the windshield may be the only clue to a passerby that the service exists. There are two points along the route considered by jitney drivers as the downtown and residential ends of the route, but there is no official recognition of these points nor of any place where vehicles can stand to wait for passengers.

Publicos in Puerto Rico are organized into hundreds of routes ranging in length from about 2 miles to over 100 miles. Practically all routes have an officially designated stand to park and wait for customers within the downtown area. These stands are located near the city central plaza or its immediate surroundings. This location is at or near the heart of the business district (multiple activity center), and many transportation routes converge on it. In general, these stands are within walking distance of major trip attractors and of other transportation modes or facilities such as buses, taxis and parking lots.

Some downtown publico facilities include an off-street terminal with shelter space for passengers, while others are small shelters built by government on the sidewalk. Where shelters providing limited weather protection to passengers are not available, publico vehicles

parked at the "ready zone" of the stand are used as shelters by passengers and drivers.

Government installed signs indicate that a curbside is reserved for a publico route, but they provide no other information such as to which route a stand belongs. Some operators prepare signs to inform prospective passengers of their route location. Also, vehicles parked at the stand are identified clearly with the name of the route served printed on the side and on the windshield. However, due to the large number of routes emanating from a major activity center, it is not simple for an unacquainted rider to know which route to take and where to board a vehicle. For example, Rio Piedras has 41 routes that range in length from 2.6 to 42 miles, all leading to different destinations (39). Fortunately, most publico operators know about other routes and are very willing to orientate any person asking for information.

Hours of Service

Service hours typically cover from 6:00 a.m. to 6:00 p.m., but the service period is usually extended when enough passenger demand exists. Some routes provide night service with average headways of 30 minutes or less; longer headways are considered unattractive. All routes provide weekend service with frequencies reduced according to demand.

Many drivers initiate service at 6:00 a.m. and operate until early evening hours. This allows them to carry morning peak loads and still serve the evening rush hours. It has been observed that every route is served by a core of drivers who are available throughout most

of the day. As a rule, drivers work the hours they wish, whenever they can. Working hours are usually considered as all time spent away from home including driving and idle time plus periods taken for personal chores and discussion of business and personal matters. Out-of-home time for work is not much different from other occupations, when the above periods are considered. Actually, about half of a jitney driver's working day is spent driving, but many report working on weekends for at least half a day, and some operate during holidays and Sundays.

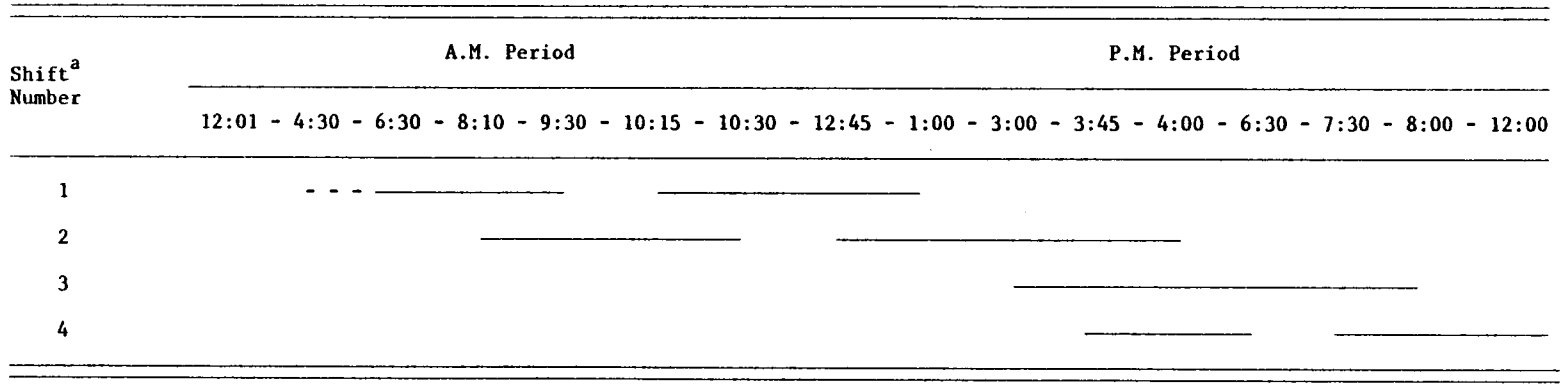
Some jitney drivers take advantage of their flexible schedule to satisfy personal needs and to engage in other jobs such as catering service, and taking children to and from school. Older drivers work fewer hours and fewer days per week until they fully retire. Others prefer to work night hours or during weekends and holidays. However, it has been observed that regardless of hours selected by a given operator, route service is never affected because there are always a few drivers waiting for the opportunity to earn a few more dollars. When a few drivers are on the road for a high level of demand, those present attempt to serve as many passengers as possible in the shortest period of time; this will not go unnoticed by idle drivers and will bring more drivers into service.

In Puerto Rico, most publico drivers report being out for work between 10 to 12 hours per day. Since routes provide continuous service from 6:00 a.m. until 6:00 p.m. or later, as shown in Table 3-1 (p. 36) most drivers need to be available during most day hours. Routes that provide evening service usually rely on a schedule, and

drivers rotate the responsibility to serve the routes. Some routes, such as Route 10 connecting Rio Piedras with Caguas, are operated by a different association using smaller vehicles during evening hours. However, the two groups overlap in service. For example, the regular day group uses its larger vehicles to bring the heavy afternoon peak traffic from Rio Piedras to Caguas (the dormitory city) until 6:00 p.m., while lighter traffic going from Caguas to Rio Piedras is moved in the smaller vehicles starting about 5:30 p.m.

The Atlantic City jitney driver works whenever he selects but within the constraints of shift schedules shown in Figure 3-5. Schedules are prepared by the Jitneymen Association to ensure each member an equitable opportunity to work for his income and to provide continuity of service to the general public. Operators are assigned into three categories, A-B-C, to schedule the days of the week each can operate, thus allowing for days off and for vacations (10). Several vehicles are covered by more than one category, apparently indicating more than one operator. Four independent shifts are scheduled throughout the day, including evening hours. Overlapping of shifts allow for more jitneys to operate during periods of higher demand and for shorter breaks in the longer shifts. This highly organized schedule is possible because the very high demand for jitney service provides a reasonable income to drivers who work under six hours per day.

Due to shift and category schedules, Atlantic City jitney drivers seem to work roughly about half as many hours as transit bus operators (5). Nevertheless, driving is very demanding work that, according to the Jitneymen Association's president, requires high skill and concentration because jitney drivers compete with each other for passengers



[a]As posted by Atlantic City Jitneymen Association at terminal facilities, April 1978. Shift numbers apply during winter months, Monday through Friday, with several exceptions. On Shift 1, some start at 4:30 a.m. and some at 6:30 a.m. according to some internal rules. On Saturday, shifts start at 4:30 a.m. or 6:30 a.m. and operate until 11:30 a.m. Shift 2 operates on Saturdays between 1:00 p.m. to 4:00 p.m. Shifts 3 and 4 remain on Saturdays as from Monday through Friday, with Sundays off. Shifts 1 and 2 preschedule Sunday service according to some internal rules. Each shift is further segmented into three categories. Category C operates Mondays and Tuesdays, Category A operates Wednesdays and Thursdays, Category B operates Friday, Saturday and Sunday. Understanding exactly how all vehicles are scheduled is further complicated by the fact that practically every vehicle has at least two designations of shift and category (for example, vehicle 123A1 also operates as 179C2).

FIGURE 3-5

ATLANTIC CITY JITNEYMEN ASSOCIATION SHIFT SCHEDULE

(35). To ameliorate the hazards introduced by competitive driving, the Association requires members not to overtake each other unless the jitney to be passed has a full load or is stopped with its door open for passenger access (5).

Operating hours of Chattanooga cruising cabs extend from about 6:00 a.m. to about 6:00 p.m., after which vehicles that remain in service do so in the taxi mode. Brooke (15) observes that jitney drivers report maximum working hours per day to be 12, but many serve less than the maximum. Out of 36 operators interviewed by Brooke, 11 worked less than four hours per day, and three had jobs in the local industry and thus provided service during peak periods only. Others received fixed income such as social security and drove on an irregular basis, apparently for the extra income and enjoyment. From field observations it has been noticed that several operators perform just a few runs along the jitney route and then go back to other chores and activities, including regular taxi service.

Fares and Collection Procedures

Fare collection procedures vary by location and route, but in general fares may be paid while boarding, alighting or at any time during the trip, in some instances at the passenger's convenience. Free transfers are not provided as each vehicle on each route belongs to a different owner/operator. Discounted school fares may be mandatory with or without reimbursement from the government in return for the privilege of operating a jitney on public roads. Change is generally available for small denomination bills. No tipping is expected.

Each passenger occupying a seat must pay for the trip. There are no meters, and passengers must pay a flat fare for the entire route or a specified fare by zone. The Mission Street route in San Francisco is reported to have a dual fare of 25 cents for the first half of the trip and 35 cents for the entire route (36). Atlantic City jitneys charge a flat fare of 35 cents, but senior citizens can obtain 10-trip tickets for $1.50 (22). Chattanooga jitneys charge a flat fare of 45 cents (five cents less than transit buses) within their corridor. However, in Chattanooga passengers may ask for route deviations at 30 cents additional charge anywhere within a three block distance of the route and 10 cents per block thereafter (15).

In Puerto Rico several payment options exist. Fares are established by the Public Service Commission for passengers riding the regular route. This may be a flat fare or a zoned fare for longer routes. Regular full fares are shown in Table 3-1 (p. 36). If a passenger requests a slight route deviation and the driver agrees to provide this extra service, an additional charge may be paid. A passenger also has the option to pay for empty seats to have an earlier departure from the stand since drivers will not depart until vehicles attain a minimum load or are filled. A passenger also may elect to charter a vehicle for an agreed upon fare to a preselected destination. A small group may have a standing contract with a driver to be picked up at a given time at a specified location on a daily basis. The contract usually provides that charges per passenger remain at a predetermined low level (say 50 cents) when enough members of the group show up for the trip.

User Characteristics and Trip Purposes

San Juan publico users[2] are relatively young with 46% being under 25 years of age and 70% being under 40. Fifty-four percent of users are male, and 56% reside on the countryside. Approximately 80% live in their own homes even though only 21% of those interviewed have a family car, indicators commonly related to middle or higher income levels. Fares were considered low or reasonable by 81% of the riders interviewed, and 80% reported publicos were available when passengers needed them most. Work trips constitute over 38% of all publico trips, school trips (including university students) make up 26% and other purposes add an additional 36%.

Chattanooga cruising cab users[3] are also on the young side with 66% being under 31 years of age. Forty-three percent of users are male and 57% are female. About 48% of the respondents have a family car, and 40% may be classified in the middle or higher income category (1975 family income over $5,000). The most important reasons cited for using jitneys were more frequent and faster service than bus and time savings. Work trips constitute 42% of all cruising cab trips, shopping comprises 26% and other purposes add 22%.

---

[2]This information was obtained from 350 publico riders interviewed within the San Juan Metropolitan Area in a 1971 survey (40).

[3]This information was obtained from questionnaires designed by Brooke and administered by drivers to 350 jitney users while riding in Chattanooga cruising cabs (18).

Information about other systems is less detailed. Atlantic City riders are composed of office workers, professionals, hotel employees, shoppers, conventioneers, school children, tourists and others (10), but proportions are unknown. Income levels of these riders varies widely. Affluent tourists and conventioneers find it more convenient to travel by jitney than using their own car due to shortage of convenient parking space. San Francisco riders are reported to be primarily middle- and upper-income commuters to the CBD and low-income residents of the Mission Street District (6).

Understanding Jitney Services

A brief examination of characteristics of existing jitney systems indicates that it can be an effective and efficient urban transportation mode. Its flexible organization and operating schemes allow for providing economic services attractive to a broad market of potential riders. Jitneys can provide a source of income to families that have a skilled driver who has difficulty securing steady employment or livable income. Almost any low capacity vehicle may be used to provide jitney service.

Jitneys operate along natural travel corridors and avoid deviations unless it is for the benefit of on-board passengers. Jitneys cruise or operate from a stand depending on which is more efficient and lucrative. They mix well with other transportation modes for the common benefit of operators involved and users, although revised regulations may be required to allow this to happen in more places.

Terminal operations and services may be coordinated with bus transit. Jitneys provide service during day hours or whenever sufficient demand ensures a reasonable income. Fares are kept low to attract as many riders as possible. Jitneys cost government practically nothing, and the only effort required is to enforce minimum regulation and to collect taxes and license fees.

Jitneys have the potential to complement public transportation while supporting community goals; but jitneys are poorly understood. Planners of public transportation think in terms of conventional transit because they understand its economics, performance and operational characteristics. To plan for jitneys and to propose changes to existing regulations which preclude jitney operations, the same critical understanding is required. Without detailed knowledge of jitney benefits, there is no way to justify jitney service. The chapter following analyzes performance of selected jitney routes to advance the understanding of this promising mode.

CHAPTER 4

PERFORMANCE OF SELECTED ROUTES

Introduction

Jitney performance may be measured from the point of view of the passenger and from the point of view of the operator. The passenger is interested in the quality of service provided by a given transportation mode, while the operator is concerned with the passengers moved (output) and with resources used (input). Quality of service is measured conventionally by passenger trip time, while service performance by the operator is measured in terms of productivity (output to input ratios).

Since jitneys are a private enterprise and only a few systems remain in operations, no comprehensive attempt has been made previously to investigate its quality of service and productivity measures. A quantitative analysis of existing jitney services is needed to gain a better understanding of this mode and to derive parameters required for service planning and comparisons with other modes.

This chapter investigates service provided on 10 jitney routes based on field survey information collected in four urbanized areas. All routes provide service connecting multiple-activity centers (downtown areas) with residential areas, ranging in length from 2.2 to 15.1 miles as shown in Table 3-1 (p. 36).

Correlation analysis has been used to investigate relationships between performance measures and route length. The hypothesis has

been devised that jitney service productivity and quality of service factors will vary with route length. This is expected as a result of jitney operators adjusting route operations to provide expeditious service to the highest number of passengers in the shortest period of time. Thus, income and passengers served are maximized while fixed resource inputs such as capital costs are minimized. The field data was analyzed to identify these relationships for application in service simulation and other planning procedures presented in Chapter 6.

Field Procedures

On-board and roadside surveys (Appendix B) were the principal means used to gather field data on jitney operations. Over 30 round trips were made inside jitney vehicles to record data on passenger trips and vehicle operations. Roadside surveys were conducted to record arrival and departure times of jitneys, an observer was located at the stand or at a convenient location where a stand was not available.

The on-board survey was designed to investigate passenger productivity measures and average passenger trip length. Passenger observations were begun at a route location where vehicles were empty and ready to start loading, and all passenger trips made were recorded for the entire length of the route. Vehicle load and location were recorded every time a passenger would enter or exit the vehicle to determine passenger miles for every route segment traveled. This was designed to provide information for determining average passenger-miles per vehicle-mile and average passenger trip length for every

jitney trip surveyed. The observer would select a position within the vehicle to allow counting passengers getting in and out and either to read the vehicle's odometer or to observe roadside features that determined precise location along the route. Enroute time was obtained from route end departure and arrival times. Enroute time and distance traveled provided the information required to calculate average speed.

Several on-board trip surveys were conducted in each cruising route to record 30 or more individual passenger trips. In stand-dispatched routes, one peak trip and one off-peak vehicle trip were made by the on-board observer. Definition of peak or off-peak periods were based on auto traffic and typically were taken as the period between 6:30 a.m. and 8:30 a.m. for the morning peak and between 4:00 p.m. and 6:00 p.m. for the evening peak.

The roadside survey was designed to investigate headways and to validate other data from on-board surveys. Headways were recorded as the time elapsed between vehicles departing from the observer's location during a given period of the day. Roadside observations were made at downtown stands except in Atlantic City and Chattanooga where jitneys operate without a stand. Vehicles were identified by the vehicle number or by the license plate number if this was the only legible designation. Field data became the basis for determining productivity and trip time measures discussed in following sections.

Productivity Measures

Productivity measures are output to input ratios useful for evaluating service performance or for comparing different modes providing similar services. Bus transit companies traditionally have used passengers per vehicle-mile[1] as a measure of service productivity. Passengers per vehicle-mile rates can be used to estimate route revenue based on a given fare or, conversely, may be used to set fares. These outputs and inputs are collected by virtually all transit companies, although very commonly on a system-wide basis rather than by individual routes.

However, passengers per vehicle-mile disregards the effect on productivity caused by modifications in service such as extensions in route length. For example, extending a route into the suburbs may add enough new passengers to reflect a passengers per vehicle-mile rate similar to that prevalent before the extension. However, if that new demand is generated very close to the route end previously served and a substantial portion of the extended segment is served with close to empty vehicles, the passengers per vehicle-mile measure will not reflect overall vehicle utilization.

A more meaningful productivity measure then may be revenue passenger-miles per vehicle-mile. In this measure, the output variable passenger-miles is obtained from the multiplication of average passenger trip length by the number of passengers riding. Thus, this output

---

[1]Passengers are first-ride patrons only, excluding transfers and nonrevenue rides; vehicle miles are the sum of all bus operations, including charter and nonrevenue service (1).

variable helps to explain vehicle usage resulting from passenger trips added or modified due to route realignments or adjustments of service made to cope with the expansion and suburbanization of urban areas. Service mode comparisons, concerning items such as cost, energy consumption and pollutant emissions are possible with this productivity measure as will be explained in Chapter 6.

Passenger-miles per seat-mile is another refinement of productivity to consider the effect of vehicle seating capacity. This productivity measure is very useful for direct mode comparisons when vehicles of different seating capacity are being considered. Passenger-miles per seat-mile is an efficiency index that indicates the intensity of vehicle usage and is useful for evaluating service modifications or for assessing the potential of different vehicular options at a very preliminary stage.

Productivity measures have been computed for each on-board trip made during field studies. Table 4-1 presents productivity values obtained from each jitney trip made for passengers per vehicle-mile, passenger-miles per vehicle-mile and passenger-miles per seat-mile. Vehicle trip distance, expressed in vehicle-miles, has been used as the service input (denominator) for obtaining passengers per vehicle-mile and passenger-miles per vehicle-miles. Vehicle trip distance multiplied by vehicle seating capacity has been used as the service input for obtaining passenger-miles per seat-mile. Since jitney drivers commonly adjust vehicular trip distance to satisfy passenger demand, the one-way distance traveled by each vehicle trip made during the study has been used to determine productivity instead of route length.

TABLE 4-1

JITNEY PRODUCTIVITY BY TRIP

Route	Trip Number	Vehicular-Trip-Dist (Veh-Miles)	Passengers per Veh-Mile	Pass-Miles per Veh-Mile	Pass-Miles per Seat-Mile
1. Caguas to Villa Blanca	1	3.65	2.60	6.55	0.468
	2	2.25	2.44	3.98	0.362
	3	2.20	1.82	2.30	0.209
2. Patten to Citico, Chattanooga	4	3.97	.38	1.48	0.370
	5	3.21	.31	0.71	0.176
	6	4.79	.52	1.10	0.275
	7	4.17	.36	1.03	0.259
	8	3.17	.95	1.84	0.461
	9	3.58	1.26	2.78	0.696
	10	3.12	.48	1.36	0.339
	11	4.73	.53	1.42	0.353
3. Caspian to Jackson, Atlantic City	12	4.08	3.06	5.01	0.556
	13	3.13	2.72	4.40	0.488
	14	3.13	2.08	3.95	0.439
	15	4.08	2.82	4.27	0.474
	16	4.08	1.10	1.45	0.161
	17	4.08	2.33	3.77	0.418
4. Bayamon to Regional Hosp.	18	4.35	2.64	5.93	0.539
	-	-	-	-	-

TABLE 4-1 (Continued)

Route	Trip Number	Vehicular-Trip-Dist (Veh-Miles)	Passengers per Veh-Mile	Pass-Miles per Veh-Mile	Pass-Miles per Seat-Mile
5. Bayamon to	19	4.50	1.89	5.39	0.490
Sabana Seca	20	4.50	3.22	8.28	0.753
6. Rio Piedras	21	5.55	3.33	12.51	0.894
to Campo Rico	22	5.60	2.59	10.25	0.732
7. Bayamon to	23	4.15	1.81	5.01	0.456
Rio Hondo	24	4.20	2.74	8.46	0.769
8. Rio Piedras	25	9.35	1.28	7.14	0.553
to Caimito	26	9.50	1.42	6.89	0.628
9. Rio Piedras	27	10.85	1.52	11.64	0.831
to Canovanas	28	10.75	1.16	8.37	0.668
10. Rio Piedras	29	15.15	0.79	11.65	0.832
to Caguas	30	15.15	0.99	14.16	1.011

Correlation analysis has been used to test the relationship between productivity and vehicular trip length since the latter is a nondeterministic variable with a population of its own. The correlation coefficient rho (ρ) has been used to measure the relationship between a selected productivity and vehicular trip distance. The sample coefficient of correlation is used instead of ρ to estimate the degree of linear relationship between the two variables. This can be expressed as follows:

$$r = \frac{\sum_{i=1}^{n} (Xi - \bar{X} (Yi - \bar{Y}}{\sum (Xi - \bar{X}) \sum_{i=1}^{n} (Yi - \bar{Y})^2}$$

The following t-test may be used to test the significance of linear relationship against the null hypothesis $H_o: \rho = o$, that implies no linear relationship:

$$t = r \frac{n-2}{1-r^2}$$

An equivalent method is to examine the computed value against critical values for correlation coefficients, obtained from statistical tables (41). The latter method has been used to determine the existence of linear relationships.

Linear regression models have been developed for jitneys operating with vans or modified delivery trucks (seated capacity ranging from 10 to 15 passengers). Where no significant regressions have been found, such as for cruising cabs and bus transit, average productivity values have been presented. No differentiation has been made between

peak and off-peak periods for lack of information and/or lack of significance in the results.

Passengers per Vehicle-Mile

A brief analysis of passengers per vehicle-mile trip values shown in Table 4-1 indicates that higher productivities correspond to jitneys making short vehicle trips, excluding cruising cabs. Figure 4-1 presents above productivities plotted against vehicular trip distance and the regression line describing such relationship. This regression for larger-jitney vehicles has a negative slope indicating that passengers per vehicle-mile decreases as distance traveled increases. The sample correlation coefficient obtained is 0.69. Tested against the critical r-value with 26 degrees of freedom r supports the hypothesis of linear relationship at the 1% significance level. The resulting model is:

$$Y = 2.937 - 0.136X \qquad (1)$$

where: Y is passengers per vehicle-mile productivity and

X is one-way vehicular trip distance

This model provides unbiased estimates of the parameters, but may not provide for the minimum variance. Examining the scatter of data points indicates the possibility of decreasing variance as one-way vehicular trip distance increases, and a homogeneous variance is an underlying assumption of least squares regression analysis. Data limitations preclude further investigation.

Chattanooga cruising cab data has been deleted from the regression model because the lower seating capacity of vehicles used result

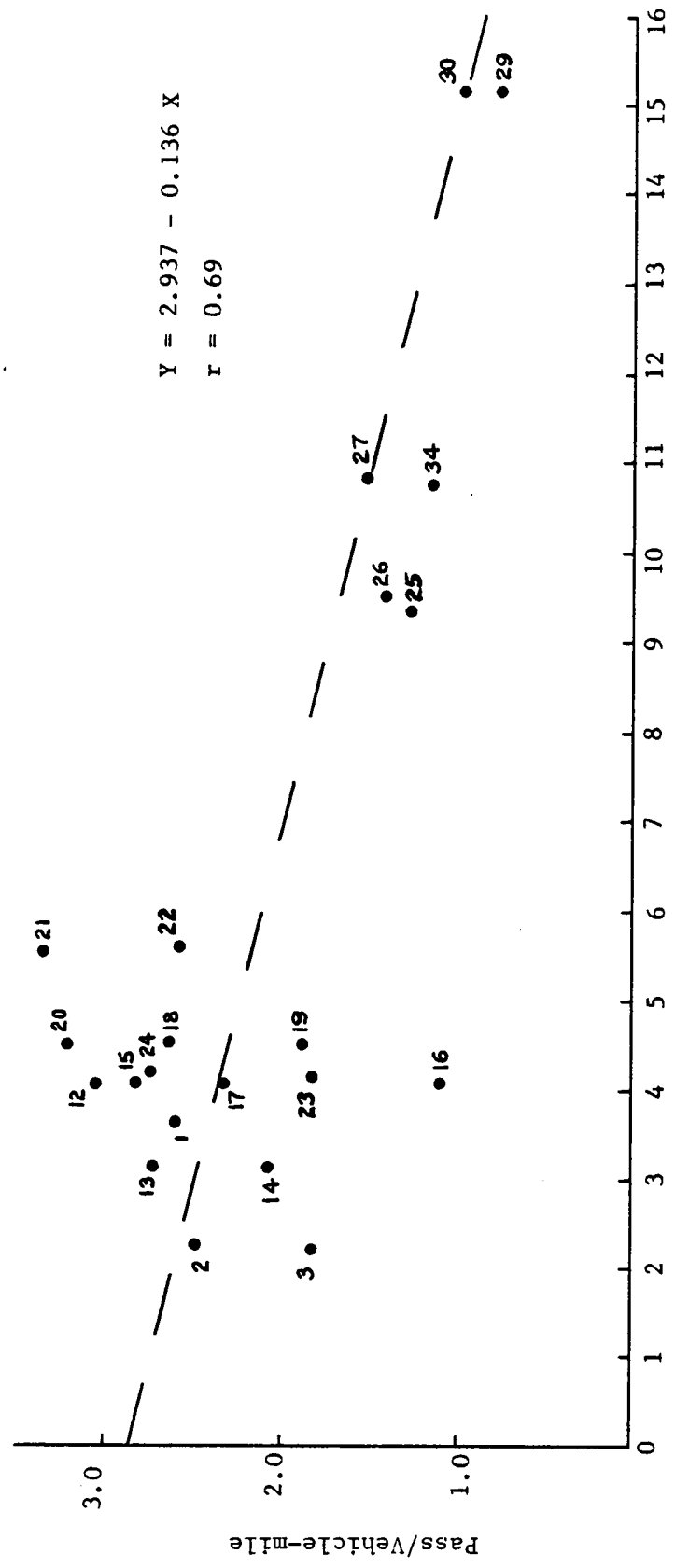


FIGURE 4-1

JITNEY VAN PASSENGERS PER VEHICLE-MILE

in very low productivity and makes the above relationship statistically insignificant. In Chattanooga, a cruising cab's low productivity also may be attributed to the higher quality, door-to-door service that commonly is provided to jitney users. Since productivity data for cruising cabs is limited to that from only one route in Chattanooga, no linear relationship with trip distance should be inferred. Instead, average productivity values ($\bar{Y}$) have been computed. Cruising cab passengers per vehicle-mile productivity averages 0.60 based on Chattanooga data. Table 4-2 presents cruising cab statistics together with similar computations for the bus transit routes studied. Standard deviation and the coefficient of variation (S.C./$\bar{Y}$) are also included within the table, as a measure of dispersion about the average.

For planning purposes, passengers per vehicle-mile productivities can be taken as the average value for cruising cabs and from the regression line for cruising and stand-dispatched vans. Those productivity values can then be used to estimate ridership, route gross income, net income per operator and to establish fares. This will be explained later in Chapter 6 through the use of scenario analyses.

Passenger-Miles per Vehicle-Mile

A closer inspection of passenger-miles per vehicle-mile trip values in Table 4-1 shows that lower productivities correspond to cruising jitney vans operating on short routes, while jitney vans making longer trips show higher productivities. Based on those values, it can be demonstrated that passenger-miles per vehicle-mile of jitney vans increases as trip distance increases.

TABLE 4-2

CRUISING CAB AND TRANSIT BUS
AVERAGE PRODUCTIVITIES

Productivity	Class	$\bar{Y}$	S.D.	S.D./$\bar{Y}$	n
Passengers per vehicle-mile	Cruise cab	0.60	0.33	0.56	8
	Bus transit	4.04	1.59	0.39	5
Passenger-miles per vehicle-mile	Cruise cab	1.47	0.63	0.43	8
	Bus transit	11.11	4.95	0.45	5
Passenger-miles per Seat-mile	Cruise cab	0.37	0.16	0.43	8
	Bus transit	0.29	0.11	0.40	5

Figure 4-2 presents passenger-miles per vehicle-mile van productivities plotted against vehicular trip distance and the regression line describing such relationship. This regression has a positive slope indicating that longer trips have greater passenger-miles per vehicle-mile productivity. The resulting model is:

$$Y = 2.840 + 0.661X \quad (2)$$

where; Y is passenger-miles per vehicle-mile productivity and

X is one-way vehicular trip distance

The sample correlation coefficient r is 0.75, that tested against the critical r-value indicates a linear relationship at the 1% significance level.

Cruising cabs have been excluded from the model because they reduce the significance of the regression and their operations differ from those of vans. Based on Chattanooga data, average cruising cab passenger-miles per vehicle-mile is 1.47 as shown in Table 4-2.

For planning purposes, cruising cab passenger-miles per vehicle-mile may be taken as the average value shown in Table 4-2 while van productivities may be obtained from the regression line. These productivity values can then be used to estimate cost, energy consumption and pollutant emmissions of each service mode and to make gross comparisons between different modal options. This will be explained in Chapter 6 by means of scenarios.

Passenger-Miles per Seat-Mile

Analysis of passenger-miles per seat-mile trip productivities in Table 4-1 shows that lower values correspond to jitneys making short

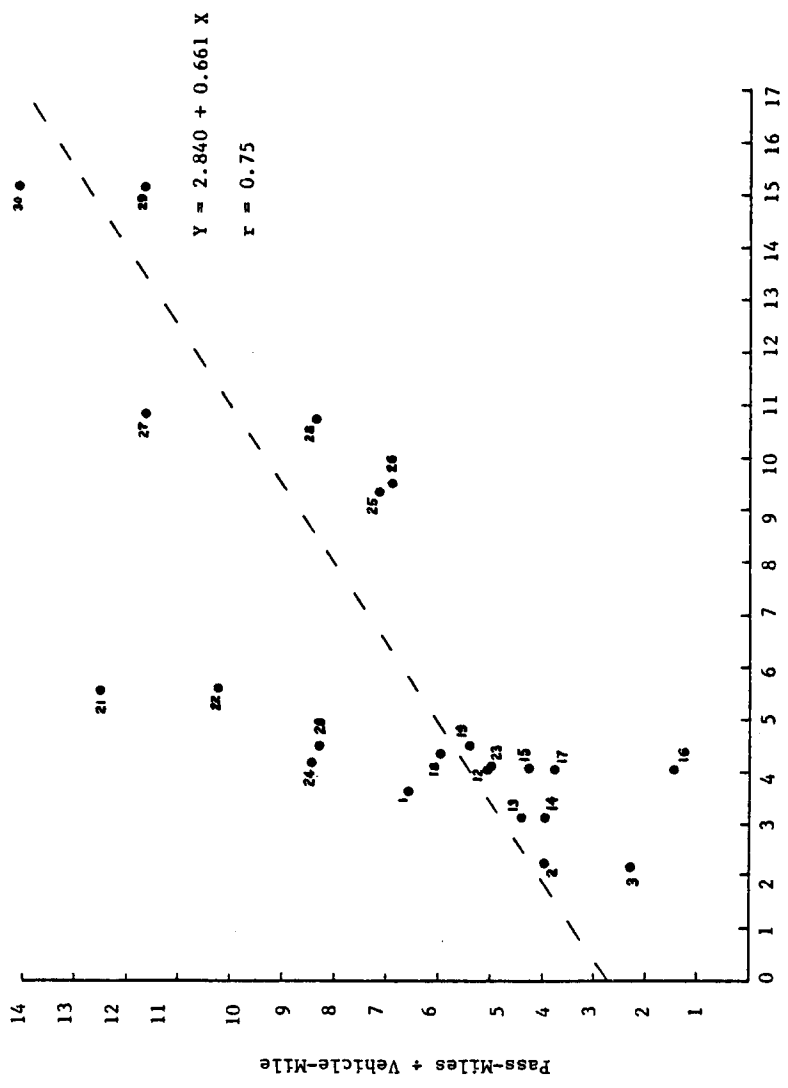


FIGURE 4-2

JITNEY VAN PASSENGER-MILES PER VEHICLE-MILE

vehicular trips and higher values correspond to those making longer vehicular trips; cruising cabs are excluded.

Figure 4-3 presents passenger-miles per seat-mile productivities for jitney van service plotted against vehicular trip distance. The regression line describing such relationship has a positive slope, indicating that longer trips have greater passenger-miles per seat mile productivity. The resulting model is:

$$Y = 0.345 + 0.0384X \qquad (3)$$

where; Y is passenger-miles per seat-miles productivity and,

X is one-way vehicular trip distance.

The sample correlation coefficient r is 0.69 and tested against the critical r-value indicates a significant linear relationship at the 1% significance level.

Cruising cabs have been excluded from the regression model but their average computed value of passenger-miles per seat mile ($\bar{Y}$) is 0.37 as shown in Table 4-2.

As for other productivity measures previously discussed, cruising cab passenger-miles per seat-mile may be taken as the average value shown in Table 4-2, while van productivities may be obtained from the regression line. These productivity values can then be used as a measure of system efficiency indicating how intensively available seating capacity is utilized for each seat-mile operated. Passenger-miles per seat-mile is very useful for direct comparisons between modes providing the same kind of service with vehicles of substantially different seating capacities.

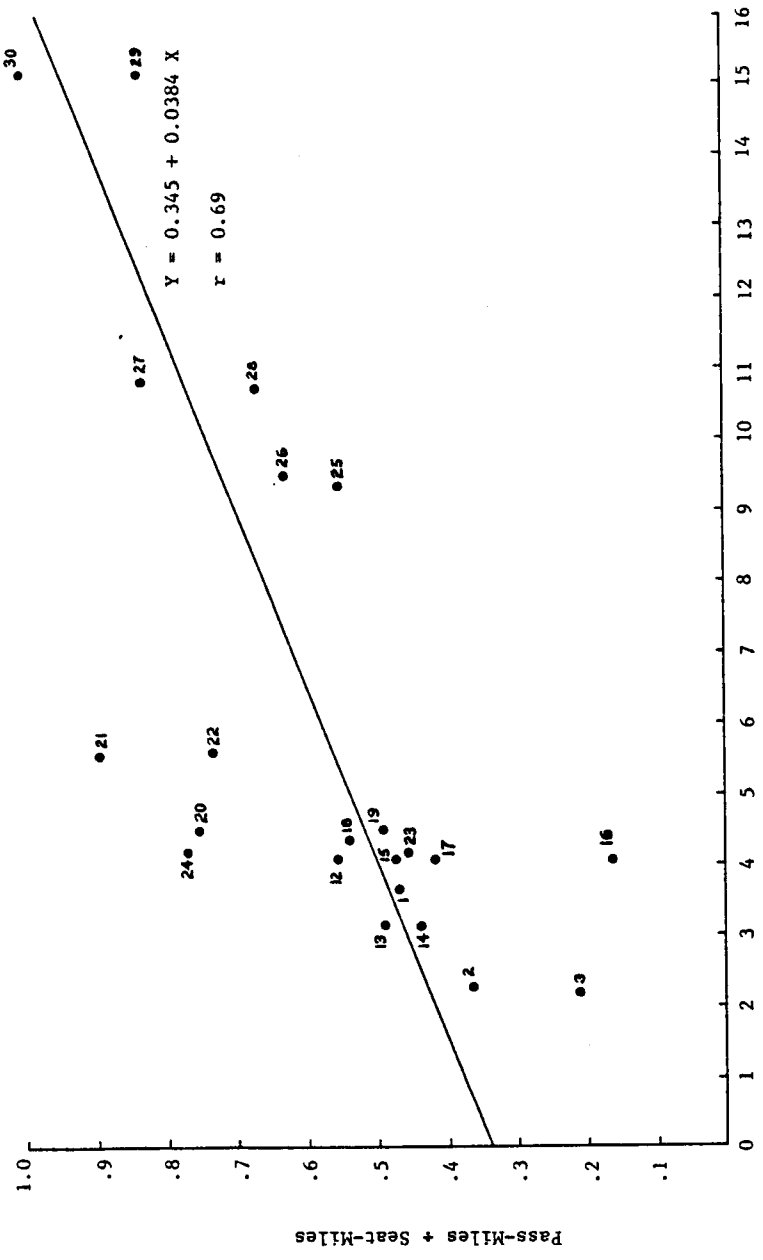


FIGURE 4-3

JITNEY VAN PASSENGER-MILES PER SEAT-MILE

Jitney Productivities Compared to Bus and Other Modes

Productivity measures are useful for evaluation of service provided by a given mode as well as for comparisons between modes. Jitneys, being an alternative to other public transportation modes, may be understood better through productivity comparisons.

The principal mode to be compared with jitneys is bus transit; but except for passengers per vehicle-mile, only limited productivity information is available for this mode by individual route. Thus, onboard bus surveys were conducted in Atlantic City and Chattanooga. Two surveys were conducted during peak hours, two during off-peak hours and one during early evening hours. The two bus routes serve the same general corridor as jitney routes studied in those communities but often traveling different roadway segments and serving longer routes.[2]

Cruising cab passengers per vehicle-mile productivity is on the low side at 0.6, while the regression line for jitney vans ranges from 0.9 to 2.6 (for trip distances ranging from 2 to 16 miles). Bus passengers per vehicle-mile productivity in corridor service is roughly estimated at 4.0. The bus figure is 5.7 times higher than for cruising cabs and from 0.6 to 3.5 times higher than for jitney vans. Nationwide bus transit productivity is 3.26 passengers per vehicle-mile for all kinds of services, according to the American Public Transit Association data for 1977 (1), but this average is dominated by very large systems in the larger urbanized areas. According to the

---

[2]It is worth mentioning that these bus routes are the most patronized routes within their respective systems. This may be partly attributed to the interaction with jitneys.

1974 National Transportation Report (42), passengers per vehicle-mile median productivities range between 1.8 to 2.6 for urbanized areas between fifty thousand and one million population. It is evident that, based on passengers per vehicle-mile buses have a higher productivity than jitneys, as expected.

Cruising cabs also show the lowest passenger-miles per vehicle-mile productivity of jitney modes at 1.47; however, this is close to that achieved by the private auto reported at 1.53 passenger-miles per vehicle-mile during a typical weekday (42). The regression line for jitney vans range from 4.0 to 13.4 (for trip distances ranging from 2 to 16 miles). Equivalent bus service is calculated at 11.1 passenger-miles per vehicle-mile, and this value is 7.6 times higher than that for cruising cabs and ranges from 0.83 as high to 2.8 times higher than that for jitney vans. Nationwide, passenger-miles per vehicle-mile dominated by reports from larger urbanized areas, is estimated at 12.15 for all kinds of bus services, according to American Public Transit Association data for 1977 (1). Another report (42) shows median bus productivities to range between 5.6 and 9.3 passenger-miles per vehicle-mile for urbanized areas between fifty thousand and one million population. It is significant that jitney vans serving trips close to five miles or longer (principally stand-dispatched routes) show passenger-miles per vehicle-mile productivities close to those achieved by bus transit. It is also interesting to note that passenger-miles per vehicle-mile values for stand-dispatched jitneys approach or surpass the values for vanpools whose average occupancy including the

driver can be estimated at 9.6 passengers per vehicle-mile (43), assuming all passengers travel the whole length of the vehicle trip.[3]

Passenger-miles per seat-mile productivity for cruising cabs has been calculated at 0.37, and this is somewhat higher than private autos whose productivity has been estimated at 0.28. However the cruising cab estimate may be misleading when compared to the estimate for autos because this jitney mode seated capacity has been based on four seats since one passenger-seat was always occupied by the on-board observer during field counts. The regression line for jitney vans range from 0.42 to 0.96 (for trip distances ranging from 2 to 16 miles). This compares with bus productivity calculated from field data at 0.29 and implies that bus utilization per capacity-mile is considerably lower than for jitneys. The 1974 National Transportation Report (42) shows median bus productivities to range between 0.15 and 0.21 for urbanized areas below one million population. Undoubtedly, jitneys are used more intensively and achieve higher passenger-miles per seat-mile than buses.

Trip Time Measures

Total trip time is perceived by passengers as the quality of service afforded by a mode. Both frequency of service and in-vehicle travel time are very important to a passenger deciding which transportation mode to select. Equally important are the variability of both

---

[3]Actually, vanpool passenger-miles per vehicle-mile must be lower than the 9.6 average reflects since this value does not account for empty seats during collection and distribution of vanpool participants.

factors, as altogether they determine the probability (reliability) that a passenger will have to arrive on time at destination. Previous research has identified reliability of arriving on time at a destination as the single most important criteria in urban mode selection (44).

However, many more observations than those collected are necessary to draw conclusive inferences on trip time variability for any particular route. Continuous adjustments of vehicular trip length require an on-board surveyor or observers at several locations to ascertain jitney trip length since, unlike bus transit, not all jitneys traverse the whole length of a route. Because of data limitations, only trip time is considered to determine quality of service in this report.

Trip time is achieved as the sum of average wait time and in-vehicle travel time. Wait time is taken as half the time of the average headway. Vehicle speed has been investigated instead of travel time because it provides more generalized relationships for planning. Average passenger trip length also is discussed since passenger's in-vehicle time is dependent on trip length as well as on vehicle speed.

Statistical comparisons between modes serving the same corridor have been more difficult than expected. Jitney services have been observed to approach the speed of private autos along a short roadway segment, but it becomes nearly impossible to observe strictly both modes serving a common corridor because autos have an infinite number

of destinations. Also, comparisons with bus transit were found difficult because jitneys do not travel the same route and thereby encounter different traffic and service conditions.

An attempt has been made to compare jitneys with bus transit concerning speed and headways, but, unfortunately, the available field data for bus transit does not permit an in-depth comparison. (Surveys conducted by others have been used to supplement the data collected for this research.)

Headways

Headways are as important as in-vehicle travel time in determining overall passenger trip time. Since jitneys do not follow schedules and passengers are served at random, average headways must be short for trip time to be attractive to passengers.

Headways are the elapsed time between vehicles passing a specific location during a selected period of time, traveling in a given direction (outbound or inbound). Headways are influenced by travel demand and vehicle capacity; thus, highly traveled routes and those served with smaller vehicles commonly are served more frequently.

Average wait time for a prospective passenger at some point on the route can be expected to be half the time of the average headway. Actually, a potential rider may have to wait longer than the average expected wait time because of the variability of jitney headways.[4] Unscheduled jitney trips may be judged as poor service by unacquainted observers, but high frequency of service greatly reduces this concern.

---

[4]Also, vehicles passing by a waiting passenger may be fully occupied and thus will not stop.

Table 4-3 presents average headways during peak and off-peak periods for each route studied; the standard deviation is included as a measure of variability from route average headway. Comparing the unweighted average of route peak period headways with the off-peak period equivalent headways (see Table 4-3), it becomes evident that peak service is about 67 percent more frequent than off-peak service. However, four routes do not share this imbalance, i.e. Routes 2, 3, 6 and 7, since they provide approximately the same frequency of service during peak and off-peak periods. On the other hand, averaging headways for routes providing more peak service than off-peak service discloses that peak service is provided every 5.5 minutes compared with off-peak service every 12.2 minutes. Thus, peak service is about 2.2 times more frequent for the latter group of routes. Overall, no definite pattern can be distinguished between headways, period of the day or route length (associated with vehicular trip length) since jitney headways are principally a function of demand.

Variability of headways is also very significant in mode selection. The uncertainty of deviations from scheduled service is the major reason for commonly weighing wait time higher than in-vehicle time (usually 2.5 times) in transportation planning models. Reliable headways, such as achieved by rapid transit, reduce the inconvenience of waiting for a vehicle. Jitney routes providing service at short headways have lower variabilities than routes operating with longer headways.

High demand routes such as Routes 2, 3, 4, 5, 8a and 10 operate with headways under five minutes during peak hours and standard

TABLE 4-3

JITNEY ROUTE HEADWAYS FOR PEAK AND OFF-PEAK PERIOD
(Minutes)

	Route	Peak			Off-peak		
		Headway ($\bar{h}$)	S.D.	n	Headway ($\bar{h}$)	S.D.	n
1.	CBD to Villa Blanca Caguas, PR	9.3	6.2	4	16.7	7.4	7
2.	Patten to Citico, Chattanooga, TN	3.8	3.0	23	3.9	3.9	28
3.	Caspian to Jackson, Atlantic City, NJ	2.2	1.7	31	2.1	1.9	56
4.	CBD to Reg. Hosp., Bayamon, PR	-	-	-	3[a]	<1.0	-
5.	CBD to Sabana Seca, Bayamon, PR	3.1	1.6	39	7.1	3.8	16
6.	CBD to Campo Rico, Rio Piedras, PR	15.5	10.9	4	13.5	9.4	13
7.	CBD to Rio Hondo, Bayamon, PR	6.3	4.4	14	7.2	3.1	17

TABLE 4-3 (Continued)

Route	Peak			Off-peak		
	Headway ($\bar{h}$)	S.D.	n	Headway ($\bar{h}$)	S.D.	n
8a. CBD to Caimito Bajo, Rio Piedras, PR	3.5	3.2	17	7.5	5.0	29
8b. CBD to Caimito Alto, Rio Piedras, PR	6.1	4.3	9	16.8	8.4	12
9. Rio Piedras to Canovanas, PR	7.8	3.5	15	19.3	10.8	6
10. Rio Piedras to Caguas, PR	3.0	1.6	15	5.7	3.9	46
	$\bar{H}$ = 6.0			$\bar{H}$ = 10.0		

[a] Jitneys dispatched with the aid of a three-minute egg timer.

deviations under four minutes. This means that on the average, passengers will have to wait to ride a jitney under 2.5 minutes plus or minus 4 minutes 68% of the time, assuming trip departures are normally distributed about an average headway. During off-peak hours, some of the group routes studied increase headways to a maximum average of 7.5 minutes, with standard deviations increasing up to 5 minutes.

Routes operating with longer headways show higher standard deviations from their average headway. However, off-peak jitney trips may tend to become more evenly spaced as headways grow longer. This is probably influenced by the increasing probability of passenger demand becoming more uniform as the elapsed time between vehicles increases. This off-peak relationship can be shown by dividing standard deviation by headway for routes operated at different frequencies.[5] The ratio (S.D./I) grows smaller as headways increase. For example, during off-peak hours Route 3 with very short average headways (2.1 minutes) has a ratio of 0.90, while Route 9 with much longer average headways (19.3 minutes) has a ratio of only 0.56. This would result in less uncertainty and inconvenience to passengers waiting for service on jitney routes operated less frequently during off-peak hours.

The above comparison can be used in judging quality of service provided by jitneys to passengers or in comparing the quality of jitney service with other modes. Even changes to existing or proposed services may be judged based on headways and the associated variability.

---

[5]This relationship may also be observed by use of a regression line.

Vehicular Travel Speed

Jitney travel speed has been reported to be very close to speed attained by autos (5) and thus higher than possible by conventional transit bus. Travel speed of a public transportation mode (non-exclusive guideway) is determined by characteristics of roadways traveled, traffic congestion, volume of passenger operations and modal ability to blend with auto traffic. Limitations imposed by these factors on bus transit are greater than on jitneys. Jitneys may not be able to change traffic conditions but, if permitted, they can and will deviate from their route to avoid severe traffic congestion. Individual jitneys serve fewer passengers and make fewer stops than conventional transit. In addition, use of small size vehicles allows for merging with auto traffic with little or no problem.

As for auto, route and corridor characteristics may be expected to affect the average jitney operating speed. Even the roadway classification of each segment traveled[6] and its location within the urban area have an impact on travel speed (45). Jitneys serving longer routes (usually over six miles) tend to travel at higher speeds than those serving shorter routes because their operations commonly are characterized by more extensive use of higher type roadways and stops clustered close to route ends.

To investigate the assumption that jitney speeds are higher than attained by buses, travel times of all 10 routes studied were

---

[6]Speed by roadway classification would have been highly desirable for comparison with other modes but could not be calculated from data collected.

recorded. Average running speed was determined dividing time by distance traveled. Since a major objective was to investigate how average speed varies with vehicular trip distance, speed has been calculated independently for each trip made.

Table 4-4 presents jitney speed data by direction of travel. The travel speed represents normal operating conditions including minor route deviations within the corridor served. Speed values are average for the whole one-way distance of the vehicle trip without consideration for the classification of roadways traveled.

Figure 4-4 presents average running of jitney van speed plotted against one-way distance traveled. A correlation analysis provides a regression line that describes such relationships. The regression line has a positive slope indicating that longer trips travel at higher average speeds than shorter trips. The resulting model is:

$$Y = 9.510 + 1.048X \qquad (4)$$

where; Y is average running speed in miles per hour
and X is one-way vehicular trip distance.

The sample correlation coefficient r is 0.80 and tested against the critical r-value indicates a significant linear relationship at the 1% significance level. This information can be used for planning route service or to check on the reasonableness of assumptions in services similar to those studied when field data are not available.

Average cruising cab speed was found to be 15.2 mph for an average vehicular trip length of 3.9 miles. Line-haul speed, as observed by passengers, was even higher since average speed reflects several

TABLE 4-4

JITNEY TRIP ONE-WAY DISTANCE AND AVERAGE SPEED

Route	Trip	Vehicular Distance (one-way miles)	Average[a] Speed (mph)	
1. Caguas to Villa Blanca, P.R.	1	3.65	14.6	Out
		3.65	14.6	In
	2	2.25	10.4	Out
		2.25	10.4	In
	3	1.90	10.4	Out
		2.50	11.5	In
2. Patten to Citico, Chatt., Tennessee	4	3.97	13.6	Both
	5	3.21	14.8	Both
	6	4.79	15.5	Both
	7	4.27	16.7	Both
	8	3.17	16.5	Both
	9	3.58	15.3	Both
	10	3.12	12.5	Both
	11	4.73	16.2	Both
3. Caspian to Jackson, Atlantic City, N.J.	12	4.08	13.6	Out
		4.08	14.4	In
	13	2.82	15.4	Out
		3.43	13.7	In
	14	3.43	15.8	Out
		2.82	14.1	In
	15	4.08	11.7	Out
		4.08	12.9	In
	16	4.08	11.1	Out
		4.08	11.1	In
	17	4.08	12.9	Out
		4.08	12.9	In
4. Bayamon to Reg. Hosp., P.R.,	18	4.3	10.3	Out
		4.4	10.6	In
5. Bayamon to Sabana Seca, P.R.	19	4.3	16.1	Out
		4.7	13.4	In
	20	4.3	15.2	Out
		4.7	15.7	In

TABLE 4-4 (Continued)

Route	Trip	Vehicular Distance (one-way miles)	Average[a] Speed (mph)	
6. Rio Piedras to Campo Rico, P.R.	21	6.1	13.1	Out
		5.0	9.4	In
	22	5.9	12.2	Out
		5.3	13.3	In
7. Bayamon to Rio Hondo, P.R.	23	3.3	19.8	Out
		5.0	16.7	In
	24	3.5	17.5	Out
		4.9	16.3	In
8. Rio Piedras to Caimito, P.R.	25	9.1	23.7	Out
		9.6	16.0	In
	26	9.4	25.6	Out
		9.6	21.3	In
9. Rio Piedras to Canovanas, P.R.	27	10.9	18.7	Out
		10.8	18.0	In
	28	10.9	19.2	Out
		10.6	21.2	In
10. Rio Piedras to Caguas, P.R.	29	15.1	21.1	Out
		15.2	26.1	In
	30	15.2	32.6	Out
		15.1	23.8	In

[a]Out or In refers to outbound or inbound trips with respect to the downtown area. Both means an average of outbound and inbound trips.

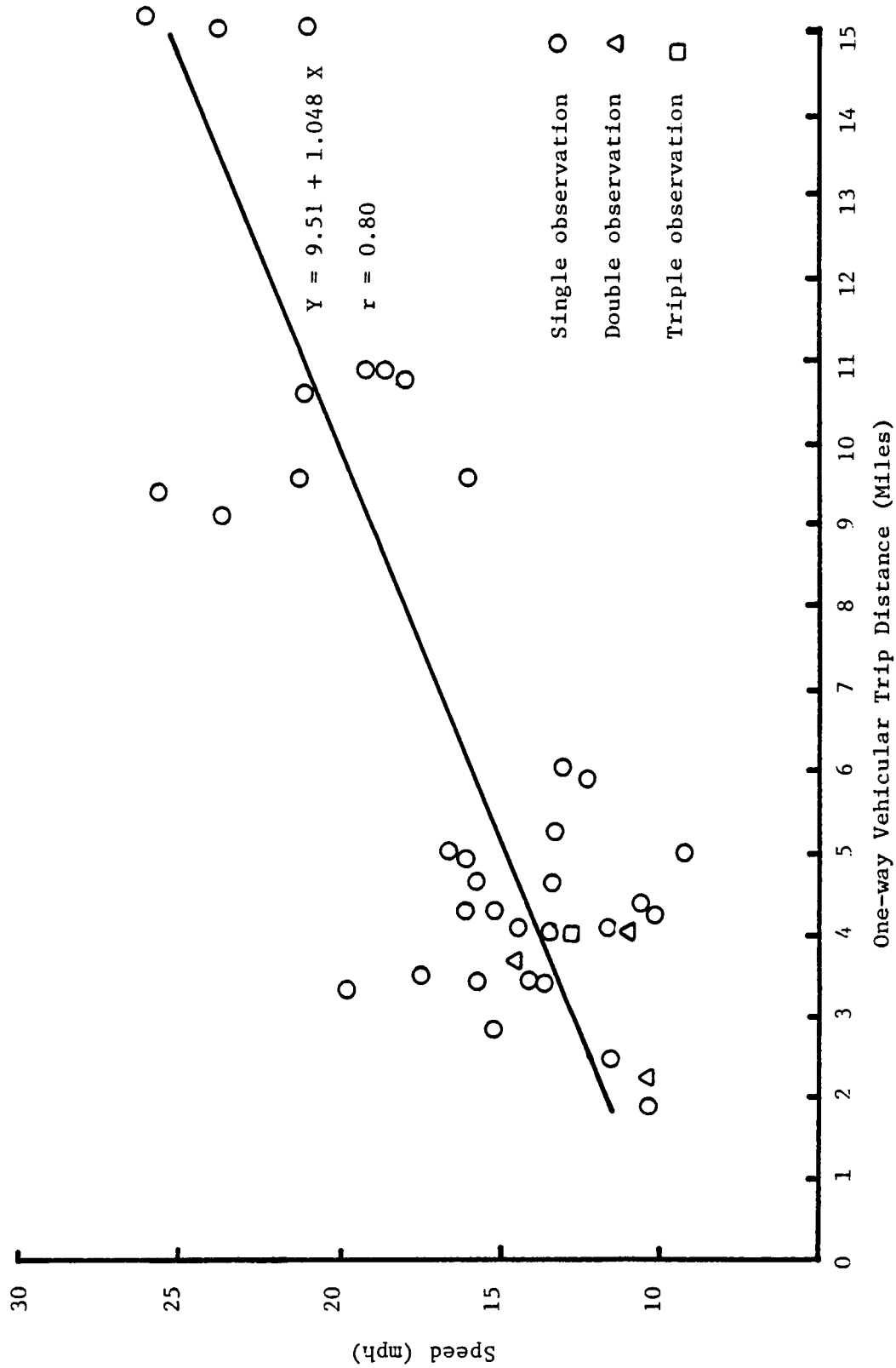


FIGURE 4-4

JITNEY VAN SPEED (10-15 SEAT VANS)

route deviations and the search for passengers within residential areas.

Peak and off-peak period jitney speeds have been investigated, and two significant correlations with vehicular trip distance can be obtained from sampled values. However, the two regression lines overlap at short trip distances (between four and five miles), and only longer trips exhibit significant differences useful for planning. Also peak and off-peak speeds should have been related to the classification of the roadway traveled, but further research and field data would still be required. For those reasons, no further discussion of speeds by period of day is given.

Passenger Trip Time

Total passenger trip time is the sum of walk, wait and on-board travel times. Walk time commonly is regarded as dependent on system coverage and local geographical conditions. For a given corridor provided with nondeviating route service, walk time will be the same for any one mode. For planning purposes, walking to a bus or jitney route can be considered to take the same time even though some jitneys may deviate to provide close to doorstep service.

Disregarding walk time in modal comparisons leaves only wait time and on-board travel time for investigation. Wait time is dependent on service headways or frequency of service. The basic consideration for establishing headways is commonly to satisfy a known level of demand or to provide minimum frequency of service. Modal comparisons frequently consider both. For example, a 45-seat bus operating on a route at a 30 minute headway could be substituted by 11-seat jitney

vans operating at an average of 5.5 minute headways. In this way, jitneys provide the same seating capacity as transit buses, or, in other words, jitneys can satisfy the same level of demand that buses provide running at a minimum frequency.

On-board trip time is more elusive than the other two components of travel time, because passenger trips are shorter than the route length. This is a known fact for bus transit where the average passenger trip length is about 3.7 miles (1); but disregarding downtown circulators most bus routes exceed five miles in length. In contrast, private autos take most passengers from vehicle-trip origin to destination. Rather than investigating on-board trip time, it seems more appropriate to investigate this variable indirectly by reviewing the passenger trip length to route length relationship. If such relationship is known, on-board trip time can be estimated dividing passenger trip length by average speed, for a route of known length. Average speed can be determined from local sources, from estimates based on speed for each mode by roadway functional classification, or from relationships already developed.

Also, if the average passenger trip length is known, then productivity measures such as passenger-miles per vehicle-mile may be estimated from a commonly available statistic, passengers per vehicle-mile. Passengers per vehicle-mile is usually available from transit companies and can be estimated from revenues. If a passenger trip length to route length relationship ratio can be established then average passenger trip length may be estimated at different time intervals without conducting an on-board survey.

It has been proposed that short jitney routes tend to promote passenger trips much shorter than the one-way route length. This hypothesis is based on the premise that low fares charged by jitneys encourage passengers to get on and off a vehicle at any point along the route. Also, that this is more pronounced when very high frequency of service, typical of short routes, exists because jitneys can substitute for some walking trips.[7]

On longer jitney routes, average passenger trip length might be expected to approach the length of the route. This hypothesis is based on the premise that the high fares charged by jitneys (compared to public bus transit fares) attract those passengers traveling most of the one-way route distance. The more common use of higher type roadways also may discourage short trips by making pedestrian access to intermediate points along the route more difficult.

The relationship between passenger trip length to route length relationship and route length was found weaker than originally expected. Inspection of passenger trip length to route length relationship ratios by route length suggests a clustering of such ratios about the average of each jitney service mode. Table 4-5 provides average passenger trip length to route length relationship values, standard deviation, and coefficient of variation for each jitney service mode and for buses. The number of trips studied is limited, but, in the absence of better local information, passenger trip length to route length relationship averages may be used for planning purposes.

---

[7]This condition, where jitney trips replace some walking trips seems probable in systems such as that in Atlantic City.

TABLE 4-5

AVERAGE PASSENGER TRIP LENGTH TO ROUTE LENGTH RATIO BY SERVICE MODE

Service Mode	$\bar{Y}$	S.D.	S.D./$\bar{Y}$	n
Cruising Cab[a]	0.69	0.18	0.26	8
Crusing Van	0.44	0.11	0.5	10
Stand-Dispatched	0.63	0.08	0.21	0
Intercity Stand-Dispatched	.97	-	-	2
Bus Transit	0.41	0.08	0.20	5

[a]Cruising cab ratio is based on passenger trip length to vehicle trip length because route length as such cannot be established since almost every trip deviates from the established route. The cruising cab operating on a fairly fixed route can be expected to have a mean value similar to that of a cruising van.

The average ratio for cruising cabs is 0.69, for cruising vans is 0.44 and for stand-dispatched vehicles is 0.63; the respective coefficients of variation are at or below 0.26 for these jitney service modes. Intercity stand-dispatched jitneys seem to carry most passengers close to the whole length of the route, but available data represents only two vehicular round trips. With such ratios, on-board trip time can then be estimated as follows:

$$OBTT = \frac{PTLTRL * (Route\text{-}miles)}{(Average\ Route\ Speed)}$$

where; OBTT = on-board passenger trip time and,

PTLTRL = passenger trip length to route length ratio.

Table 4-5 also includes similar statistics for bus transit based on the cases studied. Passenger trip length to route length relationship average is shorter for bus transit than for any jitney service mode. The variability is fairly stable as indicated by the coefficient of variation.

Nevertheless, it should be clear that each passenger trip length to route length relationship ratio used for determining the overall average represents an average of several individual passenger trips related to route length. For example, the five bus trips carried 274 passengers, and the trip length distribution of those individual passenger trips is unknown. The standard deviations are related to the average passenger trip length in each independent vehicle trip observed, and the actual deviation of individual passenger trips is probably much higher.

In summary, total passenger trip time can be approximated by the sum of on-board travel time and half of the average headway. Headways can be obtained from design parameters or from policy considerations. On-board travel time can be approximated if speed and route length are known, using the procedure presented above.

Jitney Comparisons with Bus Transit

Comparisons with bus transit are difficult because jitneys do not serve the same routes even when serving the same general corridor. An attempt has been made to generalize headways and speed of bus routes serving corridors similar to those by some jitney routes. Yet, bus data has been obtained from various sources that are not necessarily compatible or under the same controls as those for jitney data.

Headways. Bus headways are determined by capacity requirements at the maximum load point or by some criteria on quality of service. Bus routes serving corridors with high passenger demand usually have shorter headways than routes serving lower density corridors. For the latter, bus headways are more commonly determined by the quality of service desired (in terms of headway spread and standee criterion) than by capacity needs. Therefore, the critical factor perceived by the user becomes headway variability and total waiting time.

With very frequent headways, i.e., under 10 minutes, passengers may arrive at random and the average passenger will wait half the time of average headways. With longer headways, i.e., over 20 minutes, most passengers learn route schedules and commonly arrive at a bus stop about 8 minutes before scheduled bus arrival. If a person is not

aware of the current route schedule, waiting time will be about half the prevailing headway. For example, with a typical 30-minute headway, a passenger would have to wait about 15 minutes to board the next bus. Yet, the uncertainty of the next arrival implies that this event may happen at any time within a uniform distribution that extends from 0 to 30 minutes.

Based on a 1975 survey of 22 bus runs in Atlantic City (46), the average bus run started 4.5 minutes late with a standard deviation of 5.5 minutes. The earliest bus left 4 minutes before scheduled time, and the latest 21 minutes late. Consequently, using Atlantic City as a typical location where jitneys operate, it may be argued that a person aware of bus schedules will wait for a bus an average of 12.5 minutes. Variability of headways as measured by one standard deviation is 5.5 minutes but tapers off gradually from scheduled time toward late arrivals.

That compares with waiting times for jitneys that average 3.0 minutes during peak periods and 5.0 minutes during off-peak periods, based on waiting time being equal to half of the average headway (see Table 4-3, p. 75). The unweighted average of standard deviations in routes studied is 4.0 minutes during peak periods and 5.3 minutes during off-peak periods.

The above comparison is not intended to evaluate headways (because headways depend on demand) but rather to compare variability of headways and the overall effect on wait time in what may be considered typical of operations along low- to medium-density travel corridors. For a given level of demand, jitney headways are much shorter than

those of bus transit because jitney vehicles have lower seating capacity. Jitney headways are as short as required to satisfy passenger demand and maximize income.

Speed. Information on bus routes serving common corridors with jitney routes was sought during the field survey period. On-board surveys were conducted on Chattanooga and Atlantic City buses serving a common segment of the corridor served by jitneys. In Puerto Rico, this was not possible due to an on-going bus strike, but data from the San Juan Metropolitan Bus Authority provided running times for various routes serving corridors that typically could be served by jitneys. Actually, one of those corridors is also served by jitneys in the Rio Piedras to Campo Rico route, although significant differences in route alignment, length and intensity of service exists between buses and jitneys.

Table 4-6 shows bus average running times and speeds for routes providing corridor service between multiple activity centers and residential areas. These bus routes were selected based on route length to investigate relationship with speed; however, no significant correlation was found. During peak periods average running speed is 11.9 mph, and during off-peak periods average running speed is 13.4 mph. Average bus route length considered is 7.0 miles.

From the above information, only simple comparisons can be made between bus and jitney. Using the relationship obtained for jitneys based on one-way vehicular distance traveled, jitneys serving a 7-mile route travel at about 17 mph. Bus speeds can be expected to be slower than those attained by jitneys, but no direct comparisons can be made

TABLE 4-6

BUS RUNNING TIME AND SPEED FOR PEAK AND OFF-PEAK PERIODS
(Minutes)

Bus Route[a]	One-Way Length (miles)	Round Trip Running Time[b] Peak	n	Off-Peak	n	Running Speed Peak	Off-Peak
MBA # 16	5.45	54.4	10	48.8	49	12.1	13.5
MBA # 22 See Jitney Route 6	5.9	58.5	>10	57.6	>38	12.1	12.3
ATC # 5 See Jitney Route 3	6.0	67	1	69	1	10.7	10.4
CARTA #10 via Avondale and Glenwood See Jitney Route 2	6.4	68	1	54	1	11.3	14.2
MBA # 23	6.85	60.0	9	53.0	>31	13.7	15.5
MBA # 34	7.15	82.7	>10	70.9	>63	10.4	12.1
MBA # 26	9.45	85.1	8	70.9	>31	13.3	16.0
						$\bar{v}$ = 11.9	$\bar{v}$ 13.4

[a]MBA refers to San Juan Metropolitan Bus Authority, ACTC to Atlantic City Transit Company and CARTA to Chattanooga Area Regional Transit Authority.

[b]MBA running time calculated from on-board survey data collected by that agency.

due to substantial differences in route alignment. For example, the Rio Piedras to Campo Rico jitney route and its companion bus route (San Juan Metropolitan Bus Authority Route 22) serve along some common sectors. However, this jitney route is very circuitous in the residential end, traversing many local streets (about 63% of the whole route length), while the bus route travels through principal collectors to serve the same residential sectors. Jitneys serving this route also take passengers to and from the Rio Piedras central plaza while the bus route ends about a half-mile away from that point to avoid downtown traffic congestion.[8] In direct route to route comparisons, it would seem that jitneys travel at about the same speed as buses; however, on this particular route, jitney passenger trip time is much lower than for bus riders due to high frequency of jitney service and the close to door-to-door service provided.

In Atlantic City, a jitney traversing the segment from New Hampshire Avenue to Baltic Avenue travels 18% faster than its companion bus route (Atlantic City Transit Company Route 5) during peak periods and 7% faster during off-peak periods. Jitneys travel faster than buses even though jitneys travel through Pacific Avenue which is much narrower and local in function than Atlantic Avenue.

Chattanooga cruising cabs travel 19% faster than buses serving the same corridor (Chattanooga Area Regional Transportation Authority Route 10) during peak periods and 13% faster during off-peak periods. This jitney route is much more circuitous than the bus route because

---

[8]Several years ago most buses serving Rio Piedras were routed by the city plaza but due to traffic congestion many of them were realigned to serve a newly built bus terminal located 0.6 miles away.

it travels through local residential streets, while the bus route travels extensively over residential collectors with low volume auto traffic. Comparisons on variability of travel time would be desirable but further research is required.

Assessment of Findings

Jitney performance measures have been investigated to look for useful planning relationships. Statistics frequently used in transit planning such as average speed, headways, passengers per vehicle-mile and passenger trip length have been measured from existing jitney operations. Some jitney performance measures have been found to be related to vehicular trip length in routes connecting multiple-activity centers with residential areas.

Statistical analyses have been conducted to examine for linear relationships. Significant linear relationships have been found between one-way vehicular trip distance by jitney vans and the following performance measures: average speed, passengers per vehicle-mile and passenger-miles per vehicle-mile. Headways appear more related to passenger demand and no relationship was detected with vehicular trip distance or other measurable parameters. Passenger trip length is not necessarily related to vehicular trip distance or route length but, can be estimated from the passenger trip length to route length relationship ratios found for the service modes studied.

The information available is limited because this is the first known attempt to measure jitney performance factors. The analysis has been principally confined to van-size jitney vehicles. These operate

in three different service modes: cruising, intracity stand-dispatched and intercity stand-dispatched. The information gained through the relationships found is intended to be used in context with Chapter 6 for planning of jitney transportation services.

CHAPTER 5

ENERGY, COST AND AIR POLLUTANT EMISSIONS

Measurements

Planners are becoming increasingly involved with short-term activities to increase the occupancy level of all vehicles in support of transportation policies. There is a need to search for more effective and efficient means to deliver public transportation services, yet most alternatives to public transit fall short of satisfying these needs. Jitneys seem able to complement transit by attracting latent demand for public transportation as well as current transit users while consuming less energy and operating at a lower cost than other paratransit modes.

The preceding chapter investigates system and service performance measures used by planners. This chapter extends the analysis of selected jitney systems to investigate three policy issues. These analyses will provide planners with the parameters needed for energy and cost assessments and will introduce some considerations on air pollutant emissions. Other important policy issues will be discussed in subsequent chapters.

Energy consumption rates commonly are expressed as a productivity index, e.g., vehicle-miles per gallon. Ratio measures are desirable because they are an index of marginal utility such as that represented above by the output (vehicle-miles) to input (gallon of fuel) ratio. Also, the productivity index above is readily available for many

transportation modes. Passenger-miles per gallon is another index which is very useful for intermodal comparisons on energy consumption. The higher the index, the more desirable that a mode becomes based on this policy consideration. However, this measure is dependent on knowing passenger-miles per vehicle-mile as discussed in Chapter 4.

In regards to costs, data should be available by categories that reflect policy issues and that can be identified readily. For example, summary costs by categories such as capital, maintenance, transportation service or overhead represent readily identifiable areas which address policy issues. The system design approach based on the aggregation of major cost items is recommended. Once unit cost for each major item is identified, and service inputs such as number of vehicles and vehicle miles are determined by system design, summary costs by category can be estimated. Thus, summary costs by category can allow a planner to evaluate and make recommendations based on the effects of allocating or shifting resources to satisfy selected policy changes.

The use of the system design approach allows for more precise information in the comparison of service alternatives than the simple but deceptive method of applying one single rate to estimate all expenditures, such as dollars per vehicle-hour. This is particularly important in the comparison of peak versus off-peak services. The system design approach can be used to allocate costs and permits comparisons between private and publicly owned modes. This is important because one mode may disregard capital subsidies and tax exemptions while the other may not.

Based on current policy considerations and evaluation needs, air pollutant emissions should be determined. Emission rates can be

calculated using Environmental Protection Agency (EPA) publications (47,48). Emission rates in grams of pollutants per vehicle-mile combined with previously explained service productivity indices allow for modal comparisons. For example, the combination of EPA rates with passenger-miles per vehicle-mile provides an estimate of emissions in terms of grams of a specific pollutant, e.g., carbon monoxide per passenger-mile. However, air pollutant emissions are discussed in Appendix C because this information is not related directly to field studies conducted by this researcher.

Data Collection

Several jitney operators and various route presidents (system managers) were interviewed to learn more of their operations and to collect specific data on fuel consumption and costs. Information requested included cost of fuel, oil, tires, repairs, insurance, license plates, association dues and the frequency with which these costs were incurred. Capital costs also were requested.

Reliability of the information obtained was lower than expected. It was found that jitney operators do not keep formal records on fuel consumed and miles driven, although some provided rough estimates on fuel mileage rates that seemed reasonable. Operating cost estimates were based on experience from jitney operators rather than from records. Some operators did not seem to know in detail the cost information requested. A few operators refused to provide any information at all arguing that they did not have the time to comment or simply that they did not want to answer any questions. Nevertheless, field data obtained

through personal interviews provides approximations that are useful for planning purposes.

Energy Consumption

In recent years the availability and cost of petroleum resources have become a critical domestic issue. All principal sources of energy are in limited supply, and all have undergone drastic price increases. However, of particular concern is petroleum because it is being consumed at a faster rate than can be produced domestically. The continuous dependence on large amounts of imported petroleum to bridge the gap between domestic production and demand threatens to debase the financial and political independence of the United States.

Since 1950, petroleum consumption for transportation has remained at about the 50% level of all petroleum used in the nation (49). Auto travel alone accounts for about 25% of domestic petroleum consumption (50). Compounding the problem from 1950 to 1976, the average automobile fuel mileage dropped from 15.0 to 13.7 miles per gallon. However, the energy efficiency of the gasoline-powered engine is relatively low (20 to 30%), and this suggests ample room for improvement. On the long-term, various policies can be pursued to reduce petroleum consumption such as improving the mileage rate of new cars. Of immediate concern to planners are short-range activities that can be taken to increase the occupancy levels of transit and paratransit vehicles. Thus, planners must be able to measure the effectiveness of alternative energy efficient activities; one measure of energy efficiency is the energy productivity ratio.

Passenger-miles per gallon of fuel is a direct index of fuel efficiency and energy productivity. In this way outputs are directly related to the source of energy. British Thermal Units (BTUs) are sometimes used to compare urban transportation modes using different fuel types, but this measure has a major disadvantage. A smaller amount of petroleum and less refining energy is required to produce a gallon of diesel than a gallon of gasoline. Yet, diesel fuel has more energy per gallon than gasoline, and burning the same volume of either fuel would indicate higher BTUs expenditure by diesel. In addition, diesel engines are more efficient than gasoline engines. For the above reasons a productivity index that considers gallons of fuel by type rather than BTUs expended has been selected for the assessment of energy consumption of non-electrically powered modes.

Energy conservation policies concerning urban transportation services may be grouped into three classes--those affecting the private auto, conventional transit and paratransit. Since the private auto is the dominant mode of urban transportation, the effect of selected actions on the private auto should be considered wherever possible in any plan conducive to conserve fuel through shifting emphasis to more extensive use of transit or paratransit. When decisions are being made between transit and paratransit only, autos may be disregarded.

Mileage Rates

Table 5-1 shows estimated fuel mileage rates for the jitney routes studied. This table provides approximations based on questionnaire

TABLE 5-1

JITNEY SPEED AND GASOLINE MILEAGE

Route	Average Speed[a] (mph)	Gasoline Mileage[b] (miles/gallon)
1. Caguas to Villa Blanca	12.0	8.2
2. Patten to Citico, Chatt.	15.1	10.0
3. Caspian to Jackson, A.C.	12.5	8.5
4. Bayamon to Regional Hosp.	10.4	
5. Bayamon to Sabana Seca	15.1	11.+
6. Rio Piedras to Campo Rico	12.0	9.5
7. Bayamon to Rio Hondo	17.6	10.0
8. Rio Piedras to Caimito	21.7	
9. Rio Piedras to Canovanas	19.3	12.3
10. Rio Piedras to Caguas	25.9	14.8

[a]Average all-day speed was calculated from speed data from Table 4-4, p. 80.

[b]Based on driver gas mileage estimates or driver reported daily gas consumption and trips made. Sources: Interview with Mr. William Lee, former president of the Chattanooga Cruising Cab Association and president of the Airport Limousine Association, May 31, 1978; personal interview with Mr. Milton Greenberg, President of Atlantic City Jitneymens Association, April 17, 1978; From Atlantic City, Home of the Boardwalk and Miss America to Anaheim, California, Home of the Angels and Disneyland, unpublished mimeographed paper available from the Atlantic City Department of Revenue and Finance, December 1967.

responses from jitney operator interviews conducted for this study. Due to the limited number of responses, statistical analysis becomes irrelevant. Instead, rate validity may be judged against relationships established by others. Equations have been derived by Alan M. Voorhees & Associates to estimate gas mileage by speed of passenger cars and light duty trucks traveling through at-grade arterials in Baltimore (51,52). Table 5-2 presents that set of equations.

Figure 5-1 shows a plot of jitney mileage rates together with a smooth plot of the Baltimore equations. The combined plot seems to indicate that the jitney's fuel mileage resembles the fuel mileage of private autos traveling through at grade arterials. A Chi-square test would indicate a good relationship between jitney mileage rates and the low speed end of the Baltimore curves. However, since jitney operator responses were limited and were obtained through many different means, let it be assumed that the Baltimore equations may be used for estimating jitney fuel mileage. Cruising cab mileage rates can be estimated using the passenger car curve, while jitney van rates may be taken from the light duty vehicle curve. A visual inspection of the Baltimore curves will show that at low speeds both curves are essentially the same. At higher speeds, the light duty vehicle (van) has lower fuel mileage than the passenger car (sedan); the lower fuel mileage of the light duty vehilce may be attributed to the higher wind resistance resulting from the vehicle's larger cross section.

Use of the Baltimore curves may look suspicious due to the frequent stops which jitneys make and, in the case of vans, because of their heavier loading. However, private autos begin most trips

TABLE 5-2

FUEL MILEAGE RATES FOR AUTO AND LIGHT DUTY VEHICLES

Vehicle Category	Speed Range (mph)	Fuel Economy (mpg)
Automobile	10 - 39	$2.3 * V^{0.568}$
	39 - 45	18.3
	45 - 55	$26.3 * V^{0.18}$
Light-Duty	10 - 32	$2.3 * V^{0.568}$
	32 - 40	16.5
	40 - 55	$27.4 * V^{0.27}$

Where V stands for average speed in mph

Source: Baltimore Regional Environmental Impact Study: Technical Memorandum No. 8, Analysis of Energy Consumption, Alan M. Voorhees & Association for the Interstate Division of Baltimore City, June 1976.

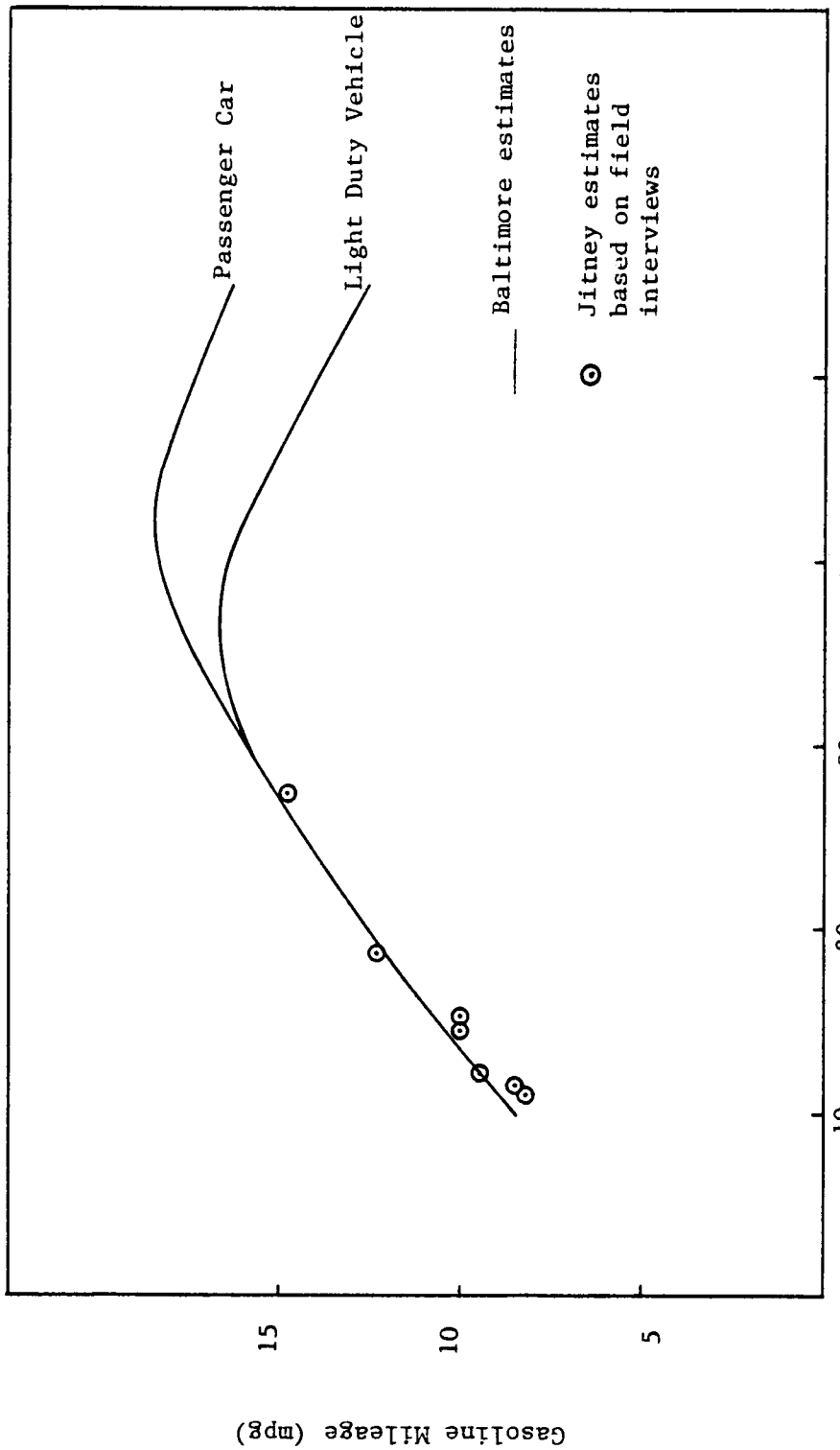


FIGURE 5-1

GASOLINE MILEAGE RATES BY SPEED

with a cold engine. Vehicles starting a trip with a cool engine consume much more gasoline during the first few minutes of operation until the engine fully warms-up (53). Hirst (54) suggests that most autos warm up after driving for over 10 miles. Except for their first trip in the morning, jitneys commonly operate with a warm engine. It seems reasonable to assume that similarities in engine design make private autos and jitneys exhibit the same fuel consumption pattern based on speed.

Fuel Consumption Rates

Modal efficiency can be compared more readily using fuel consumption rates at various speeds. Fuel consumption rates are preferable over fuel mileage rates because they are a productivity ratio that indicates the marginal effect on consumption by each mile of service produced. Table 5-3 shows estimates of fuel consumption rates for five vehicle types based on average speed of travel along arterials and other roadways without access control. Sedan consumption rates were obtained from the inverse of fuel mileage rates calculated from equations in Table 5-2; van consumption rates have been assumed conservatively at 5% higher than sedan rates. Full-size bus consumption rates have been obtained from vehicle simulation studies conducted by General Motors (55), and supported and confirmed by others (56,57). Minibus rates have been estimated by adjusting downward from full-size bus consumption rates according to the overall fuel mileage ratio between the full-size bus and the minibus (see footnote d in Table 5-3).

Fuel consumption rates by speed can be used to determine total fuel consumed per vehicle trip considering speed characteristics of

TABLE 5-3

FUEL CONSUMPTION RATES BY SPEED[a]
(Gallons/Vehicle-mile)

Average Speed (mph)	Gasoline		Diesel	
	Sedan[b]	Jitney Van[c]	Minibus[d]	Full-Size Bus[e]
Idle	0.840[f]	0.840[f]	0.180	0.440
5	0.174	0.183	0.180	0.446
10	0.118	0.123	0.103	0.251
15	0.093	0.098	0.078	0.193
20	0.079	0.083	0.068	0.167
25	0.070	0.073	0.064	0.156
30	0.063	0.066	0.063	0.154
35	0.058	0.064	0.053	0.095
40	0.055	0.064	0.044	0.108
45	0.055	0.069	0.050	0.123
50	0.058	0.076	0.057	0.139

[a]Fuel consumption rates apply to vehicles traveling through arterials and other roadways without access control.

[b]These rates apply to both passenger cars and jitney sedans.

[c]These rates apply to 10 through 14 passenger vans and modified delivery trucks rates used are 5% higher than for the sedan vehicle, excepting idle speed.

[d]Estimate based on full-size bus rates times the ratio of average diesel fuel mileage (mpg) for a full-size bus to a 19-passenger minibus (4.1 ÷ 10.0 = 0.41). Full-size bus data from Sanders, D.B., and Reynen, T.A., Characteristics of Urban Transportation Systems: A Handbook for Transportation Planning, DeLew Cather and Co. for Urban Mass Transportation and Federal Highway Administration, May 1974; minibus data from "Ultra-Personalized Service in Morgantown, West Virginia," Metropolitan, Nov./Dec. 1974.

[e]Sources: Sanders, D.B., and Reynen, T.A., Characteristics of Urban Transportation Systems: A Handbook for Transportation Planning, DeLew Cather and Co. for Urban Mass Transportation Administration and Federal Highway Administration, May 1974, pp. 3-7; idle/speed obtained by estimates in Batchelder, J.H., Englisher, L.S., and Sokol, K.L., Operational Implications of a Major Modal Diversion to Transit: Program Users' Guide, Multisystems, Inc. under contract to U.S. Department of Transportation, April 1976, DOT-OS-50266 and Claffey, P.J., Running Costs of Motor Vehicles as Affected by Road Design and Traffic,

TABLE 5-3 (Continued)

National Cooperative Highway Research Program Report 111, Highway Research Board, Washington, D.C., 1971.

[f]Idle fuel consumption in traffic is for a 1972 Chevrolet sedan with the engine at normal operating temperature. Source: Claffey, P.J., Passenger Car Fuel Conservation, for Federal Highway Administration, Washington, D.C., July 1976, PB-265-369.

roadway types traveled. Other relationships with passenger trips and passenger-miles are possible by use of productivity measures previously discussed in Chapter 4. For example, planners may desire to select the best service option based on the mode or route alignment having the highest ratio of passenger-miles per gallon of fuel. This will be demonstrated in Chapter 6.

Cost of Services

The high cost of subsidizing public transportation is one of the major problems confronted by cities today. During the past three decades, transit costs have increased faster than revenue. Faced with the prospect of being deprived of transit, many local governments have decided to assume control or possession of systems on the verge to collapse. But, since government takeover, deficits have increased faster than ever before. Publicly owned transit has failed to increase economic productivity following the pace of private transportation industries (58).

There are locations where conventional transit remains economically viable such as where highway congestion, land values, or travel demand are very high. Along less traveled corridors and where substantial differences in passenger demand exists between off-peak and peak periods, transit costs are well above revenues. Although social and indirect economic benefits of transit are relevant to a community, it is the ability or willingness of a community to subsidize transit service that makes a system viable. Today, it becomes even more difficult to justify increasing transit subsidies when taxpayers are

complaining about poor transit service and reductions in service are being considered simultaneously with increased fares. More efficient alternatives should be investigated, and jitneys are an attractive service mode capable of providing high quality corridor service without subsidies.

Detailed cost information is required to estimate costs of providing a given amount of service. Jitney costs have been surveyed in the systems visited to gain an understanding of their magnitude and the cause for incurring them.

Table 5-4 provides estimates of major item costs for jitney, private auto and bus transit based on 1978 conditions (59). Basic information has been drawn from field interviews and from various documents. Costs incurred for fuel, oil and tires are related with vehicle miles. However, fuel costs have been expressed in dollars per gallon and need to be adjusted by fuel consumption rates, as previously discussed. Administration, insurance, advertisement and traffic, maintenance and garage overhead, dispatching and taxes and licenses are more related to time period (hours) of operation and may be allocated on an annual basis. Capital expenses are related primarily to number of vehicles, but other costs may be included, such as stations and other buildings or structures, when these are required for service-related operations. An off-peak to peak period factor is included to reflect the typical imbalance in the number of vehicles operating during those periods.

Typical cost factors are provided as a basis for estimating costs of any given or proposed service, but they do not represent any specific system. For example, today's fuel prices are increasing constantly, however, in 1978 a gallon of gas was priced commonly at 60 cents at

TABLE 5-4

TYPICAL MAJOR ITEM COSTS
(1978 Dollars)

Item	Gasoline			Diesel	
	Private Auto	Jitney Sedan	Jitney Van	Minibus Transit	Full-Size[a] Bus Transit
Fuel ($s/gal.)[b]	0.60	0.60	0.60	0.46	0.46
Tires ($/mile)	.003	.006[c]	0.017[d]	0.20	0.027
Oil ($/mile)	.002	.002[c]	.008[c]	.003	0.003
Driver ($/veh-hr)[f]	1.50	3.00	3.00	6.50	6.50
Dispatch cost ($/veh)	0	0	0 or 150[h]	3,256	3,256
Annual Insurance ($/veh)	400	962	1,200	2,000	3,839
Annual Admin ($/veh)	0	120	120	9,853	9,853
Annual Maint. & Garage ($/veh)	200	500	500	9,369	9,369
Annual Advt. & Traf. ($/veh)	240	100	100	514	514
Annual Taxes & Lic. ($/veh)	40	70	85	1,000	2,672
Annual Deprec ($/veh.)	540	900	1,200	3,400	5,667
Off-peak/Peak Factor	0.5	0.78	0.78	0.50	0.50

[a]Calculations are based on: Atlantic City Transportation Company's Fiscal Year 1979 Application for Operating Assistance, as submitted to the New Jersey Department of Transportation, August 28, 1978.

[b]Estimate for 1978: cost of gas at any pump; diesel at bulk rate cost (no tax).

TABLE 5-4 (Continued)

[c]Calculations are based on: Brooke, T., An Analysis of an Urban Jitney System in Chattanooga, Tennessee, Transportation Center, The University of Tennessee, August 1976, p. 69.

[d]One set of tires @ $200.00/set every 12,000 miles.

[e]Oil change @ $10.00/change every 1,250 miles or every 15 days.

[f]Jitney driver wage taken as the prevailing minimum wage, bus driver at typical wage for median to small size city (Atlantic City, N.J.), private auto at half the minimum wage.

[g]Dispatch not necessary for cruising vehicles, although some jitneys in Chattanooga pay $780/year for a taxi stand.

[h]Drivers in San Francisco and Puerto Rico pay 50¢/day for dispatching services. Source: Jurkat, M.P., Lesser, A., Pianese, V., and Mott, J., A Publico System for Highly Congested Urban Areas, Center for Municipal Studies and Services, Stephens Institute of Technology, under contract to U.S. Department of Transportation, December 1976.

service stations and diesel cost 46 cents at the bulk rate then available to transit companies. Cost of tires was based on national highway statistics for private autos, on costs reported by Brooke for jitney sedans in Chattanooga, and on field survey responses from jitney van operators. All full-size bus information is from Atlantic City except for the peak-hour factor. Table 5-4 footnotes explain in more detail the sources of information.

Findings and Information Usage

This chapter has analyzed field data on energy consumption and costs of jitneys. Such data has been presented with comparable information from other transportation modes.

Energy consumption has been expressed in terms of gallons of fuel per vehicle-mile. Jitneys have been found to consume gas at about the same rate as private autos while traveling along arterials. Fuel consumption rates based on average travel speed can be used to determine fuel expenditures per vehicle trip considering the roadway types traveled. That is, a fuel consumption rate multiplied by the length of a given roadway type traversed gives the consumption for that segment of the vehicle trip. Adding the fuel consumption for all segments provides an estimate of total fuel consumption for a given vehicle trip. With this information, mode comparisons and selection of the best alternative can be made based on the specific option that consumes the least amount of fuel. Combining this information with other productivity ratios such as passenger-miles per vehicle-mile allows for more refined modal comparisons based on marginal changes of service provided.

Allocation of costs based on the causative relationship of major item costs allows for the use of the system design approach to estimate overall costs. This method provides more reliable cost information than common methods that rely on a single system-wide average rate and that disregard peak period factors. Used in conjunction with productivity measures, extensive cost analyses can be made of items such as driver costs, vehicle-operating costs, maintenance and overhead costs and depreciation.

The chapter following presents procedures for using the information developed in Chapters 4 and 5 obtained from secondary sources to conduct service simulation and economic analyses. A computer program has been developed and introduced as a planning tool to simulate system operations to allow for the evaluation of alternative services.

CHAPTER 6

SIMULATION OF JITNEY OPERATIONS: PLANNING PROCEDURES

Introduction

Several models and procedures have been proposed to analyze auto and transit services provided within urbanized areas. Among these, the most sophisticated battery of programs have been developed for the U.S. Department of Transportation as exemplified by the Urban Transportation Planning System (UTPS) used in transit planning (60). These programs can simulate route conditions and service parameters along a specified corridor. Unfortunately, programs that consider route details are very intricate, time consuming and expensive to operate. They also require specialized personnel to formulate inputs, to run the computer programs and to analyze outputs. Even with such programs, cost factors are often expressed as system wide averages in terms of dollars per vehicle-mile (see program ULOAD within the UTPS).

The procedures proposed in this chapter can be used to determine service quality, economic viability, energy efficiency and air pollutant emissions. These procedures allow for the assessment of corridor service such as provided by jitney and other public transportation services by dividing the route traveled into different roadway segments that exhibit similar traffic conditions. This methodology intends to provide planners with the tools to identify the route service that can best satisfy selected transportation policies.

Due to the iterative nature of the procedures proposed, a computer program named "Corridor" has been developed as part of this research to simulate route operations based on specific route characteristics. In addition to route characteristics, the program is provided with data input cards describing typical parameters of selected service modes to include fuel type used, fuel cost per gallon, fuel consumption rate and annual cost of insurance. Those data input cards are external to the program and thus can be modified by the program user to define modal parameters closely matching the specific service being considered and the local environment and conditions. The computer program is used to simplify the handling of the large number of assumptions, parameters that define route service and the speed-related variables in the simulation of route service. Manual computation is possible but limits the number of alternative modes, services and route alignments that can be tested.

Outputs include data related to the vehicle trip operations, service quality as perceived by passengers, route service costs, fuel consumption and air pollutant emissions. Vehicle trip operations outputs include distance traveled, running time and vehicles required. Service quality as perceived by passengers is represented by total travel time taken as the sum of time waiting for service and time on board the vehicles. Route service costs subsume major item costs into four categories--driver-related costs, vehicle operations, capital depreciation and maintenance and overhead. Fuel consumption data shows the gallons of fuel consumed per trip or per period of time and whether it is diesel or gasoline. Air pollutant emissions are specified based

in grams of pollutant per trip or by period of time; pollutants considered are carbon monoxide, hydrocarbons and nitrogen oxides.

Simulation of Route Operations

Four aspects of public transportation are of major concern to the planner in the evaluation of service from the operator's point of view. These are service characteristics, overall cost, energy consumption and air pollutant emissions. Other aspects such as special services to the handicapped and noise pollution are important to the planner in the evaluation of a community's public transportation system but are beyond the scope of this study.

Program Outline

Figure 6-1 outlines the general activities conducted in running the route operations simulation procedure. Several steps lead to the desired outputs, as follows:

1. Define or identify basic inputs;
2. Define the route and the frequency of service by mode;
3. Prepare input data to the computer program;
4. Run the corridor program; and
5. Retrieve outputs for analysis and evaluation of route service.

Regulatory constraints, vehicle type and travel method, temporal and spatial demand and roadway type and length of each segment are basic inputs to the procedure. Regulatory constraints refer to restrictions on jitney operations or other alternative services. These include minimum frequency of service, bonding or insurance costs and taxes. Vehicle type refers to seating capacity, fuel type and

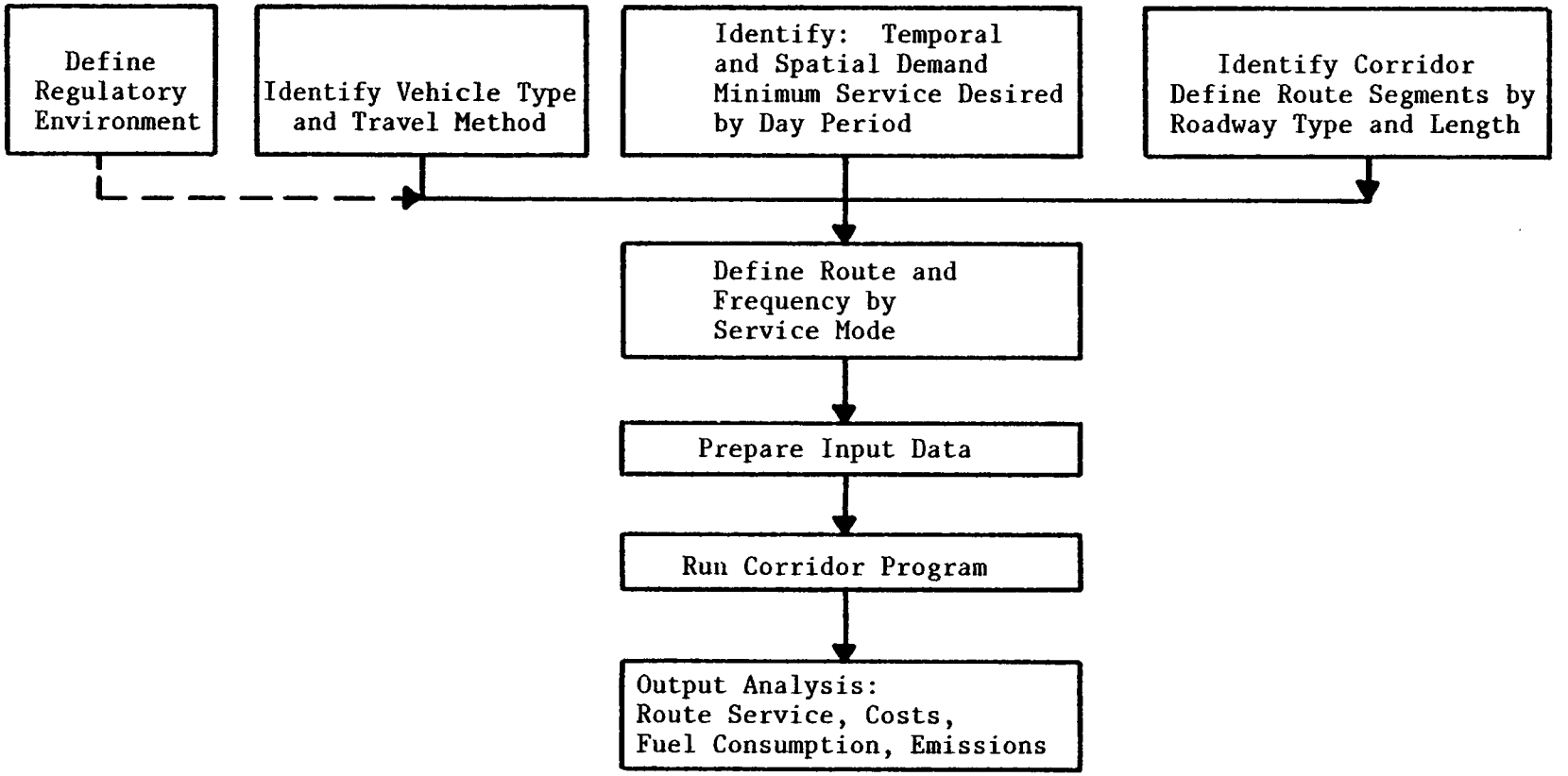


FIGURE 6-1

ROUTE OPERATIONS SIMULATION PROCEDURE

vehicle type (sedan, van or bus), while travel method refers to cruising, stand-dispatched or scheduled service. Temporal and spatial demand refer to observed or expected passenger trips per period of time and how that demand is geographically distributed along the corridor. In the absence of specific demand data, minimum service levels may be specified arbitrarily such as in vehicle trips per hour. The route considered for each particular service mode is specified by segment. For example, a route segment may be described as X miles on CBD arterials and Y miles on residential collectors. Appendix D describes the Corridor program input data in more detail.

The second step consists of determining service frequency and how the route will be served. Planners must estimate passenger demand to determine minimum service frequency based on capacity. If capacity is of little concern, frequency may be determined from established policies that specify maximum headways, e.g., a minimum of one vehicle passing a given point every 20 minutes. Route service must consider if all vehicles will travel the whole length of the route or if a turnback is to be established for selected vehicles at a given point of the route.

The three remaining steps deal directly with the corridor program usage. The third step is to prepare route cards and modify service mode cards, as appropriate. The fourth step is to run the Corridor program or to perform computations manually following the program's procedures. The fifth step is to retrieve the computer's outputs from which analyses and evaluation of route services will be performed. Appendix D provides details and further documentation of the Corridor

program. However, program provided vehicle/mode input cards and program outputs need further discussion at this time.

Vehicle/Mode Input Cards: Program Provided Parameters

The program provides vehicle and mode related input cards based on field study findings, on published references and on assumptions. These are default values since the program will run with provided input cards that specify all basic vehicle and mode related parameters unless changed by the user. Other variables, such as route data and period of day, must still be provided by the program user. However, all such parameters may be changed by the user to reflect local conditions or to update factors, such as for inflation.

Figure 6-2 shows program provided parameters related to operating data, cost data, cost relation ratios (factors) and average running speed by roadway type. Operating data identifies fuel type, fuel cost, emission rates and fuel consumption rates at various speeds. Cost data reflects 1978 relationships for drivers, tires, oil, depreciation, insurance, administration, maintenance, advertisement, and traffic, dispatching and taxes and licenses. Cost-related ratios provide factors for determining fleet size from operating vehicles (SIZFAC), deadheading factor to be applied to revenue-miles (DEDHED) base period pay hours to be applied to all salaries (BPPH), a peak period labor usage (PPLU), and an off-peak to peak period ratio of operating vehicles (OFF-RATIO) (Appendix E). Average running speed is based on values obtained from the Characteristics of Urban Transportation Systems: A Handbook for Transportation Planning (55) for autos

and full-size transit buses and on interpolations for other service modes.

A set of parameters has been provided for each of the six service modes considered; each is identified in Figure 6-2 by the seating capacity of the vehicle. These are the private autos, cruising jitneys operating with sedans, stand-dispatched jitneys operating with 11-seat vans, stand-dispatched jitneys operating with 14-seat vans, conventional transit operating with diesel minibuses, and conventional transit operating with full-size diesel bus. Other service modes can be selected by replacing those specified by the Corridor program but, all parameter cards associated with that service mode should be reviewed carefully and revised as necessary.

Program Outputs

The Corridor program output areas are shown in Figure 6-3. The output includes the following areas:

1. Trip summary of operations;
2. Daily summary of operations;
3. Annual summary of operations and costs;
4. Average peak (or off-peak) operations and costs; and
5. Average peak (or off-peak) costs per vehicle-mile and per vehicle-hour.

The heading for each area indicates its specific function and those computations belonging to a peak or an off-peak period.

The trip summary of operations identifies each mode by line served and associates it with the vehicle capacity being considered as well as with headway being tested. Round trip vehicle data includes

********** VEHICLE/MODE PARAMETER CARDS **********

OPERATING DATA

CAPACITY	FUEL TYPE	FUEL $/GAL	EMISSIONS (GMS/V-MI) CO	HC	NOX	FUEL CONSUMPTION GAL/V-H IDLE	GAL/V-H 5	10	15	20	25	30	35	40	45	50
6	GAS	0.60	35.1	7.2	3.5	0.840	0.174	0.118	0.093	0.079	0.070	0.063	0.058	0.055	0.055	0.058
5	GAS	0.60	53.3	4.8	3.0	0.840	0.174	0.118	0.093	0.079	0.070	0.063	0.058	0.055	0.055	0.058
11	GAS	0.60	45.3	4.2	2.6	0.840	0.183	0.123	0.098	0.083	0.073	0.066	0.064	0.064	0.069	0.076
14	GAS	0.60	45.3	4.2	2.6	0.840	0.183	0.123	0.098	0.083	0.073	0.066	0.064	0.064	0.069	0.076
20	DSL	0.46	14.2	2.3	10.2	0.180	0.183	0.103	0.078	0.068	0.064	0.063	0.053	0.044	0.050	0.057
45	DSL	0.46	31.7	4.4	20.9	0.440	0.446	0.251	0.193	0.167	0.156	0.154	0.095	0.108	0.123	0.139

COST DATA

CAPACITY	DRIVER	TIRES	OIL	DEPREC	INSUR	ADMIN	MAINT	ADVETF	DISPA	TAX&LIC
6	1.50	0.003	0.002	540.	400.	0.	200.	240.	0.	40.
5	3.00	0.006	0.002	900.	962.	120.	500.	100.	0.	70.
11	3.00	0.017	0.008	1200.	1200.	120.	500.	100.	150.	85.
14	3.00	0.017	0.008	1350.	1400.	120.	500.	100.	150.	85.
20	5.50	0.020	0.003	3400.	2000.	9853.	9369.	514.	3256.	1000.
45	6.50	0.027	0.003	5667.	3839.	9853.	9369.	514.	3256.	2672.

COST RELATED RATIOS

CAPACITY	SIZFAC	DEDHED	BPPH	PPLU	OFF-RATIO
6	1.00	1.00	1.00	1.00	0.50
5	1.10	1.00	1.00	1.00	0.78
11	1.50	1.00	1.00	1.00	0.78
14	1.50	1.00	1.00	1.00	0.78
20	1.15	1.10	1.14	1.00	0.50
45	1.15	1.10	1.14	1.00	0.50

AVERAGE RUNNING SPEED BY ROADWAY TYPE

CAPACITY	MODE	CBD COL	CBD ART	CBD ROW	CBD XWY	FRINGE LOC	FRINGE COL	FRINGE ART	FRINGE XWY	SUBURBAN/RES LOC	SUBURBAN/RES COL	SUBURBAN/RES ART	SUBURBAN/RES XWY	OTHER LOC	OTHER COL	OTHER ART	OTHER XWY
6	1	15.	18.	0.	33.	18.	22.	24.	35.	20.	25.	28.	44.	0.	0.	0.	0.
5	2	13.	15.	0.	33.	16.	19.	21.	35.	18.	22.	26.	44.	0.	0.	0.	0.
11	3	12.	13.	0.	33.	14.	17.	19.	35.	16.	20.	24.	44.	0.	0.	0.	0.
14	4	12.	13.	0.	33.	14.	17.	19.	35.	16.	20.	24.	44.	0.	0.	0.	0.
20	5	9.	10.	13.	25.	11.	14.	16.	30.	13.	17.	21.	35.	0.	0.	0.	0.
45	6	8.	9.	12.	25.	10.	13.	15.	30.	12.	16.	20.	35.	0.	0.	0.	0.

FIGURE 6-2

TYPICAL PARAMETER INPUT PROVIDED WITH CORRIDOR PROGRAM

TRIP SUMMARY OF OPERATIONS : PEAK

MODE & LINE	VEH CAPY	HDWY	VEHICLE ROUND TRIP DIST (MI)	TIME RUNNING	TIME TOTAL	AVG. SPEED	FUEL (GAL)	(GRAMS) CO	HC	NOX	PASS-TRIP 2/3-RT-LEN DIST	TIME	PASS-TRIP TYPICL-LEN DIST	TIME
JITNEY-ST 1A	11	8.6	20.8	72.5	72.5	17.2	1.9	1060.5	96.0	53.2	6.9	28.4	6.6	27.1
JITNEY-ST 1A	14	8.6	20.8	72.5	72.5	17.2	1.9	1060.5	96.0	53.2	6.9	28.4	6.6	27.1
FULBUS-IR 1A	45	25.0	20.8	95.5	105.5	11.8	4.5	930.5	114.7	510.1	6.9	44.3	4.3	32.1

DAILY SUMMARY OF OPERATIONS : PERIOD DURATION 5.0 HOURS : PEAK

VEHICLE CAPACITY	VEHICLES REQUIRED	VEHICLE MILES	VEHICLE HOURS	RUNNING HOURS	FUEL CONSUMED	EMISSIONS(GRAMS) CO	HC	NOX
11	9	728.0	42.3	42.3	66.1	37115.8	3360.9	1863.7
14	9	728.0	42.3	42.3	66.1	37115.8	3360.9	1863.7
45	5	274.6	23.2	21.0	59.6	12282.2	1514.0	6733.4

ANNUAL SUMMARY OF OPERATIONS AND COSTS

VEHICLE CAPACITY	VEHICLE FLEET	VEHICLE MILES	VEHICLE HOURS	ANNUAL COST ($'S) DRIVER	VEH-OPS	MAINT&OVH	DEPREC	TOTAL
11	14	182000.	10567.	31702.	14458.	11604.	8736.	66500.
14	14	182000.	10567.	31702.	14458.	12681.	9828.	68669.
45	6	68640.	5801.	55885.	8910.	68084.	23540.	156419.

AVERAGE PEAK HOUR OPERATIONS AND COSTS

VEHICLE CAPACITY	VEHICLE FLEET	VEHICLE MILES	VEHICLE HOURS	VEHICLE TRIPS	HOURLY COST ($'S) DRIVER	VEH-OPS	MAINT&OVH	DEPREC	TOTAL
11	14	145.6	8.5	7.0	25.4	11.6	9.3	7.0	53.2
14	14	145.6	8.5	7.0	25.4	11.6	10.1	7.9	54.9
45	6	54.9	4.6	2.4	44.7	7.1	54.5	18.8	125.1

AVERAGE PEAK COSTS PER VEHICLE MILE AND PER VEHICLE HOUR

COSTS PER VEHICLE-MILE ($'S) DRIVER	VEH-OPS	MAINT&OVH	DEPREC	TOTAL	COSTS PER VEHICLE-HOUR ($'S) DRIVER	VEH-OPS	MAINT&OVH	DEPREC	TOTAL
0.17	0.08	0.06	0.05	0.37	3.00	1.37	1.10	0.83	6.29
0.17	0.08	0.07	0.05	0.38	3.00	1.37	1.20	0.93	6.50
0.81	0.13	0.99	0.34	2.28	9.63	1.54	11.74	4.06	26.96

FIGURE 6-3

TYPICAL CORRIDOR PROGRAM OUTPUT

distance traveled, running time, operating vehicle time, average operating speed, gallons of fuel consumed and grams of air pollutant emissions for carbon monoxide, hydrocarbon and nitrogen oxides. One-way passenger trip distance and time also are included; passenger trip time is the sum of waiting time plus on-board travel time.

The daily summary of operations is the sum of operating data through the hours specified for a typical daily period (peak or off-peak). Vehicle capacity identifies the service mode being considered.[1] Vehicles required are an output specifying the minimum number of vehicles needed to provide service and satisfy a given level of demand. Vehicle miles, vehicle hours, running hours, fuel consumed and emissions are then summarized for the period specified.

The annual summary of operations and costs also uses vehicle capacity to identify service mode being considered. Vehicle fleet is the total number of vehicles required to maintain service, including a reserve for maintenance needs. Daily vehicle-miles and vehicle-hours are annualized based on annual period factor and a peak or off-peak factor built into the program (see Appendix D). Annual costs are summarized by category into driver related, direct vehicle operations, maintenance and overhead and depreciation.

The average peak (or off-peak) operations and costs data resembles the annual summary in content but is provided for ready comparison with similar information obtained from transit companies. The average peak (or off-peak) costs per vehicle-mile and vehicle-hour

---

[1]Data for each service mode appears in the same line of each of the five output areas in Figure 6-3.

output area is also provided for ready comparisons with information available from other sources. However, note that information shown in the two average data areas can be used in cost analysis of each of the four categories specified (i.e., driver-related costs, vehicle operations, capital depreciation and maintenance and overhead).

Planning Procedures

With the computer outputs available, a detailed analysis of route service, passenger's perceived quality of service, costs, fuel consumption and air pollutant emissions can be made. Route service is a direct result of assumption or decisions made regarding roadways to be traversed, frequency of service and service mode selected. The outputs obtained will be a result of inputs provided. However, other uses of that information warrant a more detailed explanation.

Economic Viability and Costs

Before embarking in the effort to promote the implementation of a passenger transportation service, a planner must investigate its economic viability. A private enterprise, such as constituted by a jitney, demands a profit after covering all costs and salaries. Ideally, that profit will increase together with the quality and amount of service provided, and the economic viability of a private system will be ensured.

Net income to an operator who owns the vehicle driven is gross revenue minus all costs. Net income may be subdivided into salary (or minimum livable income based on the federal minimum wage) and profit.

Gross revenue is the sum of all fares received for transporting passengers. Costs are all expenses incurred to produce the transportation services.

Gross revenue estimation must consider that operating service, passenger demand and fares interact. In the absence of known relationships between the three factors, assumptions are required to deal with this uncertainty at the planning level.

Figure 6-4 shows one approach to estimate net income of jitneys serving one route. The operating level of service is a consequence of the number of operating vehicles by each time period for each type of vehicle. Demand is a function of user cost and the quantity and quality of service provided by a given service mode. Fares (user costs) are trip charges per passenger.

Since the corridor program essentially calculates supply side factors, i.e., operating service, the economic feasibility analysis must be made for one set of assumptions at a time. Together with Figure 6-4, the steps below describe income analysis as follows:

1. Operating service is specified by type of vehicle, frequency of service and route to be served.
2. Demand is taken from existing operations or is approximated based on relationships found in Chapter 4;
3. Fares are tentatively set at a low level to follow a specified policy or to match transit fares.
4. The Corridor program is run to establish cost estimates.
5. Demand multiplied by fare estimates gross revenue.

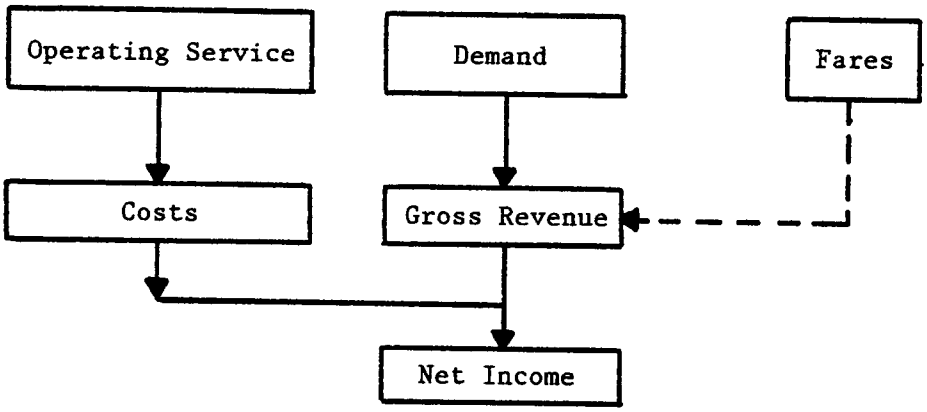


FIGURE 6-4

NET INCOME ANALYSIS

6. Net income is determined subtracting costs from revenues.

Further iterations should be made to investigate the economic viability of route service based on the sensitivity of factors likely to vary (such as the cost of gasoline) or subject to voluntary controls (such as the use of higher capacity vehicles).

Net income divided by the number of operators serving a route provides an index of income per operator. If net income per operator is too low or too high, a slight fare adjustment may be used to modify it. However, if planner's judgment indicates that a large fare adjustment would modify the demand, subsequent iterations to the whole procedure may be required to balance the service offered with the demand.

Total cost or cost by major category can be obtained from the Corridor program for each service mode investigated. Based on service mode inputs, the program outputs summarize cost by driver-related costs, vehicle operations, capital depreciation and maintenance and overhead. Briefly, driver-related costs include wages paid by transit or minimum livable income based on the federal minimum wage. Vehicle operations include fuel, oil and tire costs. Capital depreciation applies to all facilities and vehicles. Maintenance and overhead include maintenance related salaries, repair parts and maintenance equipment plus administration, insurance and taxes. Appendix D provides additional detail. Due to the disaggregate nature of cost inputs and outputs, the impact of specific cost items may be considered or disregarded in the analysis of economic viability.

However, the Corridor program must be used to consider as many variables as possible in the allocation of costs and services to route operations. Scenario No. 1 (to be presented later, together with other scenarios) demonstrates the use of the Corridor program in the simulation of route service and in the analysis of service and cost data. Scenario No. 2 provides an example of economic viability analysis building on the previous scenario and making use of some findings from Chapter 4.

Quality of Service

A method commonly used by transportation planners to determine relative quality of service is to compare passenger trip time between selected points by more than one mode. The total passenger travel time can be estimated by the sum of walk-access time, wait time and on-board travel time. Large computer programs, e.g., the UTPS, also consider transfer times and allow the planner to weigh some travel time components heavier than others.

In modal comparisons when service to the same route is being considered, walk-access time may be disregarded. Total passenger trip time then becomes the sum of wait time and on-board travel time. Wait time may be approximated as half of the average headway, and on-board travel time can be determined based on average passenger trip length and vehicular speed. Passenger trip length may be determined from local sources or from relationships found in Chapter 4. Speed may be obtained from system observations, from relationships based on route length or from default values included with the Corridor program input data.

Scenario No. 3 provides a comparison on quality of service based on perceived travel time and on passenger trips traveling the same distance. Scenario No. 5 presents an example of manual calculations in the comparison of actual quality of service afforded to passengers that travel the length of the main corridor served by existing jitneys and the service provided by buses running on a parallel route.

Fuel Efficiency and Emissions

Energy efficiency indices and air pollutant indices frequently are used for modal comparisons. The service mode providing the most passenger-miles per gallon of fuel is considered more efficient and desirable. The service mode emitting the lowest amount of a given pollutant per passenger-mile induces a lower impact in the living environment and is more desirable.

Information on fuel consumption and air pollutant emissions are outputs from the Corridor program. Passenger-miles must be estimated using information locally available or indirectly available from the relationships found in Chapter 4. The regression line shown in Figure 4-2, p. 66 discloses a relationship between jitney vehicle-miles and passenger-miles. Since the Corridor program also outputs vehicle-miles, passenger-miles can be estimated. Fuel efficiency indices can be obtained by dividing passenger-miles by the gallons of fuel consumed for a given period of time.

Similar indices can be obtained for air pollutant emissions. However, air pollutant emissions such as carbon monoxide, hydrocarbons and nitrogen oxides service input but an output, and a productivity

index is inappropriate for modal comparisons. Instead, it is customary to compare modes based on grams of a given pollutant per passenger-mile.

Scenario No. 4 presents modal comparisons based on fuel efficiency and air pollutant emission.

Scenarios

Hypothetical scenario analysis is a very useful technique to demonstrate expected results of a selected option. It also can be used to demonstrate how a planning technique works. The following scenarios are provided to demonstrate the planning techniques proposed rather than to make modal comparisons. However, realistic settings have been selected and local information has been obtained to provide a perspective on how jitneys compare with bus transit simultaneously with demonstrating the planning tools proposed. The procedures presented in Scenario No. 1 can be used by planners to investigate the service rendered by jitneys and/or buses serving a selected corridor.

Scenario No. 1

Problem statement. The Jacksonville Transportation Authority (JTA) is considering alternatives to reduce operating deficits on low ridership routes. Jitneys have been proposed to serve one such route. Bus route 30, providing service from downtown Jacksonville to a residential area (see Figure 6-5), has been selected for the test based on its low ridership (1.82 passengers per vehicle-mile) and because it serves a corridor connecting the CBD with a residential area. JTA

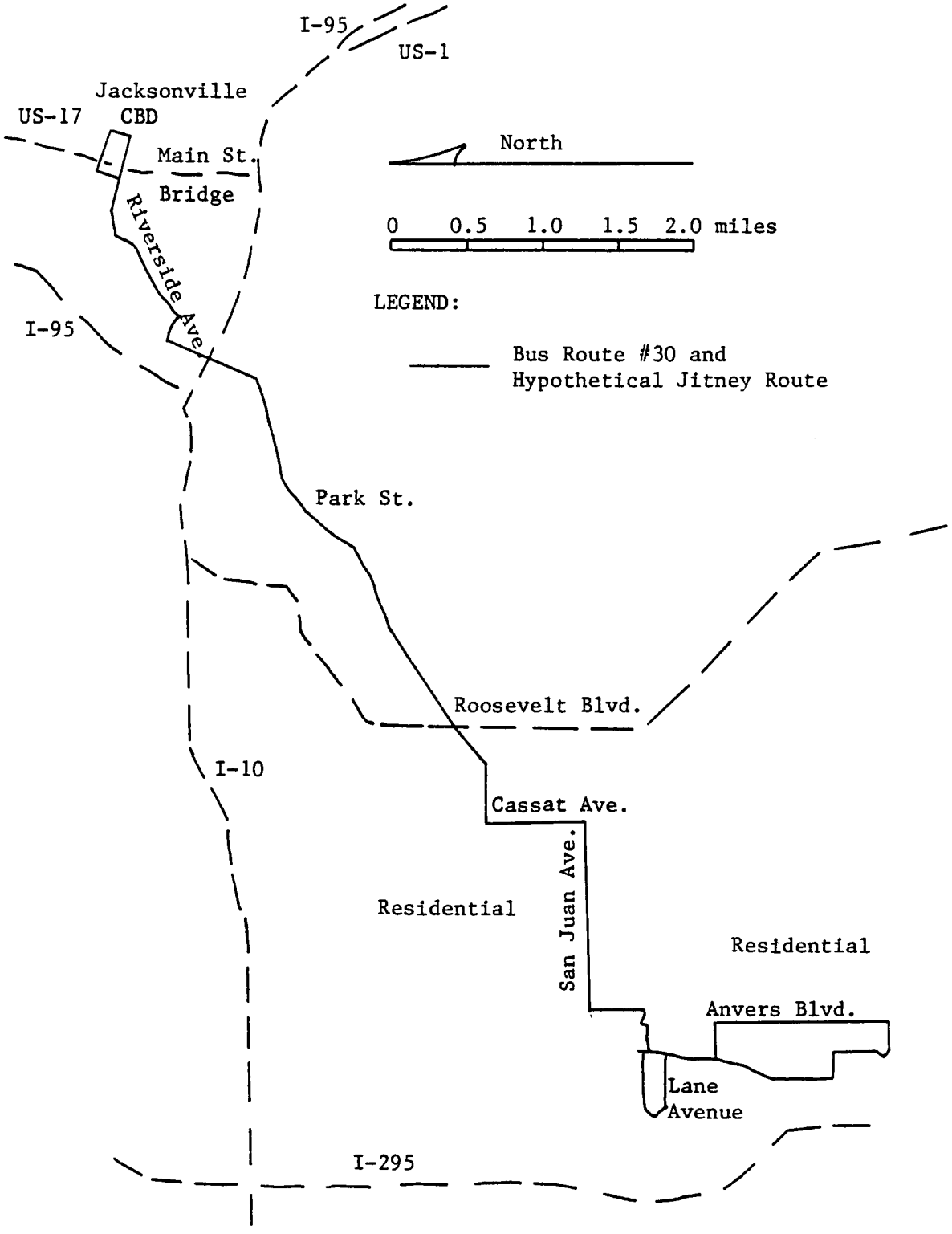


FIGURE 6-5

JACKSONVILLE TRANSIT ROUTE 30 AND HYPOTHETICAL JITNEY ROUTE

wants to look at the supply side of jitneys to determine how they compare in cost with existing bus service. More specifically, JTA wants to know the resulting reduction in annual cost if Route 30 was dropped and how jitney service compares in terms of peak versus off-peak costs.

Bus 30 traverses approximately 1.0 miles of CBD collector streets, 3.6 miles of fringe collector streets, 4.3 miles of residential collector streets and 1.5 miles of residential local streets for a total one-way length of 10.4 miles; jitneys would service approximately the same route. Peak period service is provided for five hours every weekday and for eight hours during off-peak. Saturday and Sunday service is also provided but at reduced levels.

Bus service[2] is provided with 45-seat vehicles, with headways averaging 25 minutes during peak hours and 84 minutes during off-peak hours. The highest passenger load in the peak direction during peak hours is 32, including morning and afternoon periods. During off-peak hours the highest passenger loading is 37 or higher than peak period loading due to the low frequency of service provided (long headways).

To address the JTA concerns, the planner needs to simulate bus and jitney service along the selected corridor. The Corridor computer program will be used together with speed, cost and other program provided parameters to simulate operations.

Inputs. First, the level of jitney service to be provided must be determined. Transit buses having an average load of 32 passengers

---

[2]Service data used as current, obtained from the Transit Development Program Update, 1976-1980 reflecting 1975 bus service provided by the Jacksonville Transportation Authority (61).

at the maximum load point in the peak direction and running every 25 minutes represent a load of 77 passengers per hour. This may be handled by 11-seat vans running at a frequency of 7 per hour or headways handled by 11-seat vans running at a frequency of 7 per hour or headways averaging 8.6 minutes. The use of 14-seat vans at the same frequency would increase capacity by 27% to handle peak 5-minute loads or the frequency could be reduced to 5.5 runs per hour. In order to account for maintenance and days off, the jitney vehicle fleet should be increased as a minimum by a factor of 1.1, as observed in actual operations. In actual practice, this factor should be as high as required to keep vehicle-hours below 2,000 per year and vehicle-miles below 30,000 per year. During peak periods, actual passenger handling capacity of stand-dispatched jitneys will be higher than 77 passengers per hour as jitneys resort to cruising, as turnbacks are made before jitneys reach the route terminus and as express runs are made as soon as a vehicle is filled. Thus, with a given fleet and flexible operations, jitneys can easily handle short-term peaks in demand.

Off-peak jitney service should be more frequent than service provided by bus to maintain the attractiveness of jitney service. Bus transit provides an average off-peak headway of 85 minutes while jitneys would run every 13 minutes[3] during the same period. Thus, based on seats made available per hour during off-peak periods, jitneys provide over 60% more seating capacity than bus transit.

---

[3]Off-peak headways can be selected as the result of the division of peak headway by the OFF-RATIO factor (see Figure 6-2, p. 120). In this particular scenario, the result of the division has been increased arbitrarily by two minutes.

To use the Corridor computer program, service modes and routes must be identified. Data input will indicate a peak period lasting 5 hours and an off-peak period of 8 hours, for a total of 13 hours of daily operation, from 5:30 a.m. to 6:30 p.m. Other selected data inputs specify the jitney and bus vehicular technology to be used for comparisons; vehicle types correspond to 11-seat jitney van, 14-seat jitney van and 45-seat transit bus. Peak period frequency per hour is specified as 7.0 trips for jitney and 2.4 trips for bus; off-peak frequency is specified as 4.7 trips for jitney and 0.7 trips for bus. One-way distance of each highway segment traveled by each mode are the last necessary inputs to run the program and are specified as shown in the problem statement. Base parameters provided by the Corridor program are used (see Figure 6-2, p. 120) to run the simulated test.

Analysis. Figures 6-6 and 6-7 present outputs obtained from the Corridor computer program for peak and off-peak periods, respectively. General findings are presented here.

The critical measure from the operators point of view is total annual cost. Adding annual costs from peak and off-peak operations shows that jitneys using 11-seat vans cost $144,600 per year while jitneys using 14-seat vans cost $148,700 per year. Bus total costs are estimated at $228,700 anually or 58% higher than the 11-seat jitney van option even though the latter provides much higher off-peak service. On a per-mile basis, average cost for the 11-seat jitney service is $0.37 for peak periods and $0.33 for off-peak periods. Comparable figures for bus transit (including vehicle depreciation) are $2.28 and $1.98, respectively. It can be argued that direct

******* JACKSONVILLE TEST FOR JITNEYS *******

FREQUENCY TEST NO. 1

TRIP SUMMARY OF OPERATIONS : PEAK

MODE & LINE	VEH CAPY	HDWY	VEHICLE ROUND TRIP DIST (MI)	TIME RUNNING	TIME TOTAL	AVG. SPEED	FUEL (GAL)	(GRAMS) CO	HC	NOX	PASS-TRIP 2/3-RT-LEN DIST	TIME	PASS-TRIP TYPICL-LEN DIST	TIME
JITNEY-ST 1A	11	8.6	20.8	72.5	72.5	17.2	1.9	1060.5	96.0	53.2	6.9	28.4	6.6	27.1
JITNEY-ST 1A	14	8.6	20.8	72.5	72.5	17.2	1.9	1060.5	96.0	53.2	6.9	28.4	6.6	27.1
FUENUS-FR 1A	45	25.0	20.8	95.5	105.5	11.8	4.5	930.5	114.7	510.1	6.9	44.3	4.3	32.1

DAILY SUMMARY OF OPERATIONS : PERIOD DURATION 5.0 HOURS : PEAK

VEHICLE CAPACITY	VEHICLES REQUIRED	VEHICLE MILES	VEHICLE HOURS	RUNNING HOURS	FUEL CONSUMED	EMISSIONS(GRAMS) CO	HC	NOX
11	9	728.0	42.3	42.3	66.1	37115.8	3360.9	1863.7
14	9	728.0	42.3	42.3	66.1	37115.8	3360.9	1863.7
45	5	274.6	23.2	21.0	59.6	12282.2	1514.0	6733.4

ANNUAL SUMMARY OF OPERATIONS AND COSTS

VEHICLE CAPACITY	VEHICLE FLEET	VEHICLE MILES	VEHICLE HOURS	ANNUAL COST ($'S) DRIVER	VEH-OPS	MAINTGOVH	DEPREC	TOTAL
11	14	182000.	10567.	31702.	14458.	11604.	8736.	66500.
14	14	182000.	10567.	31702.	14458.	12681.	9828.	68669.
45	6	68640.	5801.	55885.	8910.	68084.	23540.	156419.

AVERAGE PEAK HOUR OPERATIONS AND COSTS

VEHICLE CAPACITY	VEHICLE FLEET	VEHICLE MILES	VEHICLE HOURS	VEHICLE TRIPS	HOURLY COST ($'S) DRIVER	VEH-OPS	MAINTGOVH	DEPREC	TOTAL
11	14	145.6	8.5	7.0	25.4	11.6	9.3	7.0	53.2
14	14	145.6	8.5	7.0	25.4	11.6	10.1	7.9	54.9
45	6	54.9	4.6	2.4	44.7	7.1	54.5	18.8	125.1

AVERAGE PEAK COSTS PER VEHICLE MILE AND PER VEHICLE HOUR

COSTS PER VEHICLE-MILE ($'S) DRIVER	VEH-OPS	MAINTGOVH	DEPREC	TOTAL	COSTS PER VEHICLE-HOUR ($'S) DRIVER	VEH-OPS	MAINTGOVH	DEPREC	TOTAL
0.17	0.08	0.06	0.05	0.37	3.00	1.37	1.10	0.83	6.29
0.17	0.08	0.07	0.05	0.38	3.00	1.37	1.20	0.93	6.50
0.81	0.13	0.99	0.34	2.28	9.63	1.54	11.74	4.06	26.96

FIGURE 6-6

JACKSONVILLE SCENARIO CORRIDOR PROGRAM OUTPUT FOR PEAK PERIOD

******* JACKSONVILLE TEST FOR JITNEYS *******

FREQUENCY TEST NO. 1

TRIP SUMMARY OF OPERATIONS :OFF-PEAK

MODE & LINE	VEH CAPY	HDWY	VEHICLE ROUND TRIP DIST (MI)	TIME RUNNING	TIME TOTAL	AVG. SPEED	FUEL (GAL)	(GRAMS) CO	HC	NOX	PASS-TRIP 2/3-RT-LEN DIST	TIME	PASS-TRIP TYPICL-LEN DIST	TIME
JITNEY-ST 1A	11	12.8	20.8	72.5	72.5	17.2	1.9	1060.5	96.0	53.2	6.9	30.5	6.6	29.2
JITNEY-ST 1A	14	12.8	20.8	72.5	72.5	17.2	1.9	1060.5	96.0	53.2	6.9	30.5	6.6	29.2
FULBUS-TR 1A	45	25.7	20.8	95.5	105.5	11.8	4.5	930.5	114.7	510.1	6.9	43.8	4.3	31.6

DAILY SUMMARY OF OPERATIONS : PERIOD DURATION 8.0 HOURS :OFF-PEAK

VEHICLE CAPACITY	VEHICLES REQUIRED	VEHICLE MILES	VEHICLE HOURS	RUNNING HOURS	FUEL CONSUMED	EMISSIONS(GRAMS) CO	HC	NOX
11	6	742.1	45.4	45.4	71.0	39872.9	3610.6	2002.1
14	6	742.1	45.4	45.4	71.0	39872.9	3610.6	2002.1
45	2	128.1	10.8	9.8	27.8	5731.7	706.5	3142.2

ANNUAL SUMMARY OF OPERATIONS AND COSTS

VEHICLE CAPACITY	VEHICLE FLEET	VEHICLE MILES	VEHICLE HOURS	ANNUAL COST ($'S) DRIVER	VEH-OPS	MAINT&OVH	DEPREC	TOTAL
11	9	234624.	13623.	40868.	18638.	11935.	6646.	78088.
14	9	234624.	13623.	40868.	18638.	13043.	7477.	80027.
45	2	38438.	3249.	24074.	4990.	36311.	6975.	72349.

AVERAGE OFF-PEAK HOUR OPERATIONS AND COSTS

VEHICLE CAPACITY	VEHICLE FLEET	VEHICLE MILES	VEHICLE HOURS	VEHICLE TRIPS	HOURLY COST ($'S) DRIVER	VEH-OPS	MAINT&OVH	DEPREC	TOTAL
11	9	97.8	5.7	4.7	17.0	7.8	5.0	2.8	32.5
14	9	97.8	5.7	4.7	17.0	7.8	5.4	3.1	33.3
45	2	16.0	1.4	0.7	10.0	2.1	15.1	2.9	30.1

AVERAGE OFF-PEAK COSTS PER VEHICLE MILE AND PER VEHICLE HOUR

COSTS PER VEHICLE-MILE ($'S) DRIVER	VEH-OPS	MAINT&OVH	DEPREC	TOTAL	COSTS PER VEHICLE-HOUR ($'S) DRIVER	VEH-OPS	MAINT&OVH	DEPREC	TOTAL
0.17	0.08	0.05	0.03	0.33	3.00	1.37	0.88	0.49	5.73
0.17	0.08	0.06	0.03	0.34	3.00	1.37	0.96	0.55	5.87
0.63	0.13	0.94	0.18	1.88	7.41	1.54	11.18	2.15	22.27

FIGURE 6-7

JACKSONVILLE SCENARIO CORRIDOR PROGRAM OUTPUT FOR OFF-PEAK PERIOD

operating costs for bus transit should disregard capital cost; yet even in this case, bus operating costs are still fairly high at $1.94 per vehicle-mile during peak periods and at $1.70 during off-peak periods. Replacing JTA Bus Route 30 with jitney service can result in lowering the transit deficit by about $229,000 and in improved service levels to the corridor investigated.

With the above information, JTA can make an economic evaluation of the probable operational and economic consequences of introducing jitney services to replace existing bus services in Route 30. Further evaluation should consider economic viability analysis, the passenger's side of quality of service, fuel consumption levels and air pollutant emissions; these will be explained in scenarios following. Also, a full assessment of jitney impacts should consider the effect that this mode may have on other local transportation issues.

Scenario No. 2

Problem statement. The JTA has considered probable economic benefits of providing stand-dispatched jitney service as a replacement of Route 30 (see Scenario No. 1). After learning that jitneys can reduce costs to the transit service while increasing the mobility of passengers in the sectors served, JTA wants to investigate the economic feasibility of jitney service using 11-seat vans.

Annual cost has been previously estimated at $144,600 along the 10.3 mile jitney route using 11-seat vans. Demand is unknown but may be estimated using the relationship between route length and passengers per vehicle-mile discussed in Chapter 4 or as a minimum equivalent to

the demand for bus service. Fares may be selected arbitrarily at $0.35 per ride (JTA set this fare in 1978) unless further study suggests otherwise. Corridor program outputs shown in Figures 6-6 and 6-7 will be used once more.

Analysis. Existing JTA Route 30 carries 422,476 passengers per year (61). With a fare of $0.35 per ride, revenues provide a minimum gross income of $147,900 that covers the costs of providing jitney service and leaves a small profit. This amount of money will provide a total of $72,600 to compensate drivers based on minimum wages and a $4,400 profit. Since the total jitney fleet is 14, average yearly income remains low at $5,400 per vehicle. This net income seems low when the total number of active hours required by jitney vehicles are considered. Total vehicle-hours are 24,190 or 1,728 hours per vehicle per year.

However, based on observed jitney performance, revenues should be much higher. From Figure 4-1 (p. 62), which shows the relationship between passengers per vehicle-mile and one-way vehicular trip distance, an estimate can be made of passenger trips attracted by frequent jitney service operating over a principal travel corridor. Jitney service productivity is estimated conservatively at 1.52 passengers per vehicle-mile[4] based on a route length of 10.4 miles. Since annual vehicle-miles

---

[4]This estimate is conservative because the relationship in Figure 4-1 is based on a one-way vehicular trip distance which is commonly shorter than route length. Figure 4-1 shows that passengers per vehicle-mile increase for shorter routes.

as obtained from the Corridor program output add to approximately 416,600 miles, this value multiplied by 1.54 results in an annual estimate of 633,200 passengers. With fares at $0.35, gross route income is estimated at $221,600 and net profit at $77,000. Profit plus driver compensation adds to $149,600 per year or, on the average, $10,700 per jitney per year.

Assuming an inelastic demand for high quality jitney service, higher fares would raise income significantly. For example, a $0.50 fare would produce a gross income of $316,600 per year and a profit of $172,000. Profit plus driver compensation increases to $244,600 per year or on the average, $17,500 per jitney per year.

Assessment. These income levels are not excessive, yet they seem typical of many current jitney operators. The scenario can be tailored more precisely to local conditions with proper care to select parameters based on measurements of the service modes being considered. It should be realized that, like elsewhere in private business, some operators make more money and some make less based on their efforts and their abilities.

Scenario No. 3

Problem statement. As the economic viability analysis indicates that jitneys can provide frequent service and make a profit, the JTA wants to compare the quality of service afforded to passengers by bus and by jitney.

Outputs from the Corridor program will be used to make quality of service comparisons. The program provides two areas for comparison--total travel time based on passengers traveling two-thirds of the route length and total travel time of typical passenger trip for each service mode considered.

Inputs. The program's built-in functions specify two ways for computing total travel time. The first is based on the sum of wait time and on-board travel time required to travel two-thirds of the route length. The second method determines total travel time as the sum of the wait time and on-board travel time required by the typical passenger trip based on the relationships found in Chapter 4.

The relationships for typical trips specify that passengers riding in cruising jitneys travel approximately 44% of the route distance, those riding stand-dispatched intra-city jitneys travel approximately 63% of the route distance and those riding transit buses travel approximately 41% of the route distance. Even though these relationships are built into the program, they are easily identifiable and, if necessary, may be changed to match local conditions more closely.

Analysis. Outputs from the Corridor program for all service mode passengers traveling two-thirds of the distance (6.9 miles) show that total travel time for jitney riders is 28.4 minutes during peak hours and 30.5 minutes during off-peak hours. Comparable outputs for bus transit show total travel time is about 44 minutes for both peak and

off-peak hours. Therefore, travel by bus requires 55% more time during peak hours and 44% more time during off-peak hours than travel by jitneys. These differences can be attributed to the jitney's higher speed and much higher frequency of service.

Outputs of total travel time based on typical passenger trip length are also available. These show that total travel times for jitney riders are 29.1 minutes during peak hours and 29.2 minutes during off-peak hours, based on passenger's trip length of 6.6 miles. Equivalent travel times for bus riders are 32.1 minutes during peak hours and 31.6 minutes during off-peak hours, based on a length of 4.3 miles. It is curious that overall travel time is not substantially different, however, jitney passengers travel 53% greater distances than bus passengers.

General assessment. It becomes obvious that higher speed and higher frequency of service can provide higher quality of service to users, particularly to those concerned with travel time. Not so evident may be the possibility that people may be willing to travel longer distances by means of jitneys than by transit. This could be construed as another way for jitneys to attract markets yet untapped by public transportation.

Scenario No. 4

Problem statement. Out of concerns for energy and the environment, JTA wants to estimate the effects resulting from the use of 11-seat jitney vans as a replacement for bus service along Route 30.

Information on total emissions for each air pollutant and total gallons of fuel are required on a daily basis. It is also requested that comparisons be made based on passenger-miles per gallon of fuel and on passenger-miles per gram of pollutant; the higher score will indicate the most desirable service-mode for that particular measure.

Input. Based on the simulation of route service, Figures 6-6 (p. 134) and 6-7 (p. 135) show total fuel consumption and total emissions for each of three pollutants for each period of the day. Table 6-1 summarizes daily emissions and fuel consumption.

Analysis. Total pollutant emissions of carbon monoxide and hydrocarbons are evidently lower for the bus alternative rather than the jitney alternative; however, the opposite is true for nitrogen oxides. Jitneys' carbon monoxide emissions are 4.3 times higher than for buses, and hydrocarbons emissions are 3.2 times higher. Bus nitrogen oxide emissions are 2.5 times higher than emissions for jitneys.

Fuel consumption also can be compared based on total modal consumption per day. Eleven-seat jitney vans consume 143 gallons of gasoline per day, while buses use only 86 gallons. Jitneys consume 57% more fuel per day than buses.

A better comparison would consider fuel consumption and emissions based on passenger-miles since these measures are related to trips that otherwise may be conducted using autos. Passenger-mile data may be available locally or may be obtained from Chapter 4. From the relationship shown in Figure 4-2 (p. 66), a route 10.4 miles long can

TABLE 6-1

DAILY EMISSIONS AND FUEL CONSUMPTION

	Kgm/Day			Gallons/Day	
Service mode	CO	HC	NOX	Gas	Diesel
Jitney 11-seat	77.0	7.0	3.9	137.1	---
Bus 45-seat	18.0	2.2	9.9	---	87.4

be expected to operate with 9.71 passenger-miles per vehicle-mile. From Table 4-2 (p. 64), bus productivity can be expected at 11.11 passenger-miles per vehicle-mile. Using the above relationships and vehicle-mile data from the corridor output, daily passenger-miles are estimated at 14,660 for jitneys and at 4,470 for buses. With the above ratios, service mode comparisons are possible in terms of passenger-miles per gram of pollutant and per gallon of fuel. Table 6-2 shows those ratios.

Based on passenger-miles, bus and jitney effects on the environment look different. Carbon monoxide and hydrocarbons productivity indices per gram of pollution are not very different, but the jitney nitrogen oxide index is 8.3 times higher than as that for bus service. In other words, jitneys produce 8.3 more passenger miles for each gram of nitrogen oxides emitted than do buses.

Fuel efficiency based on passenger-miles is easy to understand, and ready comparisons between modes are possible. Jitneys produce 107 passenger-miles per gallon of gasoline, while buses produce 51 passenger-miles per gallon of diesel. Thus, jitneys are about twice as efficient as bus transit under the conditions and assumptions considered.

General assessment. In regards to emissions, local conditions must be considered to determine which pollutant constitutes a greater hazard. Carbon Monoxide and hydrocarbons tend to produce serious problems of localized pollution, while nitrogen oxides contribute more directly to regional pollution. Jacksonville, constituted by flat

TABLE 6-2

EMISSION AND FUEL PRODUCTIVITY INDICES

Service mode	Passenger-miles/Gram			Passenger-miles/Gallon	
	CO	HC	NOX	Gas	Diesel
Jitney 11-seat	0.190	2.09	3.76	107	---
Bus 45-seat	0.248	2.03	0.451	---	51

lands and at near sea-level elevation, is likely to experience problems of regional pollution. Thus, nitrogen oxides may be regarded as the pollutant to control. On this basis, jitneys would be an excellent option to replace bus service along the corridor studied since they produce less nitrogen oxides by both measures considered.

In regards to fuel consumption, the answer is not as clear. Overall, jitneys consume more gallons of fuel but produce more passenger-miles per gallon. Thus, two transportation objectives may seem to be in conflict. Based on the assumptions that the Jacksonville jitney route will attract more passengers (based on relationships from Chapter 4), some of those trips will very likely come from private autos. Further analysis may be required to determine if total fuel consumption is lower for jitneys. Yet, it is very clear that, based on mobility produced, jitneys are more efficient than buses. Passenger-miles per gallon comparisons with other modes are possible based on data from publications such as The Potential Savings of Different Modes (54) by the Congressional Budget Office.

Scenario No. 5

Problem statement.[5] In Atlantic City, the Atlantic County Planning Board (ACPB) wants to compare the quality of service provided by existing bus transit with that of existing jitney service along the

[5]This problem statement resembles that of Scenario No. 3. However, this scenario is based on operating jitney and bus systems, and the available information eliminates the need for simulation and the computer program. Manual calculations were used to make comparisons on quality of service.

northeast to southeast corridor during day hours. Atlantic City Transit Company (ACTC) bus route No. 5 travels along Atlantic and Ventnor Avenues and the jitney route travels along Pacific, Albany and Atlantic Avenues. Figure 6-8 shows the adjustment and sectors served by the Atlantic City jitneys and ACTC Route 5.

Inputs. Average bus running speed is 9.4 mph, average headway during peak periods (7:00 a.m. - 9:00 a.m., 3:30 p.m. - 6:00 p.m.) is 29.3 minutes and average headway during off-peak hours (9:00 a.m.-3:30 p.m.) is 33.3 minutes.[6] Average running speed for jitneys is 12.9 mph, average headway is 2.2 minutes during peak hours and 2.1 minutes during off-peak hours (see Table 4-3, p. 75). The bus route segment considered is 3.38 miles, and the jitney route segment is 3.43 miles. Based on survey data (46), ACTC buses have been found to depart 4.5 minutes late on the average.

Analysis. It can be argued that bus service with average headways exceeding 25 minutes makes patrons follow schedules more closely. Such patrons can be expected to arrive at a bus stop between 5 to 15 minutes earlier than scheduled time (on the average about 8 minutes). Total bus waiting time considering late departures then totals to 12.5 minutes.

Jitney users, not knowing when the next vehicle will come by, arrive randomly at jitney stops. So average waiting time would be half of the average headway or about 1.1 minutes during peak and off-peak periods.

---

[6]Actual ACTC bus schedule as of April 1978. Other bus service is provided along Atlantic Avenue but it does not traverse the whole length of the corridor being considered.

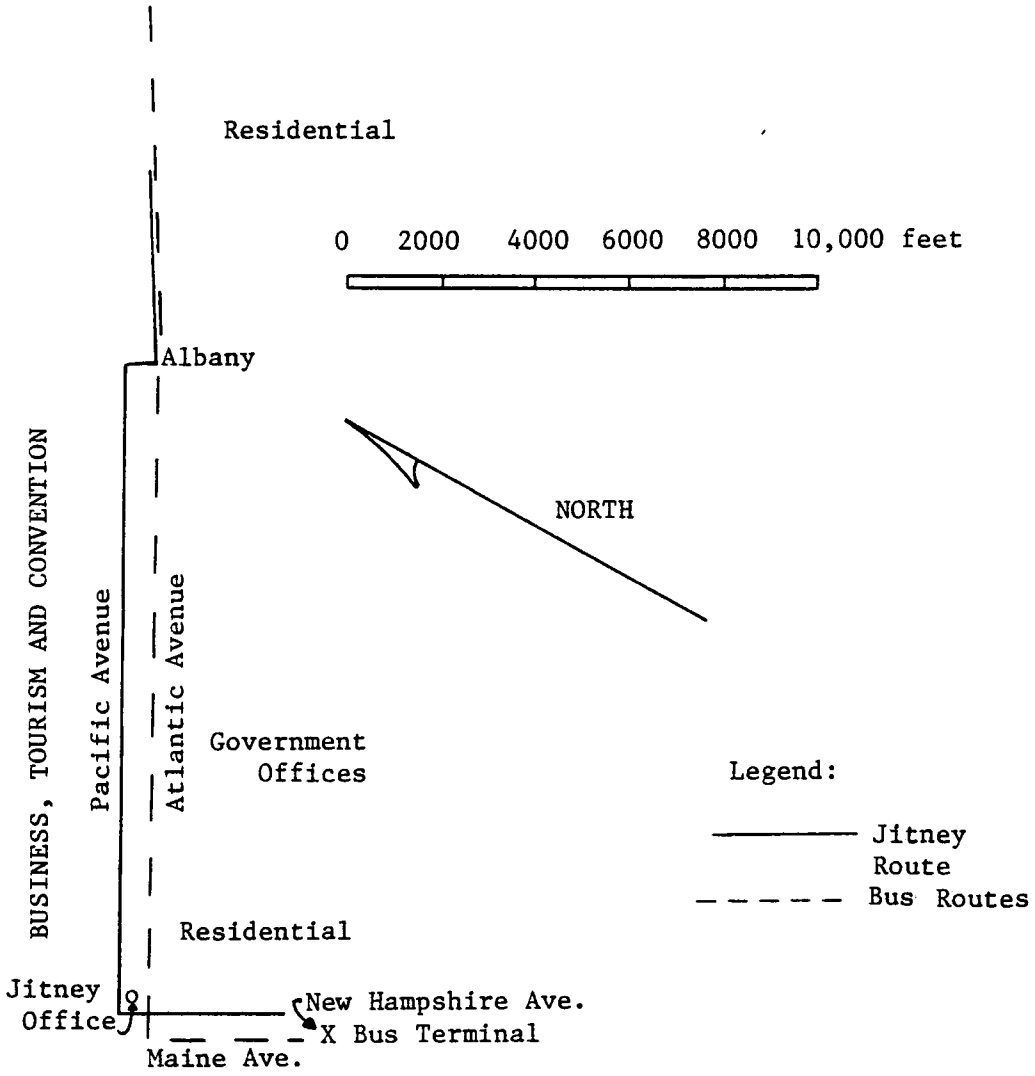


FIGURE 6-8

MAP OF ATLANTIC CITY JITNEY AND BUS ROUTES

Since route speed and length are known from local observations, on-board travel time can be estimated by simple manual calculations. Travel times for this scenario will be calculated using known field data[7] but otherwise may be obtained through simulation of route service using the Corridor program. Assuming people will travel the whole length of the corridor and using the speed data provided, on-board trip time will be 21.5 minutes for bus and 16.0 minutes for jitney.

Total passenger trip time indicates the combined quality of service measure. It takes bus passengers 34.0 minutes to make the trip that jitney passengers make in 17.1 minutes. Table 6-3 summarizes above information.

General assessment. In this particular case, jitneys provide a superior quality of service to that available from bus transit for trips following the northeast to southwest Atlantic City corridor. Total travel time by jitney is only half that for buses. Yet, this is a simplification of a fairly complex problem for the sake of explaining how to determine quality of service based on headways and travel time. Actually, in Atlantic City many of the passenger trips using Bus Route No. 5 are longer than those considered. Shorter trips also are made by boarding buses serving other routes. However, the results reflect the higher quality of service provided by jitneys on trips traveling the entire length of the corridor studied.

---

[7]Sometimes service mode input data (that provided with the program), and user input data required to operate the program, may be used to conduct simple analyses without use of the computer. For example, air pollutant emissions of a selected mode traveling at a known average speed along a road segment may be manually calculated. Other calculations such as cost analysis are particularly involved and the use of a computer is indicated.

TABLE 6-3

QUALITY OF SERVICE[a]
(Time in Minutes)

Mode	Wait Time	On-board Time	Passenger Trip Time
Bus	12.5	21.5	34.0
Jitney	1.1	16.0	17.1

[a]Quality of service based on travel time.

Review

Understanding jitney regulatory environment, operations, productivity, fuel consumption and costs is necessary before attempting to bring about changes in public transportation. Planning procedures are intended to bridge that gap by providing some tools for analysis and evaluation of specific route services.

This chapter has introduced anlaysis procedures that build upon the understanding gained from field studies. A computer program has been developed to handle data manipulation that facilitates route analyses considering such items as roads traveled, periods of the day, vehicle type and mode of operation. Scenarios have been provided to demonstrate the use of those procedures in the analysis and evaluation of proposed services.

Appendix F presents a manual procedure for estimating jitney operations costs. It is intended as an alternate tool of the Corridor program for those who would prefer not to use the program.

CHAPTER 7

IMPLEMENTING JITNEY SERVICES

Planner Concerns

Local transportation commissions and agencies commonly are entrusted with the responsibility to set transportation policy and to see that policies are implemented. Policymakers from these commissions or agencies are responsible for making critical decisions that affect existing services. Therefore, these bodies closely examine innovative but controversial ideas. Decisions are substantiated with the information supplied by planners, the general public and special interest groups, although they ultimately are based on the consensus of judgment by policymakers.

Planners are usually entrusted to provide impartial information regarding new concepts. They are required to analyze economics, operations and regulation, to propose and justify recommendations and to outline the steps needed toward implementation. Previous chapters have explained the jitney concept and jitney economics and operations. This chapter provides guidelines to define conditions favorable for jitney service that can be used in the initial justification of this innovative service mode. It also presents desirable regulatory policies that would allow jitneys to operate profitably and suggests steps that may be taken by planners to implement jitney service.

Opportunities for Service Implementation

Corridor Characteristics

In practice, jitney service is limited mostly by regulations imposed on them. Indeed, based on the field studies conducted by this researcher, jitneys have been found to engage in profitable operations in several urban transportation services. However, this study focuses on corridors with high frequency of service, connecting multiple activity centers with residential areas.

Various corridor characteristics are considered desirable for successful jitney operations and planners should be aware of those opportunities. However, it should be realized that looking for those characteristics is essentially one of the steps of more detailed analysis that matches travel demand with the desired service, at a given fare level. Desirable corridor characteristics to be considered are:

1. Traffic flow follows a natural travel corridor.
2. Multiple trip generators and attractors are located along the corridor, and travel demand is dispersed in time and space.
3. A multiple activity center is located at one route end, and a residential area or another multiple activity center is located at the other route end.
4. Many roadway segments are operating at close to capacity.
5. Downtown conditions produce traffic congestion, limited available parking and high pedestrian activity.

These characteristics will be explained in more detail to illustrate the kind of factors that planners should consider in looking for a desirable jitney corridor. Note that the conditions suggested are not very different from ideal bus route characteristics. If several of the characteristics are found in a corridor, further analysis of the corridor should be undertaken.

Traffic flow follows a natural travel corridor. Jitneys should make extensive use of collector and arterial streets in their line haul between the CBD and residential ends. This allows for expeditious service between those major origins and destination points and reduces the variability of travel time.

Multiple trip generators and attractors are located along the corridor, and travel demand is dispersed in time and space. Corridors with multiple origins and destinations along the way allow for more intensive use of the seating capacity of the vehicle by passengers getting in and out of intermediate points of the route. Demand dispersion through different periods of the day helps to maintain frequent service during peak and off-peak periods.

A multiple activity center is located at one route end, and a residential area or multiple activity center is located at the other route end. Connecting two strong trip generators or attractors with a jitney route ensures better equipment utilization. In this regard, buses may be more efficient when used to connect two major activity centers. In connecting a multiple activity center with a residential end, frequent service by jitneys during off-peak periods seems to be more attractive to nonwork trips and thus capable of maintaining efficient equipment usage during most of the day.

Many roadway segments are operating at close to capacity. High traffic volumes reduce auto speeds, and jitney intermediate stops do not induce a significant time delay to jitney users. Nearly congested highways make jitney travel time approximately equal to that of private autos. However, jitney stops must be controlled carefully in this environment to avoid excessive delays to other motorists while stopping to pick up or drop off passengers.

Downtown conditions produce traffic congestion, limited available parking space, and high pedestrian activity. These characteristics make downtown undesirable to auto users. The jitney option may lure some away from their cars. Jitneys do not need to search for parking and a route passing close to principal passenger destinations can make total travel time about the same for both autos and jitneys.

Route Operating Characteristics

Jitneys have been observed to operate financially successful in corridor service. To increase profits, jitney operators adjust their operations to match route demand. Specific route operating characteristics have been observed during field studies. These characteristics can be considered desirable in planning for attractive and efficient jitney services.

Routes under five miles in length have been observed to follow different operating patterns than longer routes. Short routes tend to serve dense corridors with highly dispersed origins and destinations. In planning for route service, the following operating characteristics are recommended.

Continuously cruising or semicruising service may be provided. Operations are conducted by continuously traveling around the route

for a selected period of time. Short stopovers may be made by some operators at either end of the route to allow for temporal spacing between one vehicle trip and the next. A semicruising mode may be selected in which jitney vehicles are released according to fixed headways that vary depending on demand along the corridor.

Six or more trips per hour are made during peak periods and four or more trips per hour are made during off-peak periods. High frequency of service allows for short passenger wait times and limited concern for missing one vehicle. Passengers arrive at the route on a random pattern, and maximum average wait time is about 7.5 minutes during off-peak periods and 5 minutes during peak periods. Low demand may be served with small vehicles such as sedans.

Jitneys have the option to stop at any safe place or at designated stops within the CBD. The jitney driver can be requested to stop at almost any safe place that will not delay unduly other traffic. Within the CBD, stops may be posted and designated as the only authorized places to collect or discharge passengers. However, in the latter case, locations may be spaced closer than transit stops to reduce walking distance.

Maximum frequency should be 45 vehicles per hour. The maximum number of vehicles passing any one point in the same direction should not exceed 45 vehicles per hour with sedans and 30 vehicles per hour with vans. Otherwise, the vehicle capacity should be increased. Vehicle capacity up to about 20 passengers may be selected (i.e., as the Mercedes Benz Model 309-D), but any vehicle should be capable of merging with auto traffic without difficulty. Otherwise, bus transit should be considered.

One single fare is desirable for the whole route. A single fare is faster and easier to collect. It encourages less familiar customers to use the service by making them fully aware of the total charges. Fares can be collected as passengers enter the jitney with minimum delays to other passengers.

Minor route deviations are desirable when sedan vehicles are used. Minor route deviations provide more personalized service that approaches the door-to-door quality for the private auto. However, when larger vehicles are used, deviations may induce too much delay to other passengers and reduce the reliability of the trip time. Route deviations should be allowed with the consent of on-board passengers regardless of vehicle size to avoid major traffic congestion and to move with a full load faster toward the final destination or under emergency conditions.

Designated downtown stand locations with shelter for passengers may be used. A stand at a downtown location serves as a gathering point for passengers, thus reducing the number of stops required to collect passengers. The shelter protects passengers from inclement weather. A stand also may serve for providing route information and for coordination of services with other transportation modes.

Vehicles with ample headroom should be used. High interior space allows walking erect within the vehicle, and this reduces time for entering and exiting the vehicle. Vehicular trips with a high passenger turnover, typical of short routes, can reduce on-board travel time for all passengers significantly. Elderly and handicapped travelers may be encouraged to ride in jitneys.

Routes over five miles in length tend to operate in the stand-dispatched manner. Corridors followed make higher use of higher type highway to connect multiple activity centers with residential areas. Thus, more passenger trips tend to travel most of the route length. In planning for route service, the following operating characteristics are recommended.

Stand-dispatched service is preferred. Operations are conducted departing from a stand after a predetermined passenger load has been reached. Jitney vehicles form a line as they reach the stand at the CBD end of the route. Intercity routes serving more than one CBD may have two or more stands. Jitneys may resort to cruising during peak hours to provide higher frequency and extra passenger handling capacity.

Four or more trips per hour should be provided during peak periods and three or more trips per hour should be provided during off-peak periods. High frequency of service allows for short waiting period and not much concern for missing one vehicle. Passengers arrive to the route on a random pattern, and those arriving to the stand board a vehicle to wait for its departure. Maximum average wait time is 10 minutes during off-peak hours and 7.5 minutes during peak. Low demand may be served with vehicles such as sedans.

Jitneys have an option to stop at any safe place along the corridor. The jitney driver can be requested to stop at almost any safe place that will not delay other traffic unduly. However, no stops may be possible while traveling on some highways, and on-board passengers should be made aware of and approve of this practice when this is a deviation from the regular route. CBD stops may not be necessary as most passengers tend to get in and out at principal collection points.

Maximum frequency should be 30 jitneys per hour. The maximum number of jitneys passing any one point in the same direction should not exceed 30 vehicles per hour or the vehicle capacity should be increased. Vehicle capacity up to about 20 passengers may be selected, but this vehicle should be capable of merging with auto traffic regardless of speed of flow through the highways traversed.

Zoned fares may be used. Zoned fares provide for equity based on the service provided to passengers. Due to longer passenger trips and lower turnover of passengers, it is not difficult to assess multiple fares provided they are posted properly and are visible to all passengers. Fares may be easier to collect as passengers terminate their trip.

Route deviations are allowed under special conditions only. Door-to-door service is less desirable as it reduces the reliability of arriving on time to a destination. Route deviations should be allowed with the consent of on-board passengers regardless of vehicle size to avoid major traffic congestion, to move a full load of passengers toward the final destination by by-passing the regular route or under emergency conditions.

Turnbacks at intermediate route points are allowed. Once a route is designated, the operators should decide how much service they will provide as long as some minimum level of service is provided to all points. Rather than regulating terminus points, it is more effective to authorize more vehicles to serve the route.

Queueing space must be provided. Adequate space must be allowed for vehicles to stand in line waiting to load. This assembly area may

be a few curbside spaces with added off-street parking depending on fleet size.

Fleet size can be estimated at 10% higher than the number of vehicles required to operate during peak periods. This will account for operator's days off, maintenance and administrative needs. Also, jitneys incur very little deadheading since they do not go far from the route to render services. Operators generally live close to the route and deadheading is well below the 5 to 10% attributed to bus transit.

It should be made clear that many of the recommended practices in route operations are illegal. For example, regulations concerning route deviations are very difficult to overcome when regular transit routes may be infringed upon by the jitney operations. However, the planner must be aware of the different options available to satisfy transportation objectives as well as ways to overcome existing impediments.

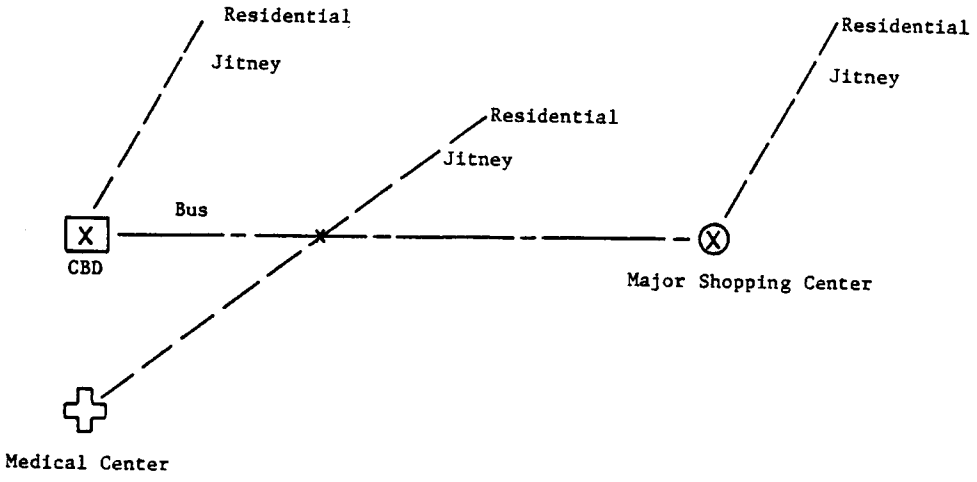
Coordination with Public Transit

All the services discussed so far are related to independent jitney operations, even though some interaction with bus transit exists in some of the routes studied. However, no coordination exists as recognized by the transit operator. That is, transit operators plan and implement changes to route and terminal facilities with utter disregard of jitney operations unless the transit operator perceives some competition for passengers. A special effort is required to provide coordinated service for the benefit of users, operators and the community.

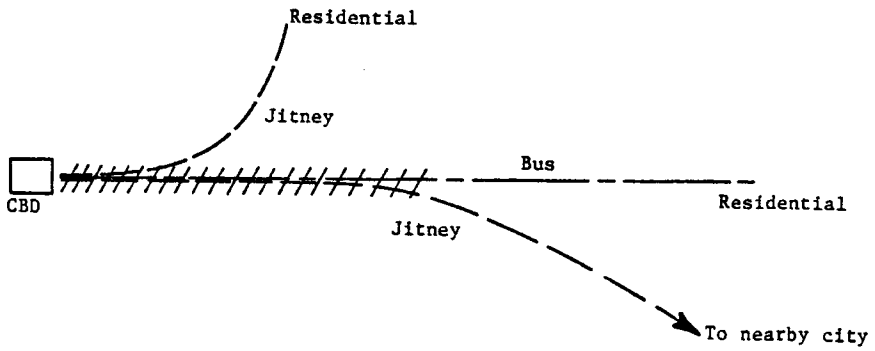
Point coordination. Jitneys can provide feeder service to bus or rail transit at designated points or terminals. Jitneys can serve areas away from the line-haul transit route to extend the service area covered by conventional transit. This can be accomplished by providing collection and distribution of passengers between residential areas and transit terminals or between residential areas and selected stops along a transit route. Figure 7-1a portrays those concepts. Some of these services may be provided by bus; but where bus service cannot be provided, jitneys should be allowed to take over.

For most effective and efficient coordination, a joint terminal would allow jitneys to extend area coverage provided by transit and to reduce travel time and inconvenience to public transportation users. Terminals should be located within a multiple-activity center (CBD) or at a shopping center, areas that are trip attractors by themselves. Jitneys crossing bus routes at some intermediate point may be allowed to collect and discharge passengers at or near the same stop as buses use.

Segment coordination. Partial overlap of services in segments where public transportation demand is large, such as segments approaching downtown, can allow service reduction in bus transit. Besides reducing transit costs, this type of coordination can help to reduce overcrowding of bus vehicles as they approach the downtown area. Common or physically-close stops will reduce vehicle loads by allowing passengers to take the first vehicle to come by; field observations and conversations with passengers tend to support this practice. Intercity jitney routes



a. Point coordination (indicated by an X)



b. Segment coordination (indicated by shading) ////

FIGURE 7-1

JITNEY AND BUS TRANSIT SPATIAL COORDINATION

also may be allowed to share heavily traveled segments of bus transit routes. Figure 7-1b shows these concepts.

Evening and weekend coordination. Some jitney routes have been organized so that a group of jitney operators using large vans serves during the day and another group operating with sedans serves during evening hours; an existing example is the Rio Piedras to Caguas route. Also, the higher capacity vehicle can serve during weekdays with the lower capacity vehicles taking over during the weekends. Similar coordination can be provided between jitneys and bus transit during evenings or weekends.

It is not uncommon for bus services to be curtailed or suspended in routes serving corridors adjoining multiple-activity centers with residential areas during evenings and over weekends. The limited ridership during these periods may not justify bus service, but jitneys may be perfectly suitable to take over. Jitneys could depart whenever a desired load is attained, observing that maximum headways are not exceeded (such as every 30 minutes) and still could provide attractive service to many. This operating scheme is used now on some routes such as in the Bayamon to Sabana Seca route (see Appendix A).

Peak hour service reduction. Peak hour service is the most expensive to transit companies because they have to provide enough vehicles and drivers to satisfy travel demand for a few hours, some of which remain idle and underutilized the remainder of the day. Attempts to economize by reducing the number of operating vehicles during peak hours results in overcrowding of those remaining in service, thus discouraging current and potential patrons.

Jitneys can provide enough peak capacity to relieve transit of the extra vehicles and drivers required to meet peak demand. Joint peak service along major travel corridors can reduce transit costs and traffic congestion. As Mr. Patricelli, former UMTA Administrator, recently stated (62), "This is not a matter of skimming off the profits; if anything, it is more a matter of skimming off the deficits."

Other Service Opportunities

Jitneys available for charter service provide added flexibility to public transportation users. This may be viewed as competition with taxicab service, but because of the area served and the economic remuneration involved, taxis are seldom interested in the jitney market. Also, emergency service may be allowed, such as to take medical ambulatory patients (those not requiring an ambulance) to the nearest medical facility regardless of route traveled.

Variations of the jitney service are found in Puerto Rico. Smaller, compact urban areas such as Mayaguez (40), where no bus transit is available, have jitneys serving multiple origins and destinations. This service resembles dial-a-ride service except that a prospective passenger hails or makes a signal to a passing jitney to be picked up rather than calling for service over the phone. Under this scheme, the driver will stop if he has any empty seats and will ask for the general destination of the passenger to determine if he can satisfy the prospective rider as well as those already on board. Otherwise, the prospective passenger will have to wait for the next vehicle. Personal experience by this author indicates a short average

wait time (five to ten minutes) within the central city, although system-wide wait time of approximately 15 minutes has been reported (40).[1]

Another service extensively provided within Puerto Rico is intercity jitney service. Various intercity services are provided but the most interesting may be the "linea" concept where vehicles depart on schedule. Prospective passengers call to make reservations; passengers are assigned to trips departing at about their desired trip time (provided there are seats still available) and then are requested their origin and destination addresses. Passengers also are advised to be ready for pick up at a specified time. These and other intercity service modes have been studied by others (63).

Overall, it may be said that service opportunities for jitney modes are limited by regulation rather than by their capabilities to provide service. Jitneys, unless otherwise regulated, serve wherever and whenever an opportunity to earn a living transporting passengers exists.

Desirable Regulation

Planners often are required to initiate actions to bring about changes in regulations as part of their effort to provide coordinated guidelines for policy implementation. Current philosophy of public transportation regulation sometimes runs contrary to the objectives they intend to serve. It is planners responsibility to identify contradictory policies and to outline the objective of required changes.

---

[1]It should be mentioned that service in Mayaguez has been available serving about the same area as more expensive taxis, and both make a profit. This also could be said about Chattanooga where taxis, jitneys and buses serve a common corridor.

It is suggested that regulation of privately-owned transportation modes should give promising alternatives an equitable opportunity to provide public transportation services.

Current Regulation

Regulation of publicly-owned and operated services is usually the responsibility of a public service commission. These agencies normally are empowered to control fares, amount of service, entry and exit, routes and areas to be served. However, in their zeal for controlling these factors, they often overlook basic transportation objectives such as to increase mobility, to increase accessibility to job opportunities or to reduce fuel consumption.

Regulation of fares is necessary to avoid confusion to users and to ensure a reasonable revenue to the service provider. Thus, this aspect of regulation serves social, economic and system efficiency goals. However, regulating amount of service, entry and exit, routes or area to be served often interferes with the operator's management options to control revenues and expenses. Private operators must have control over revenues and expenses to be able to work for a profit.

Current regulatory philosophy fails to consider changing community attitudes and market needs. First, issues of that philosophy need to be pondered in proposing changes to regulations. Travelers' attitudes toward public transportation and demands from labor have made it difficult to operate urban public transportation systems with economies of scale. Second, the level of service strived for with conventional transit is being lowered continuously as headways are increased and as

new residential developments are being denied service. Third, a reasonable rate of return may be achieved more equitably through promotion of efficient operations than by limiting competition. Fourth, it is better to allow a competing carrier to provide service where others are not willing to do so, than to assume that a newcomer is not capable. Fifth, when most or all transit routes lose money, any passengers taken over by a competing mode that lowers the amount of service required from transit helps to lower the deficit. There is a need for a fresh look at the regulation of privately-owned public transportation.

Suggested Objectives of Jitney Regulation

Prevailing transportation issues indicate the need to give promising alternatives a chance to provide public transporation services. Why should privately-owned and operated services such as jitneys be subject of regulation? Jitneys are very susceptible to regulations that promote inefficiencies because they operate close to break-even, attracting passengers with low fares and expeditious service. Yet, since routes commonly are served by independent owner/operators, jitneys do not have the financial strength nor the integrity of organization to fight unjust burdens.

Under free entry to jitney routes, the number of drivers continues to increase as long as reasonable earnings are obtained by individual drivers. When the number of operators becomes so large that earnings are diluted to unacceptably low levels, some drivers will discontinue service until an equilibrium is reached. At that point, remaining drivers operate at the minimum level of acceptable earnings,

and service is provided by the largest possible fleet. Yet, the service provided may be unstable or unreliable, and the public interest may not be served properly. Regulation seems desirable to overcome those drawbacks.

It is suggested that regulation of privately-owned urban public transportation services should follow one of three basic objectives:

1. To maximize ridership;
2. To maximize service frequency; and
3. To minimize service fare.

These objectives are not independent, but the selected option must receive top priority. Optimizing on any one of these objectives requires thorough knowledge of jitney operations and demand that is seldom available. However, proper balance can be reached based on successive appropriations. Note that fares must be controlled under each of the three alternatives.

Ridership maximization. This objective contributes to satisfy various transportation goals such as reducing highway congestion, reducing fuel consumption or increasing system efficiency. For maximizing ridership, fare and frequency of service should be regulated. In general, the lowest profit producing operation should result in the highest ridership and service frequency, if operations take place under free market conditions. But without a profit, jitneys would not operate, so regulation is necessary to reach a point reasonable for users and operators. Since revenue from fares is equal to cost plus profit, and since drivers will try to maximize profit, service frequency will be set up for maximum profit rather than for maximum

ridership unless both service frequency and fares are regulated. Fares would then be selected for maximum ridership at a minimum profit level.

Service frequency maximization. This objective requires a strategy resembling that of ridership maximization, but service frequency is selected first. Fares then are determined to satisfy cost plus a profit. Goals supported by this objective resemble those of ridership maximization except that system efficiency is not optimized. However, this policy results in the highest level of service so that, in the long run, it may prove attractive enough to increase ridership beyond expected levels.

Fare minimization. This policy contributes to social goals such as increasing accessibility to job opportunities, thus favoring lower income groups. Yet, this strategy may be attained at the expense of lowering service frequency and thereby ridership. To determine minimum fare, service frequency and fares are investigated simultaneously, but only fares are regulated (28). Captive riders may receive most of the benefit from this policy. However, since the attractiveness to noncaptive riders is limited due to low service frequency, over the long run, services may suffer the decline that private bus transit has seen in past years.

Analytical procedures to determine the points at which these objectives are satisfied are explained in detail by Garcia Pacheco (28). He develops an econometric model based on supply and demand,

and then calibrates it for intercity jitney service. However, the equations are technically complex and may lack transferability because they are based on cross sectional data reflecting site-specific conditions. Nevertheless, the theory and principles used are valid elsewhere, and its discussion can help in understanding how to achieve the objectives considered above.

A Suggested Approach Toward Jitney Operations

The procedure for implmentation of jitney operations requires a different approach and sequence of steps than required for conventional public transportation modes. It requires conceptual planning, changes in regulations, marketing the idea to various groups and initiating actual operations. Like any new or reintroduced product trying to enter the open market, it requires marketing through the whole process.

Unlike conventional transit, it is difficult to separate the planning phase from the implementation phase except for operations, because jitneys are managed as private, for-profit businesses. As for the introduction of a new product, it is difficult to define just one sequence of steps that will lead to successful operations, however, a general guideline of activities can be proposed.

Thirteen activities can define the planning steps leading toward establishing operations, plus monitoring, to complete the cycle of continuous planning. Figure 7-2 shows those activities and their relationships through the planning process. Those activities can be explained in more detail, as follows.

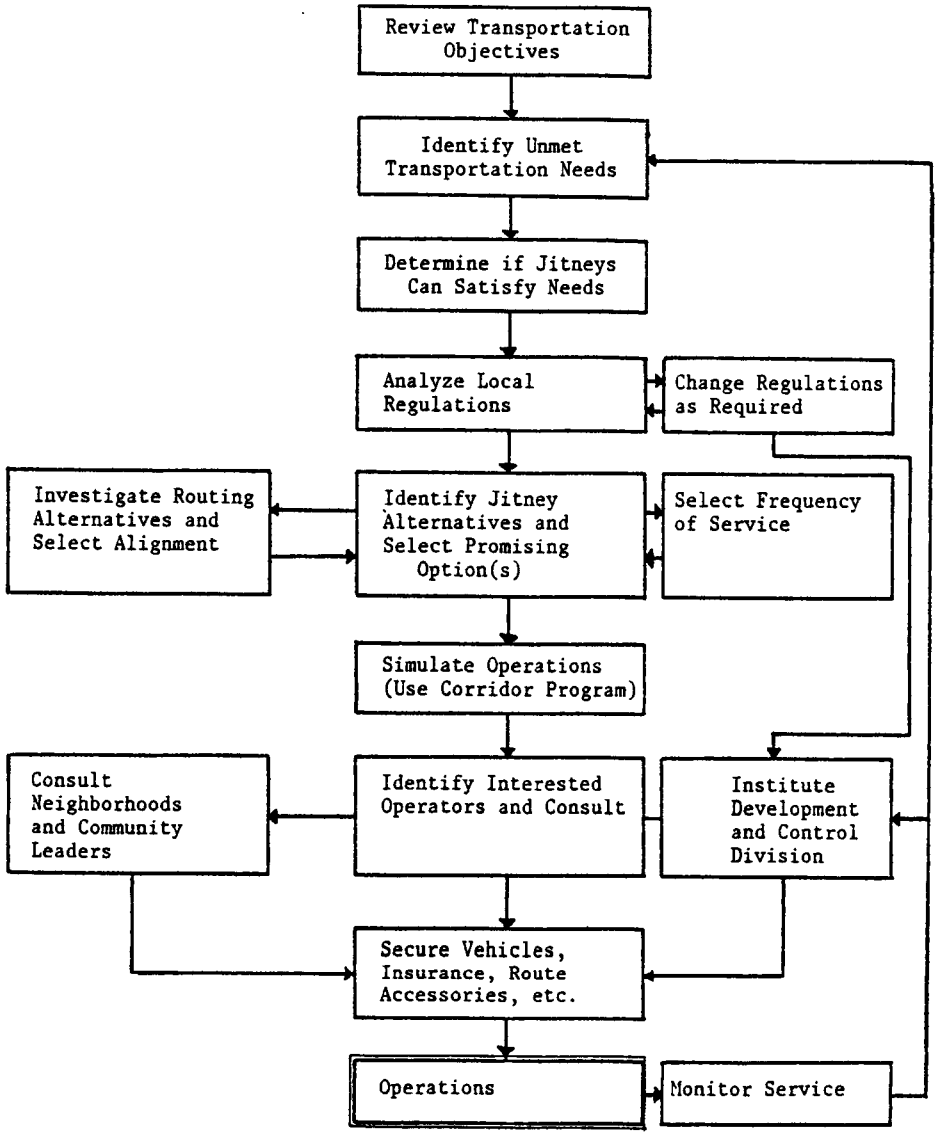


FIGURE 7-2

SUGGESTED PROCEDURE TO IMPLEMENT JITNEY SERVICE

Review Transportation Objectives

This activity is usually conducted on a yearly basis by most transportation planning organizations. However, major innovative projects may require a separate review. Conventional transit interests commonly are considered in setting community-wide transportation objectives and in implementing policies which reflect those objectives. A review of these objectives can serve to identify unmet transportation needs and may lead to viewing an innovative mode in a different perspective.

Identify Unmet Transportation Needs

In the United States, the private auto is the principal transportation mode for the majority of the people. Within urban areas, transit satisfies mobility needs of those without cars in their households or without a car for a given trip. Yet, public transportation planners continuously find transportation needs that have not been met by either. Transit agencies continuously receive requests to serve new areas or to provide more intensive or reliable service. Planners can identify and define unmet transportation needs that may be served by paratransit modes, including jitneys.

Determine if Jitneys Can Satisfy Needs

Jitneys exhibit a number of unique characteristics and potentials. Many public transportation needs that remain unfulfilled for lack of funds, for lack of flexibility in vehicle usage (e.g., a large vehicle unable to negotiate a steep roadway) or for lack of frequent service

may be satisfied by jitneys. Chapter 3 explains several of these jitney characteristics that make it unique.

Analyze Local Regulation

State or local regulations should be investigated to discover how they affect jitney services. Some regulations allow jitneys to operate; but with requirements about headways or requirements for excessively high bonds may make jitney services improbable or impossible. Analysis of such regulation can provide an understanding of needed changes and, hopefully of desirable controls that may be retained.

Change Regulations as Required

If changes to regulations are required, the necessary procedure to bring about changes must be outlined. Cooperation with other interested parties, legal groups and policymaking groups is necessary to initiate required actions to modify regulatory controls and/or to transfer such authority to a development and control agency.[2] Regulation should be limited to those aspects essential to satisfy the public interest. This interest includes the well being of private operators as without them the public cannot be served, but first priority goes for serving transportation objectives according to the policies that may be selected.

---

[2]For example, the Office of Transportation Administration (OTA) in Dade County, Florida is in the process of requesting that state legislation transfer the authority to regulate jitneys from the Florida Public Service Commission to OTA. This agency would then have authority to promote and develop jitney service as well as to regulate their operations.

Identify Jitney Alternatives and Select Promising Options(s)

This part of the conceptual planning may be conducted simultaneously with the following three activities. It includes the identification and selection of the specific service mode that may be most suitable to satisfy unmet transportation needs. For example, a five-mile long route may operate with cruising jitneys during peak hours and with stand-dispatched jitneys at regular intervals during off-peak hours; 11-seat vans are selected, and one turn-around point will be considered during peak hours only. Other reasonable alternatives may exist and should be identified before the more promising option or options are selected.

Investigate Routing Alternatives and Select Alignment

Due to jitney flexibility, more than one route alignment may serve the corridor under investigation, e.g., a given route segment may be served along collector streets or using local streets. The alignment of route segments may vary by period of the day or during weekends. Route length may be extended, reduced or split with another jitney route or with transit.

Select Frequency of Service

Service frequency is determined based on policy such as on maximum headways or based on average demand. Maximum headways would ensure that no passenger waits longer than the selected limit during a given period of the day. Frequency based on demand may be estimated from the Chapter 4 relationships and from the methods outlined in Chapter 6, or they may be taken from existing services. Future jitney

studies may bring about some other method to estimate demand based on socioeconomic factors that would have more extensive applicability.

Simulate Operations

The corridor program explained in Chapter 6 and Appendix D provides a tool for simulation of route operations. Other programs are available but may not provide the detail required for jitney operations planning, marketing and development. However, computations may be produced manually. Program outputs will provide the basic tools to determine the number of vehicles and operators required, costs, and approximate quality of service afforded to passengers.

Identify and Consult Interested Operators

Operators who are interested in providing jitney service must be identified. These may come from different sectors willing to provide shared-ride services along a corridor, charging low fares and stopping at several points for pickups and drop offs. Taxi drivers interested in becoming jitney operators should be made aware of the difference in service modes and, in particular, of how the regulatory and development agency will adjust fares and new entries as required to meet regulatory objectives.

Once interested operators are made aware of the kind of services they may provide, they will be consulted as to how they think they can offer jitney services along a selected corridor. They may be shown the basic route layout and then given details on exactly where, how and when they can serve. The regulatory and development agency should welcome suggestions from interested operators and should adjust its

plan to the extent feasible without compromising the basic service objectives. This activity should be concurrent with the following two activities.

Consult Neighborhoods and Community Leaders

The neighborhoods and/or community sectors affected by jitney services should be exposed to the proposed plan, and their comments and suggestions should be sought. Public hearings conducted in the vicinity of the affected corridor(s) may provide desirable inputs from independent citizens. Presentations and interviews to community leaders representing affected neighborhoods may provide additional understanding to tailor services to community needs and to assure successful implementation.

Institute Development and Central Division

A division in charge of development and control of jitney services should be created. These functions may be organized under a comprehensive agency with full responsibility for development of other transportation services and facilities such as a department of transportation or public transportation agency. However, fully separating the two functions of control and development under different agencies leads to inefficient allocation of resources and conflicting objectives.

This division can promote the development of jitney services through media advertisement, providing operators with marketing information and coordinating planning. The division can help in service implementation by establishing fares and by designating the number of vehicles that can operate a route. It also can help operators in

securing vehicles, insurance and route accessories. The division can ensure continuity of service by monitoring and enforcing regulations. Direct economic subsidies should be limited. Indirect subsidies such as the installation of shelters or route signs that help to increase demand and profit are highly recommended and can become a permanent function of such a development and control division.

Secure Vehicles, Insurance and Route Accessories

Vehicles can be provided by interested operators as long as they meet minimum safety standards. Ideally, operators should own their vehicles to ensure adequate maintenance and replacement as required. The development and control division can provide loan guarantees to lure new operators into service or can lease/buy vehicles at fleet rates to be subleased or resold at affordable monthly installments.

Group insurance may be secured for each route for all of its members. Lower rates may be obtained if the development and control division buys group insurance as part of a larger package that includes other transportation modes. The development and control division may become an insurance broker for various jitney routes.

Route accessories such as roadsigns, stands, vehicle signs and shelters should be provided before jitney operations begin. This may be performed by route members or by the development and control division. Roadsigns should specify at a minimum the stand locations, but they also may designate route alignment by spacing signs at regular intervals. Stands should provide queueing space for two to eight vehicles; the actual number of spaces is a function of route operations. Vehicles should be identified clearly while traveling the route by the

license plate, a peculiar sign or other convenient means. Shelters are very desirable but not essential for jitney route operations.

Monitor Operations and Service

Operations monitoring should oversee route operations so that regulatory objectives are satisfied and should provide operating experience to improve existing operations and plan for others. Regulatory objectives have been discussed previously.

Monitoring to improve existing service requires investigation of quality of service, economics, efficiency and emission aspects. These must be identified on a route-by-route basis to evaluate each route in its particular environment. With that information, the planner can go through the development and control division to modify fares, to increase or decrease the number of authorized vehicles or to propose operational changes to jitney operators. Aggregate findings can be used to go back through the planning process to identify unmet transportation needs and to implement additional services.

Monitoring to improve service also must consider the user as well as the operator. Surveying users is highly encouraged to understand demand and to improve service based on user's benefit. Control and development based on objectives favorable to the user will ensure good service without disregard for the operator.

Synopsis

Planning for jitney services is unlike planning for any other existing transportation mode. Jitneys are a very promising mode to satisfy some existing transportation needs, but severe obstacles must

be bridged before this mode becomes feasible. It is suggested that current regulation of privately-owned public transportation should be changed to follow one of three proposed objectives. Current regulatory philosophy seems to run contrary to the satisfaction of transportation objectives.

The best tool that may be available to promote jitney services would be demonstration projects to show how jitneys operate and to provide for the satisfaction of transportation needs. In the absence of local jitney service or a demonstration project, planners can simulate jitney operations planning for their implementation.

Furnished with a general concept of jitney service opportunities, guidelines on desirable objectives of jitney regulation and a suggested approach toward jitney operations, a planner can begin to implement jitney services. These procedures supplement service and economic analyses previously discussed.

CHAPTER 8

FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

General Findings

The public transportation sector, bus transit in particular, is experiencing economic problems due to increasing operating costs, increasing passenger demand for transportation services and decreasing system performance. Innumerable urban neighborhoods lack public transit, and many more are poorly served. New housing developments are commonly denied service even if it just requires extending an existing transit route. This is the result of transit costs increasing faster than revenues and of more cities becoming unable or unwilling to pay for large transit deficits.

Public transportation should be opened to private sector to allow services such as vanpooling and jitneys that provide corridor service effectively, efficiently and without subsidies. Public transportation services should become an area where private and public groups share responsibility in a coordinated manner.

Before jitneys can become a complement to public transportation, significant changes in regulation must be made. Very few jitneys operate in U.S. cities because of overregulation. Inflexible regulations prohibit or make it virtually impossible for a prospective jitney operator to provide services legally. Current regulations are a disbenefit to the public transportation user, the provider and the general public. Some regulatory controls seem desirable or necessary,

but they must allow operators enough management options to make a profit. Regulations should allow the more efficient and effective services to be rewarded with higher profits, although not necessarily higher fares.

As with other privately provided public transportation service, there is a need to understand jitney operations better and, where justified, to plan for, promote and help their development. Better understanding of jitney services and characteristics can help in bringing about changes in regulations and to aid in the conceptual planning. And better understanding of jitney performance can be used in planning for operations based on service effectiveness and efficiency.

This study has found that jitney operations vary extensively to maximize profits and serve travel demand. Jitney organizations vary extensively in the degree of internal regulation and hierarchical structure. Some designate a president, a vice-president, a secretary and other officials, while other organizations may exist only to share a route and an insignia. Where regulations allow for the use of different capacity vehicles, the vehicle with the largest seating capacity is preferred, excepting very low demand routes where frequency considerations control. Flexible regulations allow jitney operators to adjust service period, travel method in regards to cruising, stand dispatch or combination, fare collection method, route deviations, turnbacks before reaching the route to enact schedules, passenger loading methods and dispatch procedures. Jitneys can serve short to long routes (2 to 100 miles), low to high density neighborhoods; corridors with diversified land uses, and patrons of different

socioeconomic characteristics with incomes ranging from low to high. They can operate on residential, collector or arterial streets and on freeways.

Conclusions

The performance of jitneys operating along corridors connecting multiple activity centers with residential areas has been investigated by analyzing 10 existing jitney routes operating in Atlantic City, New Jersey; Chattanooga, Tennessee; San Juan, Puerto Rico; and Caguas, Puerto Rico. Performance measures related to passenger productivity and travel distance have been developed. The following findings are based on the analysis of field data from routes investigated.

Jitney vans transport more passengers per vehicle-mile in shorter routes than in longer routes. More specifically, passengers per vehicle-mile are inversely related to vehicular trip distance. Productivity varies between 2.7 and 0.9 passengers per vehicle-mile for jitney vehicle trips ranging between 2 and 15 miles in length.

Passenger-miles per vehicle-mile and passenger-miles per seat-mile for a jitney van are related directly to vehicular trip distance. This means that passenger-miles increase as vehicle-miles and seat-miles increase. Productivity varies between 4.2 and 12.8 passenger-miles per vehicle-mile and between 0.42 and 0.92 passenger-miles per seat-mile for jitney vehicle trips ranging between 2 and 15 miles in length.

Travel speed for a jitney van is related directly to trip distance. The longer the route, the faster that jitneys travel. Average jitney speed varies between 11.6 and 25.5 miles per hour for vehicle

trips ranging between 2 and 15 miles. It is important to note that routes selected traverse natural travel corridors, that short routes tend to serve short passenger trips with frequent stops and that longer routes tend to serve longer passenger trips with fewer intermediate stops.

The relationship between passenger trip length and route length depends on the specific service mode providing service. Cruising van passengers travel 44% of the route length, stand-dispatched intracity van passengers travel 63% of the route length and stand-dispatched intercity van passengers travel 97% of the route length.

Field investigations were used to investigate supply side performance concerning costs and fuel consumption. The system design approach was selected to analyze the cost of major items. Typical values of 11 major items were identified for jitneys, buses and private autos. Administrative and maintenance costs were considerably lower for jitney vans (at about $620 per vehicle) than for transit buses (at about $19,200 per vehicle). In relation to fuel consumption, jitneys consume fuel at about the same rate as private autos at any given speed. This relationship can be attributed to the fact that jitneys operate with a warm to hot engine most of the time while the majority of auto trips start with a cold engine, thus equaling the higher fuel consumption required by frequent jitney stops.

A Planning Procedure and Scenario Analysis Findings

A procedure has been developed that allows for the simulation of route service along a corridor. A computer program that handles the repetitious calculations allows the planner to examine the supply side

of jitney service concerning operating schemes, productivity and revenue, cost, energy consumption and air pollutant emission. This planning procedure is explained through the use of scenario analyses that present hypothetical situations in real settings.

Scenario analyses were conducted to present an application of the planning procedures, to provide a realistic perspective of the performance of jitneys and to demonstrate how jitney service compares with equivalent bus transit service. Although limited in scope, comparisons made through the use of scenario analysis demonstrate that jitneys can provide corridor service at or below 37 cents per vehicle-mile compared to bus service costs at $2.00 per vehicle-mile, or over five times higher. This helps to explain how jitneys make a profit while charging fares similar to transit. Jitneys also can provide higher quality service than bus transit when both rides provide the same seating capacity per period of time. Average passenger trip time is shorter for jitneys than for buses when passengers of both modes travel the same distance. Jitneys can be as fuel efficient as bus transit except for corridors with very high travel demand. Scenario analysis shows fuel savings per passenger-mile when jitneys replace buses under specified conditions.

General Recommendations

Planners have reservations concerning the implementation of new services. The following recommendations present some key features of concerns that should be addressed in planning and future research.

Jitneys are private enterprises, and regulation must recognize their profit motives. Regulation of private public transportation

must allow management options to control revenues and expenses. Primary regulatory objectives should address ridership maximization, service frequency maximization or fare minimization. These are mutually dependent objectives, and regulators should assign first priority to one of the three. Also, other regulatory controls related to registration, vehicular safety, insurance and route coverage may be considered necessary.

It is recommended that government become involved in planning and promoting jitney services. Planners can advise prospective jitney operators of needs for additional or new public transportation services. Planners can advise on organization, certification or licenses, how to best serve a route, expected operating costs and expected revenues. Planners should encourage integration of jitney services with transit and other public transportation modes. Planners also can help in the request for economic assistance, such as to build a jitney terminal or off-street stand. However, private operators ultimately must make their own decisions and must face the economic consequences of providing jitney service. Government economic involvement with the objective of regulating or controlling day-to-day operations is discouraged because it takes a short time for the economic burden to shift to government.

Demonstration projects in various U.S. cities should be promoted. This can be an initial step in getting jitneys on the way to becoming another principal provider of public transportation. But unlike in other demonstration projects, jitneys should not be subsidized directly. Government intervention should be limited to providing proper regulations, guidance and implementation assistance and should remain away from

operations. Any economic subsidies should be indirect, such as providing free standing areas for jitney vehicles, and may last as long as they are used for the original objective in an efficient manner. Direct subsidies, if at all, should be temporary and preferably directed to the user.

Further research should be conducted in several areas covered in this report. Ways to overcome organized labor objections to jitney service must be found. For example, taxi drivers may be encouraged to participate in jitney service or transit labor leaders may be informed as to how proper coordination with jitney service may increase transit ridership under certain operating schemes. Costs parameters should be updated and refined periodically, and ways to lower the cost of items such as insurance should be investigated thoroughly. Finally, performance variables and relationships found in this study should be validated in other urban settings, such as San Francisco, Chicago and Miami.

This study has covered a broad range of conditions that affect the availability of jitney service. This report is dedicated to providing a basic understanding of jitney characteristics and performance and to make available the planning tools required for the evaluation, promotion and development of such services. If more planners become aware of this very flexible mode, then jitneys and other privately-provided public transportation modes can become a complement to existing public transit.

LIST OF REFERENCES

LIST OF REFERENCES

1. '77-'78 Transit Fact Book, American Public Transit Association, Washington, DC, May 1978.

2. Burbank, C.J., "Transit Financing: Trends and Outlook," Urban Transportation Economics, Transportation Research Board Special Report 181, Washington, DC, 1978, pp. 201-203.

3. Meyer, J.R., and Gomez-Ibanez, J.A., Improving Urban Mass Transportation Productivity, Harvard University under contract with Urban Mass Transportation Admin., February 1977, p. 74, PB 266-920.

4. Davis, F.W., et al., Economic Characteristics of Privately Owned Shared-Ride Taxi Systems, Transportation Center, University of Tennessee, under contract with Urban Mass Transportation Administration, October 1974.

5. Kirby, R.F., et al., Para-Transit: Neglected Options for Urban Mobility, The Urban Institute, Washington, DC, 1974.

6. Remak, R., Potential for Flexicab Services: Innovative Users of Taxis and Jitneys for Public Transportation, INTERPLAN Corp. under contract to U.S. Department of Transportation, Santa Barbara, California, December 1975, DOT-TSC-748.

7. Saltzman, A., and Solomon, R.J., "Jitney Operations in the United States," Transit Planning and Development, Highway Research Record 449, Highway Research Board, Washington, DC, 1973, pp. 63-70.

8. St. Louis Metropolitan Transportation Study, W.C. Gilman, 1977.

9. Meade, R.W., and Black, C.N., "The Jitney-Bus Competition," Electric Railway Journal: XLV, February 13, 1915.

10. From Atlantic City, Home of the Boardwalk and Miss America to Anaheim, California, Home of the Angels and Disneyland, unpublished mimeographed paper available from the Atlantic City Department of Revenue and Finance, December 1967.

11. "Jitney Bus in Operation," Chattanooga Daily Times, February 18, 1915.

12. "Rapid Spread of New Transportation Method," Chattanooga Daily Times, February 21, 1915.

13. "Jitney Bus of Interest to Commission," Chattanooga Daily Times, February 25, 1915.

14. Steinberg, D., "History of CARTA," Chattanooga Times, September 17, 1973.

15. Brooke, T., An Analysis of an Urban Jitney System in Chattanooga, Tennessee, Transportation Center, The University of Tennessee at Knoxville, August 1976.

16. Act #75, April 13, 1916: Laws of Puerto Rico, 2nd sess., 8th Legislature 1916, p. 141.

17. Law #70, Dec. 6, 1917, Laws, 1st Session, 9th Legislature of Puerto Rico, 1917, p. 432 et seq.

18. 13 Opinions of the Attorney General of Puerto Rico, 1926, p. 151.

19. Act #366, May 14, 1949, Acts of Puerto Rico, 1st Regular Session, 17th Legislature, 1949, pp. 1104-1106.

20. Andrle, S.J., and Rodriguez, J.L., The Organization and Economics of Jitney Operations in San Juan, Puerto Rico, Paper presented at the 56th Annual Meeting of the Transportation Research Board, January 1977.

21. Study and Evaluation of Urban Transportation Regulation and Regulatory Bodies, Vol. 2, Urban Mass Transportation Administration, May 1972.

22. Jurkat, M.P., Lesser, A., Pianese, V., and Mott, J., A Publico System for Highly Congested Urban Areas, Center for Municipal Studies and Services, Stevens Institute of Technology, under contract from U.S. Department of Transportation, December 1976.

23. Gonzalez-Tejera, E., Transportation in Puerto Rico: A Search for a New Regulatory Phylosophy, Research Institue for Consumer Problems, Faculty of Business Administration, University of Puerto Rico at Rio Piedras, 1971.

24. Personal interview with Jose L. Martinez, Chairman of the Fixed Route Committee and Assistant to the President of the Puerto Rico Public Service Commission, January 1978.

25. Law #16, August 9, 1974, to amend "Public Service Law of Puerto Rico," Sec. 3, Art. 2, Laws of Puerto Rico.

26. Personal conversations with Mr. Joaquin Montesino-Colon, President of the Jitneymen (Porteadores Publicos) Federation, Bayamon, Puerto Rico, January-February 1978.

27. Regulation for Public Service Vehicles of Lower Capacity Operating Within the Commonwealth of Puerto Rico (translated from

Spanish), draft ready for approval, Public Service Commission, San Juan, Puerto Rico, 1978.

28. Garcia-Pacheco, R., An Econometric Model of the "Carros Publicos" System of Puerto Rico, doctoral thesis presented at Cornell University, January 1976.

29. Byrne, G. E., Improving Public Transportation Systems Management, thesis presented for the Master of Science Degree, University of Tennessee, June 1978.

30. Interview with Mr. William Lee, former president of the Chattanooga Cruising Cab Association and president of the Airport Limousine Association, May 31, 1978.

31. Wolfington, V.A., "Regulations and Paratransit," Paratransit, Transportation Research Board Special Report 164, Proceedings of a Conference held November 9-12, 1975, Transportation Research Board, 1976.

32. Farmer, R.N., "Whatever Happened to the Jitney?," Traffic Quarterly, ENO Foundation for Highway Traffic Control, Inc., Sangatuck, Connecticut, April 1965, pp. 263-279.

33. Internal statistics gathered by the Puerto Rico Public Service Commission for establishing fixed routes for all publico cars in Puerto Rico, 1974.

34. Aldarondo-Galvan, E., and El Gammal, F., "Level of Satisfaction with the Carros Publicos System by Car Operator and Users," Publicos Study, Transportation Institute, University of Puerto Rico, June 10, 1972, pp. 76-124.

35. Personal interview with Mr. Milton Greenberg, President of Atlantic City Jitneymens Association, April 17, 1978.

36. Act. No. 33, April 14, 1941, Acts, 1st Regular Session, 15th Legislature of Puerto Rico, 1941, pp. 548-556.

37. Law #109, June 28, 1962, "Public Service Law of Puerto Rico," Sec. 3, art. 2, Laws of Puerto Rico.

38. Ramos, A. Cost Guidelines Update for Lesser Capacity Vehicles that Provide Public Service, (in Spanish), internal memo of the Accounting Bureau, Puerto Rico Public Service Commission, July 11, 1977.

39. Route list of San Juan Metropolitan Area routes, working document, Accounting Bureau, Puerto Rico Public Service Commission, 1975.

40. Garcia-Pacheco, R., and Riesco, A., "Importance of User Related Attributes in the Carro Publico System of Puerto Rico," Publicos Study, Transportation Institute, University of Puerto Rico, Mayaguez Campus, June 30, 1972, P-R-URT-1 (71), pp. 5-64.

41. Rohlf, F.J., and Sokal R.R., Statistical Tables, W.H. Freeman and Company, San Franciso, 1969.

42. 1974 National Transportation Report: Urban Data Supplement, by Wells Research Co. and Control Data Corp. for U.S. Department of Transportation, May 1976.

43. Economic Feasibility of Independent Vanpool Operation, Office of Energy Conservation and Environment, Federal Energy Administration, September 1976, FEA/D-77/014.

44. Wallin, R.J., and Wright, P.H., "Factors Which Influence Modal Choice," Traffic Quarterly, ENO Foundation for Transportation, Inc., Westport, Connecticut, April 1974, pp. 271-289.

45. A Policy on Design of Urban Highway and Arterial Streets, American Association of State Highway and Transportation Officials, 1973.

46. Short Range Transit Plan, Atlantic County, New Jersey, Wilbur Smith and Associates for The Atlantic County Planning Board, preliminary final draft, June 1977.

47. Supplement No. 5 to AP-42: Compilation of Air Pollutant Emission Factors, Environmental Protection Agency, Washington, D.C., December 1975.

48. Mobile Source Emission Factors, Environmental Protection Agency, Washington, D.C., January 1978.

49. Shanka, D.B., Loebl, A.S., and Patterson, P.D., Transportation Energy Conservation Data Book, Edition 2, Oak Ridge National Laboratory for the Office of Conservation, Energy Research and Development Administration, October 1977.

50. Wegmann, F.J., et al., Economic, Energy, and Environmental Impacts: Market Opportunity Analysis for Short-Range Public Transportation Planning, National Cooperative Highway Research Program Report 210, Transportation Research Board, Washington, D.C., October 1979.

51. Baltimore Regional Environmental Impact Study: Technical Memorandum No. 8, Analysis of Energy Consumption, Alan M. Voorhees & Associates for the Interstate Division of Baltimore City, June 1975.

52. Bellomo, S., Liff, S., and Cheng, M., "Energy and Air Pollution Considerations in Urban Transportation Decision Making," Urban Transportation Efficiency, proceedings of the specialty conference sponsored by American Society of Civil Engineers, Institute of Traffic Engineers, and Transportation Research Board in July 1976, published by American Society of Civil Engineers, New York City.

53. Claffey, P.J., Passenger Car Fuel Conservation, for Federal Highway Administration, Washington, D.C., July 1976, PB-265-369.

54. Hirst, E., "Automobile Energy Requirements," Transportation Engineering Journal, November 1974, pp. 815-826.

55. Sanders, D.B., and Reynen, T.A., Characteristics of Urban Transportation Systems: A Handbook for Transportation Planning, DeLew Cather and Co. for UMTA, FHWA, May 1974.

56. Batchelder, J.H., Englisher, L.S., and Sobel, K.L., Operational Implications of a Major Modal Diversion to Transit: Program Users' Guide, Multisystems Inc. under contract with U.S. Department of Transportation, April 1976, DOT-OS-50266.

57. Claffey, P.J., Running Costs of Motor Vehicles as Affected by Road Design and Traffic, National Cooperative Highway Research Program Report 111, Highway Research Board, Washington, D.C., 1971.

58. Gomez-Ibanez, J.A., and Meyer, J.R., "Growth of Productivity and Labor Relations in Urban Mass Transit," Urban Transportation Economics, Transportation Research Board Special Report 181 on proceedings of Workshops, Transportation Research Board, Washington, D.C., 1978.

59. Atlantic City Transportation Company's Fiscal Year 1979 Application for Operating Assistance, as submitted to the New Jersey Department of Transportation, August 28, 1978.

60. Urban Transportation Planning System (UTPS), Urban Mass Transportation Administration, Washington, D.C.

61. Transit Development Program Update: 1976-1980, Kimley-Horn and Associates and Simpson and Curtin for Jacksonville Transportation Authority, February 1976.

62. Demand-Response Transportation Systems and Other Paratransit Services, Transportation Research Record 608, papers presented at a conference held in Washington, D.C. in March 1976, Transportation Research Board, 1976.

63. Intercity Highway Public Transportation Plan, preliminary report, CLM Systems, Inc. for the Puerto Rico Highway Authority, Cambridge, Massachusetts, January 1972.

64. Edwards, J.D., "Environmental Considerations in Traffic Engineering," Transportation Systems on Community Values, Stanford Research Institute for Dept. of Housing and Urban Development, Washington, D.C., April 1971, PB-199-954.

65. Klein, G.E., et al., Methods of Evaluation of the Effects of Transportation and Traffic Engineering Handbook, Institute of Transportation Engineers, published by Prentice-Hall, Inc., 1976, pp. 944-955.

66. Cherweny W., and Mundle, S.R., "Peak-Base Cost Allocation Models," Recent Developments in Bus Transportation, Transportation Research Record 663, Transportation Research Board, Washington, D.C., 1978, pp. 52-56.

67. Billheimer, J.W., Bullemer, R., and Holostye, M., Macroanalysis of the Implications of Major Modal Shifts in Integrated Regional Transportation Networks, Appendices: Phase 1, Systan, Inc. for U.S. Department of Transportation, April 1976, DOT-OS-50265.

APPENDICES

APPENDIX A

CORRIDOR CHARACTERISTICS AND ROUTE DESCRIPTIONS

Ten separate routes ranging in length from 2.2 to 15.1 miles have been selected as representative of jitneys serving corridors connecting multiple-activity centers with residential areas. Except for the longest route observed, each provides service within an urbanized area. They primarily serve medium density corridors, even though some segments of each route may vary in traffic density, housing or activities.

Table A-1 describes general characteristics of the selected corridors. Total route length, segment length, location of the route segment and road type are used as primary descriptors of the route. Traffic density on the roadway used, roadway lanes and land uses provide additional information to visualize corridor conditions by segment. A brief narrative description of routes follows to acquaint readers with existing services and to demonstrate that jitneys can operate under different environments.

Route 1

This route serves from Caguas to the Villa Blanca development (see Figure A-1). In 1972, the Caguas urbanized area had a population of 72,000 residing within 11 square miles (42). Route operators cruise from a stand located by the city plaza. Once it leaves downtown streets, the route proceeds through a segment of intercity highway with extensive commercial development. It then reaches Villa Blanca and the adjoining San Antonio and Santa Juana developments. These

TABLE A-1

CORRIDOR CHARACTERISTICS

Route	Route Length, Segment Length- Location - Roadway Type	Traffic[a] Density	Roadway Lanes in each Direction	Prevailing Land Use
1. Caguas to Villa Blanca Dev., Puerto Rico	2.2, 0.3 - Downtown - Street	H	1&2	Multiple
	0.6 - City - Arterial	M-H	2	Commercial
	1.3 - City - Street	L	1	Med. Res.
2. Patten to Citico & N. Orchard Chattanooga, TN	3.3, 0.3 - Downtown - Street	M-H	1-3	Multiple
	2.3 - City - Street	L-M	2,3	Com., Res.
	0.7 - City - Local	L	1	Med. Res.
3. Caspian to Jackson, Atlantic City, NJ	4.1, 1.8 - Downtown - Avenue	L-M	2	Multiple
	2.3 - City - Street	L-M	1&2	Com., M-H Res.
4. Bayamon to Regional Hosp., Via Lomas Verdes Dev., Puerto Rico	4.3, - Downtown - Street	H	1	Multiple
	- City - Street	M-H	1,2	Various
	- City - Local	L	1	Med. Res.
5. Bayamon to Sabana Seca, Puerto Rico	4.5, 0.3 - Downtown - Street	H	1&2	Multiple
	1.0 - City - Street	M-H	1&2	Com. Res.
	0.4 - City - Arterial	L-M	2&3	Com. Res.
	2.8 - Sub - Local (Road)	L	1	Low Res.
6. Rio Piedras to Campo Rico Dev., Puerto Rico	5.6, 0.4 - Downtown - Street	H	1&2	Multiple
	1.7 - City - Arterial	H	2&3	H. Com., H. Res.
	3.5 - City - Street	L-M	1&2	Med. Res.

TABLE A-1 (Continued)

	Route	Route Length, Segment Length- Location - Roadway Type	Traffic[a] Density	Roadway Lanes in each Direction	Prevailing Land Use
7.	Bayamon to Riverview and Rio Hondo Devs., Puerto Rico	6.4, 0.4 - Downtown - Street	H	1&2	Multiple
		0.9 - City - Arterial	L-M	1-3	Com., Res.
		1.3 - Sub. - Arterial	L	1&2	Res., Com.
		3.8 - City - Street	L	1	Med. Res.
8a.	Rio Piedras to Caimito Bajo, Puerto Rico	7.2, 0.4 - Downtown - Street	H	1&2	Multiple
		3.8 - City - Arterial	M-H	2&3	Com., Res.
		3.0 - Sub. - Street	L-M	1	Semi-rural, hilly
8b.	Rio Piedras to Caimito Alto, Puerto Rico	9.4, 0.4 - Downtown - Street	H	1&2	Multiple
		3.8 - City - Arterial	M-H	2&3	Com., M. Res.
		3.0 - Sub. - Street	L-M	1	Semi-rural, hilly
		2.2 - Rural - Local	L	1	Rural, Very hilly
9.	Rio Piedras to Canovanas via Carolina, Puerto Rico	10.8, 1.1 - Downtown - Street	H	1&2	Multiple
		1.3 - City - Street	M-H	1	Multiple
		7.8 - City - Arterial	L-M	2	Multiple
		0.5 - City - Local	L	1	Med. Res.
10.	Rio Piedras to Caguas, Puerto Rico	15.1, 0.8 - Downtown - Street	H	1&2	Multiple
		4.7 - City - Arterial	M-H	2&3	Com., Res.
		9.6 - Sub. - Fwy. & Exp.	L-M	2	Multiple

[a]L, M and H stand for low, medium and high traffic density respectively.

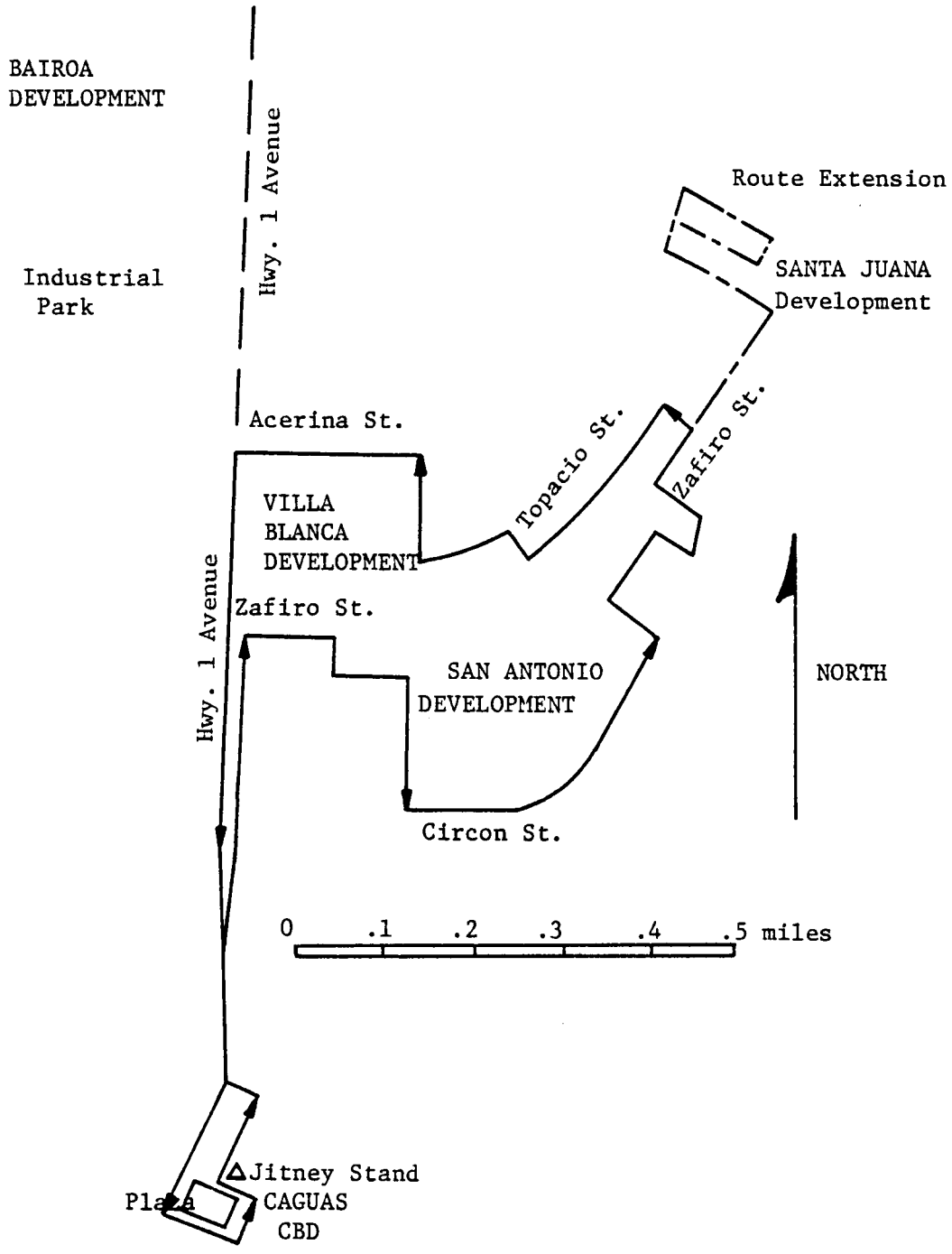


FIGURE A-1

CAGUAS TO VILLA BLANCA JITNEY ROUTE

developments provide medium density, single residential units. The route serves a loop around the residential area, always following the same direction but allowing for some deviations and modifications of the route traversed. A private bus line also provides service from downtown to this area, always following its assigned route.

Route 2

This route serves Chattanooga's city center and areas east of the city center (see Figure A-2). In 1972, Chattanooga had an urban area population of 261,000 within 216 square miles (42). Briefly, operators cruise west to east starting from Patten Square, then along East 9th Avenue, north along Magnolia and Palmetto streets, then east on East 3rd Avenue to North Orchard Avenue where the principal residential area serviced by jitneys is located. The return trip follows approximately the same route except for taking McCallie Avenue instead of East 9th Avenue to reach downtown. Since this service is provided by five-seat sedans and is a very personalized service, deviations and modifications to the route are the rule rather than the exception. Various transit routes traverse segments of the east-west avenues traveled by jitneys, and two bus routes serve the same general corridor. Also, frequent dial-a-ride service provided by the Chattanooga Human Services Department along East 3rd Avenue can be observed.

Route 3

This route serves Atlantic City along its longitudinal north-south axis (see Figure A-3). In 1972, Atlantic City had an urban area

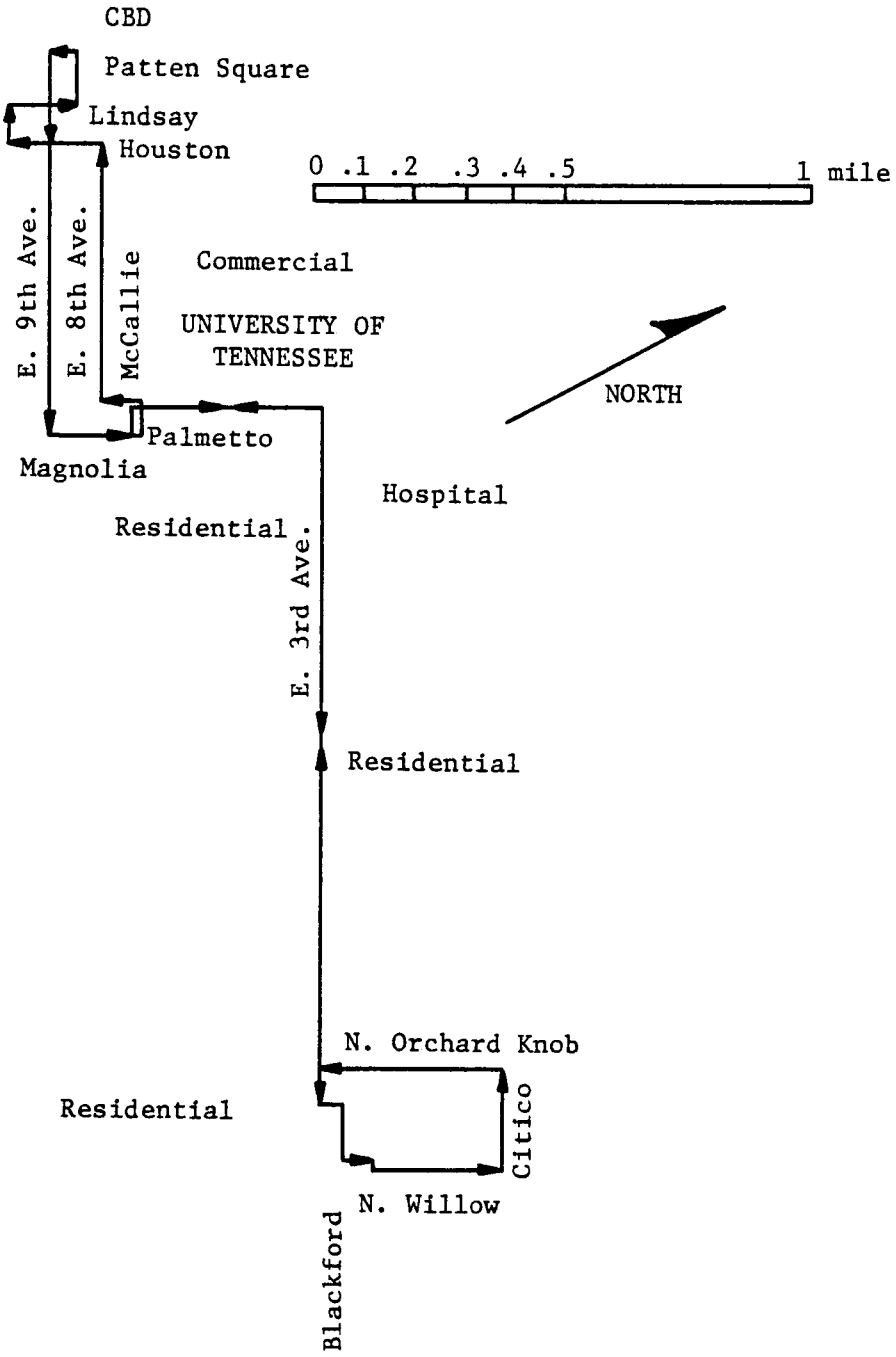


FIGURE A-2

CHATTANOOGA'S CRUISING CAB ROUTE

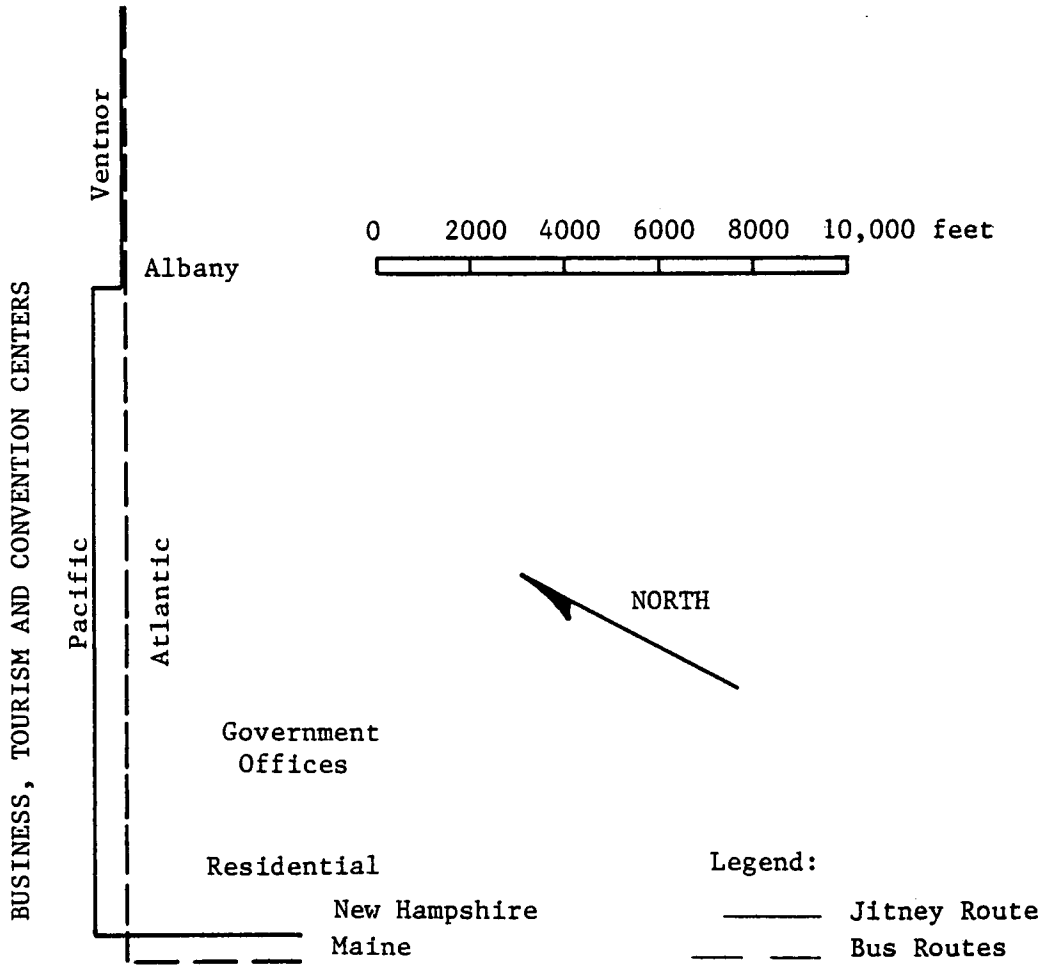


FIGURE A-3

ATLANTIC CITY JITNEY ROUTE

population of 147,000 within 78 square miles (42). Operators continuously cruise on principal avenues traveling New Hampshire from Caspian to Pacific, along Pacific from New Hampshire to Albany, along Albany from Pacific to Ventnor and along Ventnor from Albany to Jackson. The first and last segments are mostly medium density residential areas, while the Pacific and Albany segments have multipurpose land uses typical of downtown areas, plus very dominant hotel and convention facilities. Observations were made during the off-season for tourism when personal travel was conducted principally by permanent residents as may be found elsewhere. Bus transit routes parallel most of the jitney route with an overlapping segment along Ventor Avenue.

Route 4

This route serves from Bayamon to the Bayamon Regional Hospital going through the Lomas Verdes development (see Figure A-4). Bayamon is the westernmost of the major activity centers of the San Juan urbanized area. In 1972, San Juan had an urban population of 883,000 within 140 square miles (42). This route is served by jitneys dispatched at three minute intervals going south from downtown along Route 174, then southwest along Laurel Avenue, looping around Lomas Verdes development, then reentering Route 174 before arriving to the Bayamon Regional Hospital. The return trip follows the same general route and dispatch procedures except for looping around a different section of the Lomas Verdes development. This route serves a medium size activity center (the regional hospital) in addition to the corridor joining downtown to a residential area. An off-street terminal is located within the

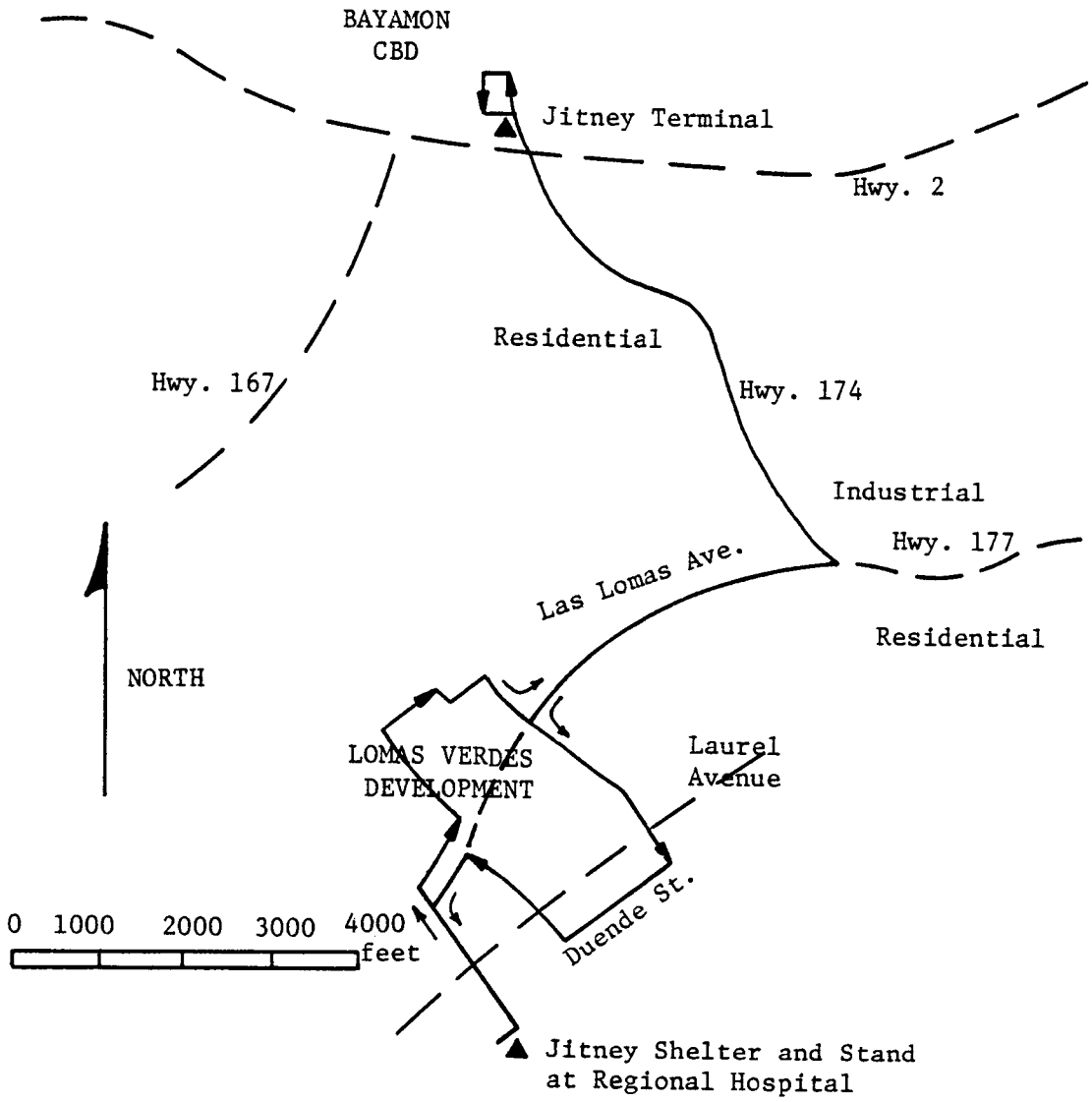


FIGURE A-4

BAYAMON TO REGIONAL HOSPITAL JITNEY ROUTE

downtown area, and a stand with a shelter is provided within the hospital grounds. A bus transit route provides peak-period service along most of the route, and other jitney routes overlap some segments of Route 4.

Route 5

This route serves from Bayamon to the Sabana Seca suburban ward traversing the Sierra Bayamon development (see Figure A-5). Jitneys depart from the downtown terminal when they have reached a predetermined load. They travel west along Betances to Highway 855, then to Highway 2, and then north along North Main to serve the Sierra Bayamon development. The jitney route turns west on 35th Street leading to Highway 872 as it reaches the suburbs. Highway 872 is followed until reaching the Sabana Seca ward where a counterclockwise loop is made via Highway 867 back to Highway 872. The return trip follows the same route in the reverse direction but may deviate as it gets to the Sierra Bayamon development to drop passengers or to reach the terminal faster. The bus transit terminal adjoins the jitney terminal making both services complementary. Other jitney routes overlap segments of this route.

Route 6

This route serves from Rio Piedras to the Campo Rico development (see Figure A-6). Rio Piedras is the principal activity center located in the geographical center of the San Juan urbanized area. Before 9:00 a.m., jitneys cruise along their designated route; afterwards they depart from the downtown stand after making a queue to

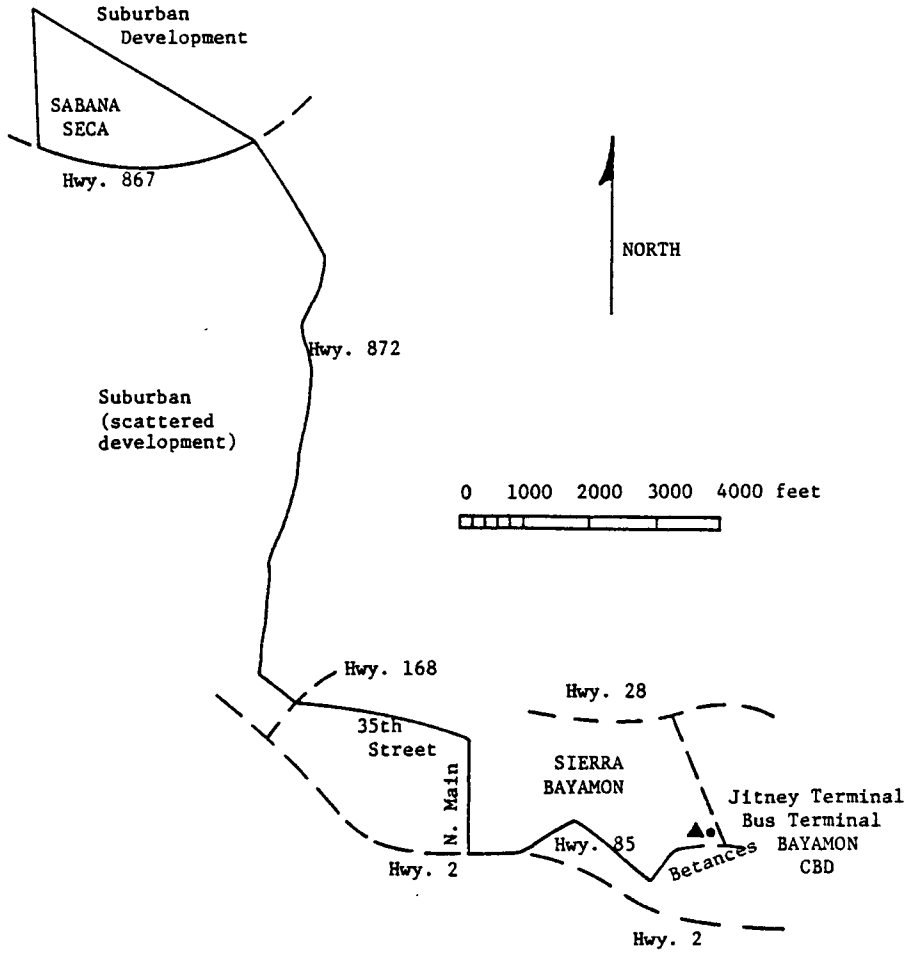


FIGURE A-5

BAYAMON TO SABANA SECA JITNEY ROUTE

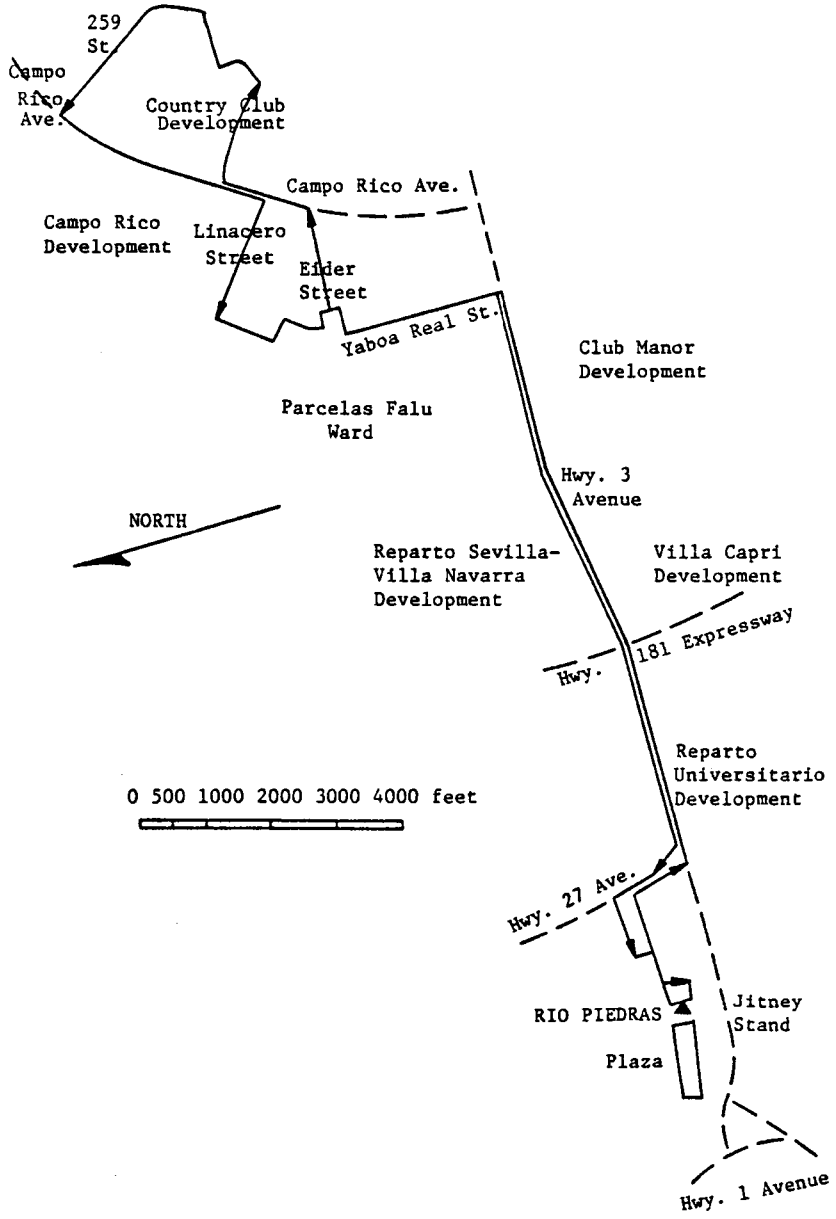


FIGURE A-6

RIO PIEDRAS TO CAMPO RICO JITNEY ROUTE

share a load of passengers. From downtown, they move east along Arzuaga Avenue until reaching Barbosa Avenue. They travel south along Barbosa, then east along Highway 3; the latter is bordered by commercial and high density residential buildings. As jitneys reach Yaboa Real they go northbound through the Country Club and Campo Rico developments. At these medium density residential areas they make a loop to return along the same roadways to downtown Rio Piedras. A bus transit route serves about the same corridor but does not make the circuitous loop made by jitneys at the Campo Rico and Country Club developments. Several jitney routes share the Highway 3 segment.

Route 7

This route serves Bayamon to Riverview and the Rio Hondo developments (see Figure A-7). Before 9:00 a.m., jitneys cruise along the route; thereafter they depart from the downtown terminal after making a queue to share a load of passengers. The route goes west along Betances Avenue, then along Highway 855, and shortly after turns right at B Avenue into Sierra Bayamon development. Going through Sierra Bayamon, Highway 168 is reached leading north to the Riverview development. Going through Riverview, Comerio Avenue is reached leading north to the Rio Hondo development. A loop is made within Rio Hondo before turning back through about the same corridor. Deviations within the developments are common even though the same principal avenues are followed most of the time. All developments are medium density residential. The bus transit terminal adjoins the jitney

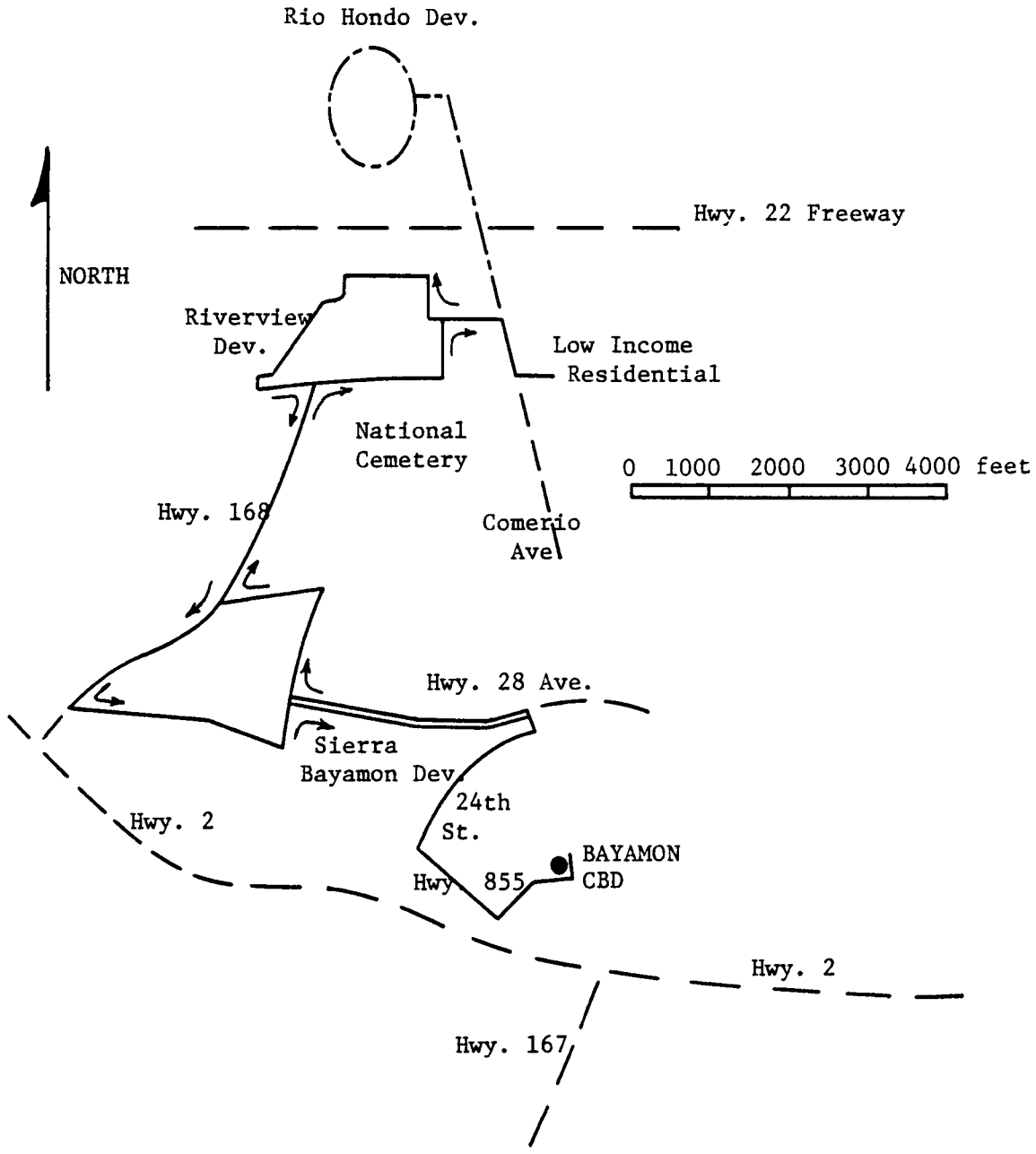


FIGURE A-7

BAYAMON TO RIVERVIEW JITNEY ROUTE

terminal making both services supportive of each other. Other jitney routes overlap the initial segments of this route.

Route 8

This route serves from Rio Piedras to Caimito Bajo and the Caimito Alto suburban wards (see Figure A-8). Before 9:00 a.m., jitneys cruise the long route to Caimito Alto unless the vehicle is filled up with passengers that want to go downtown before the jitney reaches the residential end. After 9:00 a.m., jitneys depart from the downtown stand after making a queue to share a load of passengers; at this time one van goes to Caimito Bajo and the next to Caimito Alto. The route goes south away from the center of Rio Piedras traveling about four miles along Highway 1; this corridor is principally bordered by commercial establishments. The route turns southeast at Highway 842 and continues until reaching the Caimito Bajo ward and then the Caimito Alto ward. Highway 842 is at first suburban and after going through Caimito Bajo turns into a rural highway. Highway 842 traverses very hilly terrain and encounters sharp highway curves. The segment of Highway 842 from Highway 1 to Caimito Bajo is low density residential. Service is shared with another jitney route.

Route 9

This route serves from Rio Piedras to Canovanas via Carolina (see Figure A-9). Carolina is the easternmost of San Juan's major activity centers. Canovanas is a small town east of Carolina at the border of the San Juan urbanized area. Jitneys are dispatched from the downtown

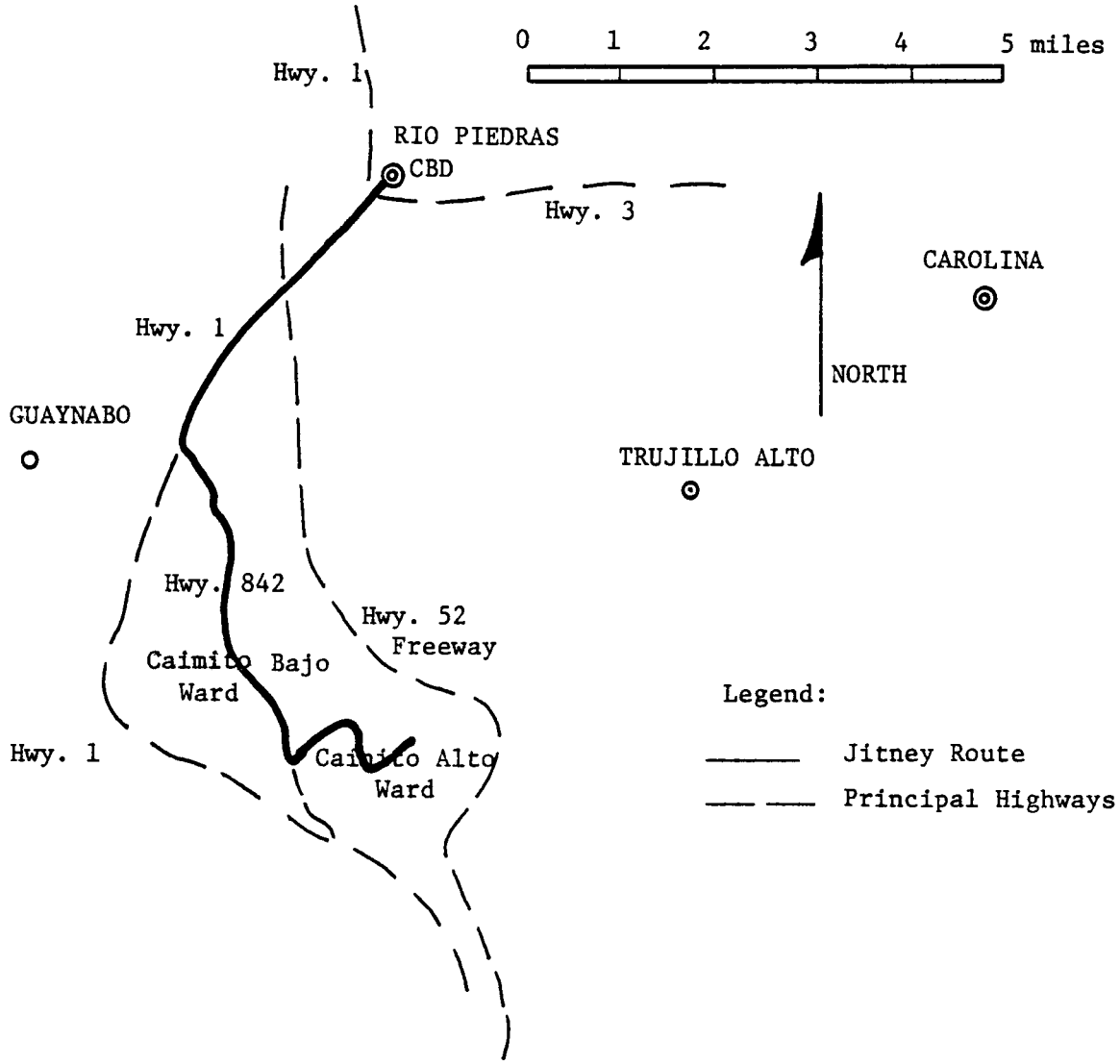


FIGURE A-8

RIO PIEDRAS TO CAIMITO BAJO AND TO
CAIMITO ALTO JITNEY ROUTES

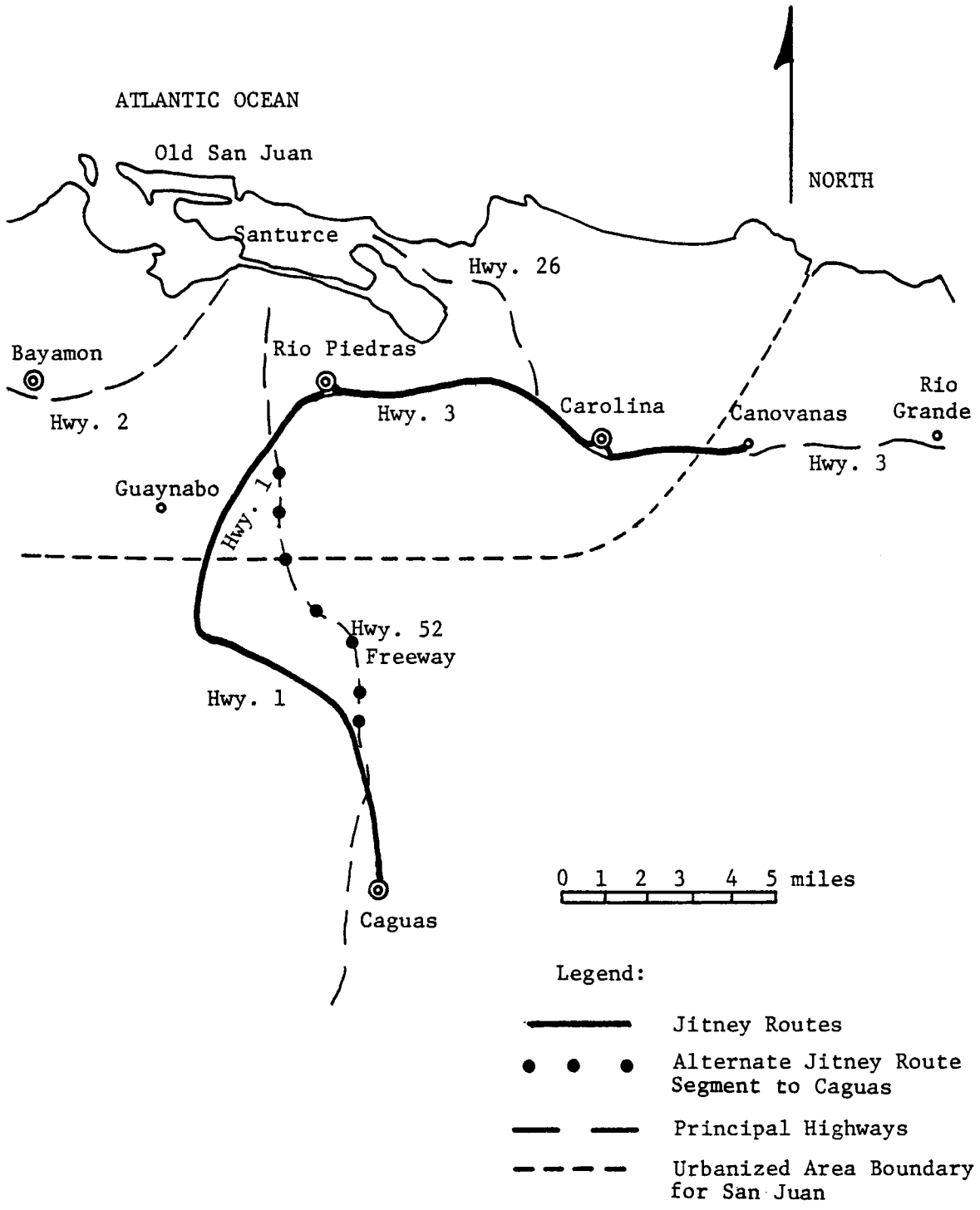


FIGURE A-9

JITNEY ROUTES FROM RIO PIEDRAS TO CANOVANAS
AND FROM RIO PIEDRAS TO CAGUAS

terminal after making a queue to share a load of passengers. Often drivers keep cruising along the route rather than making the queue, however, operating in this manner they cannot pick up passengers at the downtown stand. Jitneys leave downtown through Robles Street, turning south into Highway 27, and then moving east via Highway 3. The route deviates briefly from Highway 3 to enter Carolina and then proceeds to Canovanas through the suburban segment of Highway 3. At Canovanas jitneys enter the town through Highway 958, turn around the city plaza and make another queue at the local stand before being dispatched back to Rio Piedras. Various bus transit routes and several jitney routes overlap the segment from Rio Piedras to Carolina, while only a few jitney routes overlap service along the suburban segment of Highway 3.

Route 10

This route serves from Rio Piedras to Caguas (see Figure A-9). This is an intercity route that traverses a medium density corridor with residential, commercial and industrial activities along most its length. Caguas is to some extent a dormitory city for the San Juan urbanized area. Jitneys are dispatched from the Rio Piedras stand after making a queue to share a load of passengers. Some jitneys cruise for passengers but cannot make pick-ups at the stand. Jitneys drive south along Highway 1 for about 15 miles before arriving to downtown Caguas. Another queue is then made at the Caguas stand before being dispatched back to Rio Piedras. However, if no passenger has a destination at an intermediate point on Highway 1 and the vehicle has

a reasonable load, the driver may decide to take the toll freeway to Caguas. A private bus line serves essentially the same route but at a lower fare. Various jitney routes overlap the line haul segment of this route.

APPENDIX B

FORMS USED IN FIELD SURVEYS

1. Time and Distance Traveled--On-board
2. Arrivals and Departures--Roadside
3. Time and Mileage Reading--Jitney-driver

Route:_____ Veh. No._____ Seat Cap._____ Date:

Bound To:_____ M.P.G._____

Comments:

22 22

21 21

20 20

19 19

18 18

17 17

16 16

15 15

14 14

13 13

12 12

11 11

10 10

9 9

8 8

7 7

6 6

5 5

4 4

3 3

2 2

1 1

Location	Movement	Mileage	In	Out	On	Time	Comments
Sitio	Movimiento	Millaje	Entran	Salen	Dentro	Hora	Comentarios

Form 1. Time and Distance Traveled--On-board

Route:_____ Period:_____ to_____ Date: _____

Authorized Veh._____ Average Operating: Peak_____ Off-peak_____

Comments:

Veh. Num.	Llega	Sale	Llega	Sale	Llega	Sale	Llega	Sale
Veh. No.	Arrive	Depart	Arrive	Depart	Arrive	Depart	Arrive	Depart
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								

Form 2. Arrivals and Departures from Stand

Dear Cruising Taxi Operator:

A study of cruising taxis and jitneys is being undertaken by The University of Tennessee. It intends to provide better understanding of your operations to promote your services in Chattanooga and other cities. Can you provide us with the following information of your next trip?

Time of departure _____ Odometer reading _____

Time at end or route _____ Odometer reading _____

Time at arrival _____ Odometer reading _____

Thank you for your cooperation.

Carlos R. Bonilla
Research Assistant
Transportation Center
University of Tennessee

Form 3. Time and Mileage Readings

APPENDIX C

AIR POLLUTANT EMISSIONS

Air pollutants are emitted by mobile and stationary sources. Private autos are the primary mobile source of air pollutants while industry, dwellings, commerce, and power generation plants share responsibility as principal stationary sources. Air pollution generated by transportation modes accounts for about 60% of total emissions in major United States metropolitan areas (64).

Increased use of transit frequently is considered an effective means to reduce air pollution problems created by transportation. Yet, its greatest contribution may come from reducing pollution in localized sectors where pollutant levels exceed region-wide concentration. Region-wide pollution averages are a measure of pollutant concentration usually affecting an entire urban area and beyond. Localized concentrations affect sectors such as an activity center, a transportation corridor or any particular areas that because of weather, topograhic or man made conditions are subjected to higher levels of pollutants thus creating pockets of much higher pollutant concentration than region-wide averages. Vehicular emissions tend to create severe problems of localized pollution and thereby a shift to increase vehicle occupancy including transit and paratransit may prove beneficial.

Several vehicular emissions have been identified as air pollutants, five of which can be classified as important health hazards. Those include carbon monoxide, hydrocarbons, nitrogen oxides, sulfur

oxides and particulate matter. Carbon monoxide and hydrocarbons are emitted through the exhaust pipe as a product of the incomplete combustion of fuel during operation of an internal combustion engine. Hydrocarbons also are emitted from the carburetor and fuel tank as a result of evaporation. Nitrogen oxides are produced when oxygen and nitrogen (always present in air) combine under heat and pressure of the internal combustion engine (65). Sulfur oxides result from the original sulfur in petroleum that remains in the fuel through the refining process. Particulate matter such as smoke is an outcome of incomplete combustion and of additives like lead compounds.

Carbon monoxide, hydrocarbons and nitrogen oxides are of particular interest because their impact extends from specific locations to entire regions and because the private auto is the principal offender. Carbon monoxide produces most hazardous conditions along transportation corridors and at activity centers. Emissions of hydrocarbons and nitrogen oxides are associated more with region-wide pollution and usually become a serious problem after they are discharged into the atmosphere and are exposed to sunlight. The ensuing reaction results in photochemical smog composed of particulate matter, ozone, other oxidants and complex organic compounds (65).

The generation of air pollutants by surface vehicles is a highly complex process which is affected by several factors such as speed, hot to cold cycles, stop and go operations, ambient temperature and vehicle maintenance. The Environmental Protection Agency (EPA) has developed procedures for estimating emission rates of various vehicle types operating under different conditions (47). Yet, EPA procedures

require an understanding of their detailed methods and of the transportation system being considered. It also requires extensive manipulation of their tables and formulas for computation of modal emissions. For preliminary planning purposes, a simplified approach may be more desirable.

By examining EPA procedures, it can be demonstrated that the mix of vehicles by year of manufacture and average speed of vehicles are, on the average, the more important factors affecting emissions. The hot to cold cycle factor is relevant but closely associated with environmental temperature and thereby is too complicated to make simple generalizations.

EPA provides emission rates for light duty vehicles, light duty trucks and heavy diesel vehicles according to the year models were manufactured. Assuming or knowing the yearly mix of vehicles providing a specific service, such as an even distribution among the latest six years, it is simple to determine the average emission rate of a fleet of vehicles based on EPA tables (47). Table C-1 shows emission rates for a "typical" mix of private auto, jitney sedan, jitney van, minibus, midsize bus and a full-size bus based on an average speed of 19.6 mph.

EPA has developed speed factor equations to modify base emission rates and provide a better estimate of pollutant emissions depending on average travel speed by roadway segment. Different sets of speed factor equations have been developed for various year models to account for engine design changes, but the results are very similar

TABLE C-1

MODAL EMISSION RATES
(1978)

Mode[a]	Model Mix[b]	Emissions (grams/mile)[c] CO	HC	NOX
Private Auto (gas)	All years	35.1	7.2	3.5
Jitney Sedan (gas)	8 years	53.3	4.8	3.0
Jitney Van (gas)	6 years	45.3	4.2	2.6
Minibus (diesel) @ 0.5 of full size	6 years	14.2	2.3	10.2
Full-size Bus (diesel)	12 years	31.7	4.4	20.9

[a]Mode refers to the specific vehicle and type of service on which it is used. Since no information is available for the diesel powered minibus, it is assumed to emit 0.5 as much pollutants as a full-size bus.

[b]Model mix refers to the years vehicles were manufactured that are actively engaged in a specific service type. The model mix factors used for determining emissions account for emission controls built into vehicles manufactured during the years the model mix column specifies. The X-number of years specified indicate vehicles were manufactured during the most recent X-years, uniformly distributed among those years. All years implies a distribution as found over existing roadways. Sources: Supplement No. 5 to AP-42: Compilation of Air Pollutant Emission Factors, Environmental Protection Agency, Washington, D.C., December 1975; Mobile Source Emission Factors, Environmental Protection Agency, Washington, D.C., January 1978.

[c]Emission rates are based on EPA reference conditions: speed = 19.6 mph, ambient temperature = 75°F.

and close enough to preserve the relationship between modes. Thereby, the following set can be used for gas powered vehicles (47).

$$GSF_{CO} = \exp\ (1.241 - 0.00752\ S + 0.000609\ S^2)$$

$$GSF_{HC} = \exp\ (0.943 - 0.0592\ S + 0.000567\ S^2)$$

$$GSF_{NOX} = 0.843 + 0.00804\ S$$

For diesel powered vehicles the following speed factors can be used (48):

$$DSF_{CO} = \exp\ (1.20 - 0.072\ S + 0.0006\ S^2)$$

$$DSF_{HC} = \exp\ (0.820 - 0.051\ S + 0.0005\ S^2)$$

$$DSF_{NOX} = \exp\ (0.720 - 0.054\ S + 0.0009\ S^2)$$

The variables used are as follows:

GSF stands for gasoline speed factor and DSF for diesel speed factor, CO, HC, and NOX subscripts stand for their respective pollutant, and S stands for speed.

The above equations are valid for a speed range of 15 to 50 mph, but for preliminary estimates may be used for speeds as low as 5 mph.

APPENDIX D

PROGRAM CORRIDOR

General Description

This program incorporates operating characteristics of various modes traveling along a designated corridor. Each mode inputs and outputs are considered separately to allow for comparison between modes serving the same corridor but not necessarily the same route during selected periods of the day. For example, while serving a given corridor, a bus route makes use of a reserved bus lane to go through downtown and makes left turns prohibited to others.

Since it is possible to simulate operating conditions of various modes serving the same corridor, comparisons of cost, quality or service, fuel consumption and emissions also can be made. The program allows the user to vary several input parameters to simulate local conditions as close as possible.

Figure D-1 presents a general flow chart of the computer program. The title of the program is determined by the program user. Then the period of the day is selected as an initial program input. General vehicular operating data is specified next. Itemized cost parameters such as on driver wages per hour, tire cost per vehicle mile and vehicular annual depreciation are introduced. Cost related ratios or factors also are made part of the input; these will be discussed later. Finally, specific service data such as modal average speed by type of roadway is entered.

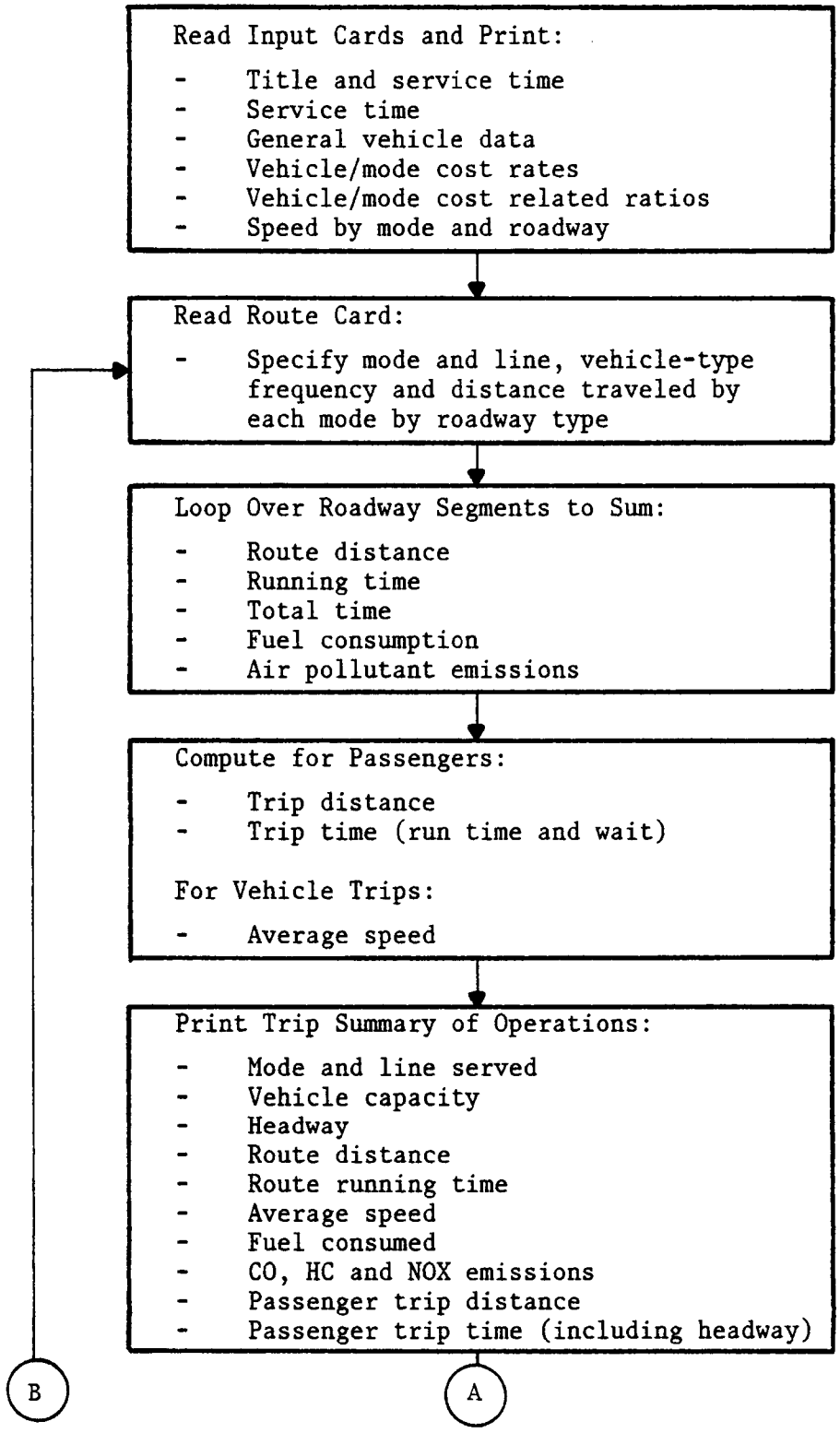


FIGURE D-1

CORRIDOR PROGRAM GENERAL FLOW CHART

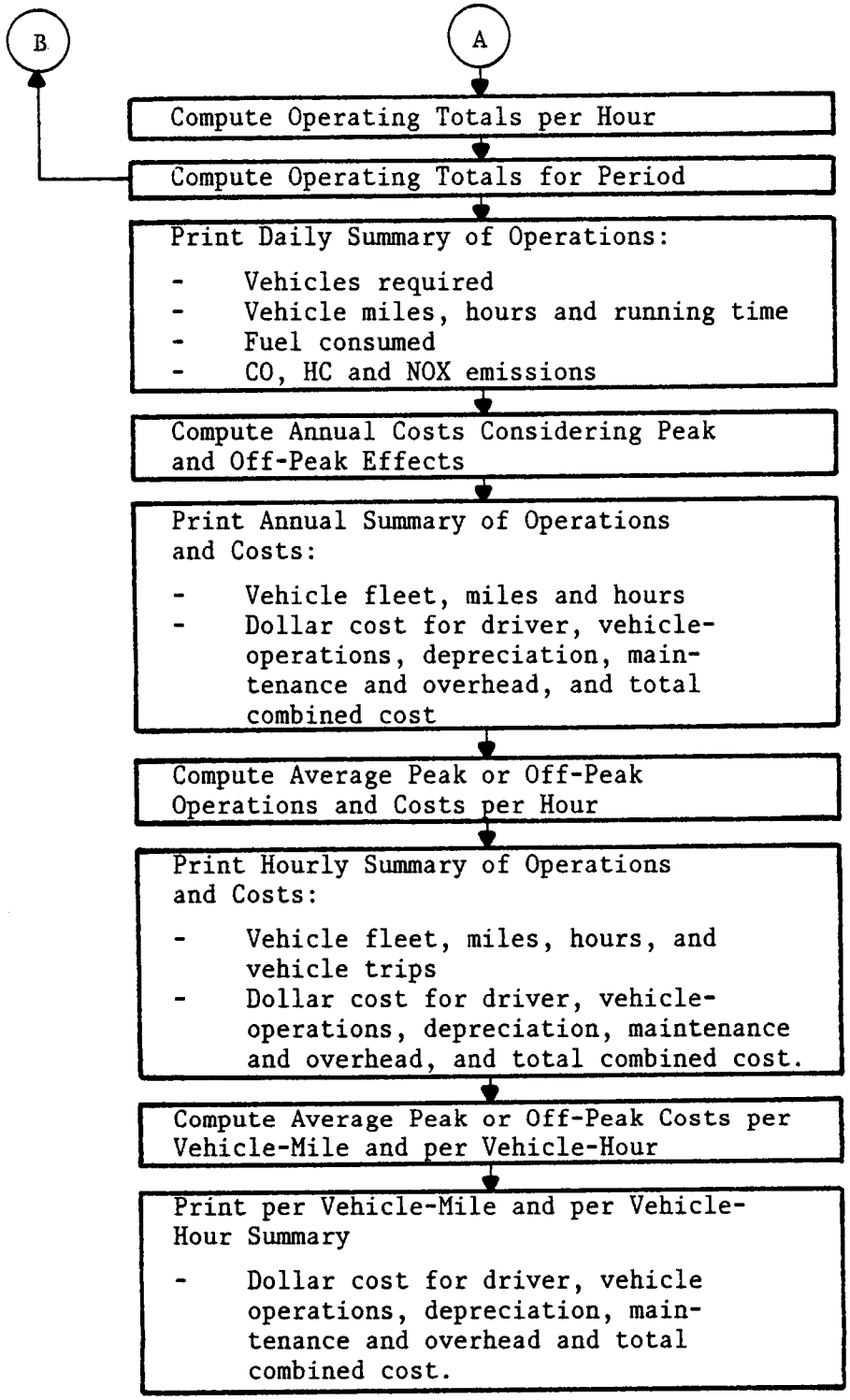


FIGURE D-1 (Continued)

The program then loops over the various segments constituting a route to determine vehicular round-trip time, distance, average trip speed (rather than by segment), trip fuel consumption and emissions. Passenger trip distance is approximated as two-thirds of the vehicle trip distance, and passenger trip time is computed as half of headway time plus on-board travel time. Passenger trip data is provided by typical passenger trip length, based on relationships established in Chapter 4. The above information then is printed as a Trip Summary of Operations for the time period selected (peak or off-peak).

Next, operating totals are computed per hour and per period. A Daily Summary of Operations is printed to include number of vehicles required for service, vehicle miles, vehicle hours and hours running. Fuel consumed and air pollutant emissions also are printed.

Annual operations and costs then are computed based on the effect of peak or off-peak service characteristics on route operation. Daily vehicle-miles and vehicle-hours are annualized by means of a service factor that accounts for the level of service provided by period. Peak period service is assumed to be provided daily during weekdays (approximately 250 days a year) and off-peak service is provided every day (factored to 300 days a year). Fleet size is determined considering vehicles required to operate at a selected level plus those available for maintenance. Daily operating buses are multiplied by a size factor of 1.15 to determine total fleet size. Jitney route operations also require extra vehicles because even though on the average up to 90% of all authorized operators show up for peak service, most maintenance is performed during off-peak hours. Total jitney fleet is determined by

multiplying daily operating vehicles by a size factor of 1.5 during either peak or off-peak period. Annual costs are allocated to driver wages, vehicle operations (gas, oil and tires), depreciation, maintenance and overhead. An Annual Summary of Operations and Costs is printed.

The program then computes for the route, average operations data and cost per hour. The computations are very simple and will not be discussed, but the printed output is necessary for service and cost assessment. Vehicle fleet, vehicle-miles, vehicle-hours and vehicle-trips per hour are printed first. Average dollar cost per hour of service also is printed for driver, vehicle operations, maintenance and overhead, depreciation and total combined costs. Separate runs must be made to obtain peak and off-peak period outputs.

Last, the program computes average costs per vehicle-mile and per vehicle-hour. The computations are simple, but the printed output is provided to simplify cost assessment. Average dollar costs per vehicle-hour and per vehicle-mile are printed for driver, vehicle operations, maintenance and overhead, depreciation and total combined costs. Peak and off-peak period outputs must be obtained through separate program runs. After going through the previous computation, the program ends unless an additional set of route cards has been provided.

Program Inputs for Operation

The Corridor program has very flexible input. Parameters can be selected by the user to match local conditions, and some can be allowed to default to those provided with the program input cards. Minimum information required for operating the program is as follows:

1. Period length of service to be investigated;
2. Service period: peak or off-peak;
3. Total hours per day that system operates;
4. Vehicle type designated by average seating capacity, i.e., 14 seats designates a jitney, 45 seats designates a transit bus;
5. Frequency of vehicles past a given point; and
6. Distance of each roadway segment to be traversed.

With the above information, corridor service may be defined in detail to match local conditions and desirable characteristics of selected modes. As an example, through the use of the Corridor program, alternate corridor service can be simulated such as to serve from downtown Jacksonville to Cedar Hills by bus or jitney. If the Jacksonville Transit Authority bus route #30 travels 1.0 mile through downtown collectors, 3.6 miles through fringe collectors, 4.3 miles through residential collectors and 1.5 miles through residential locals, operations through those route segments can be simulated by means of the Corridor program. An alternate jitney route could follow a different alignment such as to provide higher accessibility or may follow exactly the same streets as the bus route. Specifying periods and frequency of service permits extensive description of operations but requires less effort than full simulation considering network description as done by the Urban Transportation Planning System (UTPS) programs.

The program also allows for the selection of service mode parameters concerning vehicle operations, unitary cost, cost-related ratios and vehicular speed by roadway type traveled. All these parameters have been provided to represent typical conditions in American cities as selected from available literature and/or based on

the author's judgment. Whenever more reliable local information is available, parameters should be modified, as appropriate. However, most values provided by input cards are related because the vehicle used usually defines the service mode and care should be exercised when changing values in any of the input cards. The parameter data cards included with the Corridor program refer to only six modes used in corridor transportation. They are the private auto, a 5-seat cruising jitney, an 11-seat stand-dispatched jitney, a 14-seat stand-dispatched jitney, a 20-seat transit minibus and a 45-seat full-size transit bus.

The operating data card specifies fuel type, either gasoline or diesel, and the dollar cost per gallon. It should be evident that emissions, fuel consumption rates and fuel type are related not only to vehicle used but also to type of service provided. For example, the minibus selected uses diesel fuel and has lower fuel consumption and emission rates than a full-size bus. Yet, because it is used in non-freeway corridor service, fuel consumption rates are based on stop and go operations rather than on steady speed such as may be encountered by an express bus traveling through uncongested freeways. Adjustments can be made to simulate different services, provided the program user can adjust the program provided input cards accordingly.

The cost data card specifies dollar allocations for drivers per vehicle hour, and for tires and oil per vehicle mile. Also included are annual cost for depreciation, insurance, administration, maintenance, advertising and traffic, dispatching and transportation (such as tolls and parking), and taxes and licenses.

Cost related ratios are multiplication factors used to adjust results obtained from service parameters and variables to reflect actual needs and practices. The size-factor accounts for the fleet-size required to operate a route and includes vehicles undergoing repairs or maintenance. In the case of jitneys extra vehicles are required to replace operators not showing up for work, taking time off for vehicle maintenance or personal business. Jitney service from a stand may require additional vehicles to form queueing lines but this is offset by flexible operations such as resorting to cruising during peak periods, to increase capacity.

Deadheading factors account for additional mileage required to operate from a central garage such as with bus transit. The base period pay hours correction factor reflects additional wages received by transit drivers over their base pay level (a cost analysis performed for the Metropolitan Transit Commission in Minneapolis-St. Paul indicates that the base period has 14% more pay hours than vehicle-hours (66). The peak period labor usage reflects the ratio of peak driver participation during all peak hours.

The so called off-ratio factor accounts for excess resources required in vehicles and manpower to provide peak-period services. This factor is the ratio of all vehicles required to operate a system during off-peak hours to the vehicles required to operate a system during peak hours. Where the service under consideration constitutes a route addition or modification to an existing bus system, total system vehicle requirements should be considered. In the case of jitneys where routes are independent, this ratio should only consider vehicles

operating the route under investigation. Appendix E explains the theory behind the off-ratio factor used in the program.

Data on speed of vehicles by roadway type attempts to predict average travel speed of the various modes selected. The information was primarily obtained from Characteristics of Urban Tranportation Systems (CUTS) (55). Auto speeds for arterial and expressway roadways were taken from Table 34 of CUTS. Local street speeds for auto were assumed as 15 miles per hour. Speeds for bus transit were derived from Table 18 of CUTS. Jitney speeds are an interpolation between auto and bus transit based on judgment by this author and speeds observed during field studies. It is recognized that speeds may vary from one location to another as well as during different periods of the day and year. The speed input cards provided by the program can be changed by the user, who is encouraged to make adjustments whenever local conditions suggest different values.

Program Listing

Figure D-2 lists the Corridor computer program used in the simulation of jitney, bus and other route service.

Typical Program Input

This subsection lists typical card input to the corridor computer program. The cards listed are the same as used for running the peak period simulation for the Jacksonville Scenario explained in Chapter 6. However, note that part of the input cards are required to describe the corridor under investigation and must be provided by the program user.

```
C
C
C     ---------------------
C     ***PROGRAM CORRIDOR***
C     ---------------------
C
C     MODEL TO SIMULATE OPERATING CONDITIONS OF VARIOUS TRANSPORTATION MODES
C SERVING MEDIUM DENSITY TRAVEL CORRIDORS. AUTO, JITNEY AND BUS ARE BUILT-IN
C MODES BUT, ADDITIONAL MODES MAY BE INTRODUCED OR SUBSTITUTED.CHANGING DATA
C CARDS ALLOWS TO VARY SEVERAL PARAMETERS TO SUIT LOCAL CONDITIONS SUCH AS COST
C PER GALLON OF FUEL,SPEED BY TYPE OF ROADWAY, ETC. SOME CONCEPTS FOR THIS
C MODEL WERE DERIVED FROM THE 'LINEHL' PROGRAM BY J. BATCHELDER AND L. TSAI
C
C ------------------------------------------------------------------------------
C
      DIMENSION TITLE(20),DAYPER(2)
      DIMENSION FLTYP(6),CPGAL(6),CORAT(6),HCRAT(6),FPHR(6),FPVM(6,10)
      DIMENSION CLABOR(6),CTIRE(6),COIL(6),CDEPR(6),CINS(6),CADMIN(6),
     1  CMAINT(6),CADVTF(6),CDISPA(6),CTXLIC(6)
      DIMENSION DIST(16),SPEED(6,16),MODLIN(3),IVTYP(6)
      DIMENSION VMPHR(6),VHPHR(6),RNPHR(6),FUELHR(6),COPHR(6),HCPHR(6),
     1 TRIPS(6)
      DIMENSION VMTOT(6),VHTOT(6),RNTOT(6),FLTOT(6),COTOT(6),HCTOT(6),
     1 NVTOT(6)
      DIMENSION OFFPK(2),SIZFAC(6),DEDHED(6),OFRATO(6),BPPH(6),PPLU(6)
      DIMENSION AVM(6),AVH(6),ACDEPR(6),ACDRV(6),ACOPS(6),ACOVHD(6),
     1 ACTOT(6)
      INTEGER OUP,VTYP,CAPY(6),FLEET(6)
      REAL          NOXPTR,NOXRAT(6),NOXPHR(6),NOXTOT(6)
      DATA DSL/'DSL'/,INP/5/,OUP/6/,IVTYP/6*0/
      DATA OFFPK/'OFF-','PEAK'/
C
C READ AND PRINT TITLE
C
      READ(INP,1000)TITLE
1000  FORMAT(20A4)
      READ(INP,1005)PRDLEN,NVTYP,DAYPER,DAYHRS
1005  FORMAT(F5.1,I5,2X,2A4,F5.1)
      WRITE(OUP,1010)TITLE,PRDLEN,DAYPER,DAYHRS
1010  FORMAT(1H1,20A4/8X,'PERIOD DURATION  ',F5.1,' HOURS :',2A4/' DAILY
     1 HOURS OF SYSTEM OPERATION :',F5.1)
C
C  READ AND PRINT VEHICLE DATA-GENERAL
C
      WRITE(OUP,1020) (J,J=5,50,5)
1020  FORMAT(/34X,'********** VEHICLE/MODE PARAMETER CARDS **********',
     1  /' OPERATING DATA'/69X,'FUEL CONSUMPTION'/
     2           2X,'CAPACITY FUEL  FUEL   EMISSIONS(GMS/V-M)',3X,
```

FIGURE D-2

CORRIDOR PROGRAM

```
     3 'GAL/V-M',3X,22(1H-),' GAL/V-M ',23(1H-)/11X,'TYPE',2X,'$/GAL',3X
     3,'CO',4X,'HC',3X,'NOX',6X,'IDLE',I5,9I6)
      DO 6 I=1,NVTYP
      READ(INP,1030) CAPY(I),FLTYP(I),CPGAL(I),CORAT(I),HCRAT(I),NOXRAT(
     1 I),FPHR(I),(FPVM(I,J),J=1,10)
1030  FORMAT(I4,1X,A3,2X,F5.2,3F5.1,F5.3,1X,10F4.3)
      WRITE(OUP,1040)CAPY(I),FLTYP(I),CPGAL(I),CORAT(I),HCRAT(I),NOXRAT(
     1 I),FPHR(I),(FPVM(I,J),J=1,10)
1040  FORMAT(I3,4X,A3,F6.2,2X,3F6.1,4X,11F6.3)
    6 CONTINUE
C
C  COST RELATED VEHICLE/MODE RATES
C
      WRITE(OUP,1050)
1050  FORMAT(///              ' COST DATA'//2X,'CAPACITY   DRIVER',6X,
     1 'TIRES',6X,'OIL     DEPREC  INSUR    ADMIN   MAINT  ADV&TF  DISPA
     2  TAX&LIC')
      DO 7 I=1,NVTYP
      READ(INP,1070)CLABOR(I),CTIRE(I),COIL(I),CDEPR(I),CINS(I),CADMIN(I
     1),CMAINT(I),CADVTF(I),CDISPA(I),CTXLIC(I)
1070  FORMAT(F8.2,2F8.3,7F8.0)
      WRITE(OUP,1080)CAPY(I),CLABOR(I),CTIRE(I),COIL(I),CDEPR(I),CINS(I)
     1   ,CADMIN(I),CMAINT(I),CADVTF(I),CDISPA(I),CTXLIC(I)
1080  FORMAT(4X,I4,F10.2,2X,2F10.3,2X,7F8.0)
    7 CONTINUE
C
C  READ COST RELATED RATIOS
C
      WRITE(OUP,1082)
1082  FORMAT(///' COST RELATED RATIOS'//2X,'CAPACITY  SIZFAC',4X,'DEDMED
     1',5X,'BPPH',7X,'PPLU',4X,'OFF-RATIO')
      DO 72 I=1,NVTYP
      READ(INP,1083)SIZFAC(I),DEDMED(I),BPPH(I),PPLU(I),OFRATO(I)
1083  FORMAT(5F5.2)
      WRITE(OUP,1084)CAPY(I),SIZFAC(I),DEDMED (I),BPPH(I),PPLU(I),
     1 OFRATO(I)
1084  FORMAT(4X,I4,5F10.2)
   72 CONTINUE
C
C  SPEED BY TYPE OF ROADWAY
C
      WRITE(OUP,1090)
1090  FORMAT(///' AVERAGE RUNNING SPEED BY ROADWAY TYPE'//30X,'CBD',
     1 20X,'FRINGE',15X,'SUBURBAN/RES',15X,'OTHER'/2X,'CAPACITY',3X,
     2 'MODE',4X,'COL   ART   ROW   XWY',3(3X,'LOC   COL   ART   XWY')/
     3 2X,8(1H-),3X,'---- ',4(3X,21(1H-))/)
      DO 8 I=1,NVTYP
      READ(INP,2000)(SPEED(I,K),K=1,16)
```

FIGURE D-2 (Continued)

```
2000  FORMAT(16F5.0)
      WRITE(OUP,2005)CAPY(I),I,(SPEED(I,K),K=1,16)
2005   FORMAT(2(4X,I4),2X,16F6.0)
    8 CONTINUE
      N=1
   82 WRITE(OUP,2010)TITLE,N,DAYPER
2010  FORMAT(1H1,20A4//2X,'FREQUENCY TEST NO.',I3//2X,'TRIP SUMMARY OF O
     *PERATIONS :' ,2A4//30X,20(1H-),
     1    ' VEHICLE ROUND TRIP ',20(1H-),6X,'PASS-TRIP',7X,'PASS-TRIP'
     2 /' MODE & LINE  VEH  HDWY',7X,
     3 'DIST',5X,'TIME',4X,'TIME',3X,'AVG.',5X,'FUEL',10X,'(GRAMS)',
     4  11X,'2/3-RT-LEN',6X,'TYPICL-LEN'/14X,'CAPY',12X,'(MI)   RUNNING
     5 TOTAL  SPEED',4X,'(GAL)',6X,'CO',5X,'HC',5X,'NOX',5X,'DIST   TIME
     6',5X,'DIST',3X,'TIME'/
     7           1X,12(1H-),1X,4(1H-),1X,4(1H-),7X,21(1H-),2X,5(1H-),4X,
     8 5(1H-),4X,19(1H-),5X,11(1H-),5X,11(1H-)/)
C
C  READ ROUTE CARDS
C
      DO 90 I=1,NVTYP
   10 READ(INP,2020,END=150)MODLIN,VTYP,FREQ,DIST
2020  FORMAT(3A4,I1,F3.1,16F4.1)
      IVTYP(I)=VTYP
      IF(IVTYP(I).EQ.0) GO TO 90
      HDWY=60./FREQ
      RTRUN=0.
      RTTIM=0.
      RTDIS=0.
      FUEL=0.
      COPTR=0.
      HCPTR=0.
      NOXPTR=0.
C
C ***************************************************************************
C  LOOP OVER ROADWAY TYPES
C  DETERMINE ROUND TRIP TIME AND DISTANCE,AVERAGE SPEED, FUEL CONSUMPTION,
C  EMISSIONS PER ROUND TRIP, AND ONE-WAY PASSENGER TRIP DISTANCE AND TIME
C ***************************************************************************
C
      DO 20 K=1,16
      DX=2.*DIST(K)
      IF(DX.LE.0.)GO TO 20
C  ROUND TRIP ROUTE DISTANCE, SPEED, RUNNING TIME AND ROUTE TIME
      RTDIS=RTDIS+DX
      SPD=SPEED(VTYP,K)
      TX=60.*DX/SPD
      RTRUN=RTRUN+TX
      RTTIM=RTRUN
```

FIGURE D-2 (Continued)

```
C
C  FUEL CONSUMPTION
C
      IK=.2*SPD
      IF(IK.LT.1) IK=1
      IF(IK.GT.9) IK=9
      FR=IK
      FR=.2*SPD-FR
      FUEL=FUEL+DX*(FR*FPVM(VTYP,IK+1)+(1.-FR)*FPVM(VTYP,IK))
C
C  EMISSIONS FOR GAS OR DIESEL ENGINES
C
      IF(FLTYP(VTYP).EQ.DSL)GO TO 2040
      COPTR=COPTR+DX*CORAT(VTYP)*EXP(1.241-0.0752*SPD+0.000609*SPD*SPD)
      HCPTR=HCPTR+DX*HCRAT(VTYP)*EXP(0.043-0.0592*SPD+0.0006*SPD*SPD)
      NOXPTR=NOXPTR+DX*NOXRAT(VTYP)*(0.843+0.00804*SPD)
      GO TO 20
2040  CONTINUE
      COPTR=COPTR +DX*CORAT(VTYP)*EXP(1.20-0.072*SPD+0.0006*SPD*SPD)
      HCPTR=HCPTR+DX*HCRAT(VTYP)*EXP(0.820-0.051*SPD+0.0005*SPD*SPD)
      NOXPTR=NOXPTR+DX*NOXRAT(VTYP)*EXP(0.72-0.054*SPD+0.0009*SPD*SPD)
   20 CONTINUE
C
C  DETERMINE PASSENGER TRIP DISTANCE TRIP TIME AND AVERAGE SPEED,
C  ALLOW FOR DIFFERENT RATIOS OF PASSENGER TRIP LENGTH TO ROUTE LENGTH TO BE
C  SUBSTITUTED FOR EACH SERVICE-MODE
C
      IF(VTYP.GT.1) GO TO 2070
      PASDIS=RTDIS/2.
      PASTIM=RTTIM/2. +4.
      GO TO 2080
2070  WAIT=HOWY/2.
      IF(HOWY.GT.25.) WAIT= 12.0
      STDDIS=RTDIS/3.
      STDTIM=RTTIM/3. + WAIT
      IF(VTYP.EQ.2) PASDIS= RTDIS* .44/ 2.
      IF(VTYP.EQ.3) PASDIS= RTDIS* .63/ 2.
      IF(VTYP.EQ.4) PASDIS= RTDIS* .63/ 2.
      IF(VTYP.EQ.5) PASDIS= RTDIS* .41/ 2.
      IF(VTYP.EQ.6) PASDIS= RTDIS* .41/ 2.
      IF(VTYP.EQ.2) PASTIM= RTTIM* .44/ 2. + WAIT
      IF(VTYP.EQ.3) PASTIM= RTTIM* .63/ 2. + WAIT
      IF(VTYP.EQ.4) PASTIM= RTTIM* .63/ 2. + WAIT
      IF(VTYP.EQ.5) PASTIM= RTTIM* .41/ 2. + WAIT
      IF(VTYP.EQ.6) PASTIM= RTTIM* .41/ 2. + WAIT
      IF(VTYP.LE.4) GO TO 2075
C
C  ADD TURNAROUND TIME TO BUS MODES ONLY
```

FIGURE D-2 (Continued)

```
C
      RTTIM=RTTIM+4.0
      IF(RTTIM.GT.50.)RTTIM=RTTIM+2.
      IF(RTTIM.GT.70.)RTTIM=RTTIM+2.
      IF(RTTIM.GT.90.)RTTIM=RTTIM+2.
C
C  ADD FUEL CONSUMED BY BUS IN IDLING
C
      IDLFL=FPHR(VTYP)*(RTTIM-RTRUN)/60.
      FUEL=FUEL+IDLFL
2075  CONTINUE
2080  AVGSPD=RTDIS*60./RTTIM
C
C  TOTALS PER HOUR BY VEHICLE TYPE
C
      NVTOT(VTYP)=RTTIM/HOWY+.9
      VMPHR(VTYP)=RTDIS*FREQ
      VMPHR(VTYP)=RTTIM/HOWY
      RNPHR(VTYP)=RTRUN/HOWY
      FUELHR(VTYP)=FUEL*FREQ
      COPHR(VTYP)=COPTR*FREQ
      HCPHR(VTYP)=HCPTR*FREQ
      NOXPHR(VTYP)=NOXPTR*FREQ
      TRIPS(VTYP)=FREQ
C
C  PRINT TRIP INFORMATION RELATED TO QUALITY OF SERVICE, FUEL CONSUMPTION  AND
C  EMISSIONS WHEN A PARTICULAR VEHICLE/MODE IS SELECTED
C
      WRITE(OUP,2100)MODLIN,CAPY(VTYP),HOWY,RTDIS,RTRUN,RTTIM,AVGSPD,
     1 FUEL,COPTR,HCPTR,NOXPTR,STDDIS,STDTIM,PASDIS,PASTIM
2100  FORMAT(1X,3A4,I4,F6.1,F11.1,1X,2F9.1,F7.1,F9.1,2X,3F7.1,2X,2F7.1,
     1 2X,2F7.1)
   90 CONTINUE
C
C  ***********************************************
C  PERIOD OPERATIONS, VARIOUS COMPUTATIONS
C  ***********************************************
C
      WRITE(OUP,2110)      PRDLEN,DAYPER
2110  FORMAT(         ///2X,'DAILY SUMMARY OF OPERATIONS : PERIOD DURATIO
     1N',F5.1,' HOURS :',2A4)
      WRITE(OUP,2200)
2200  FORMAT(//9X,'VEHICLE    VEHICLES',2(4X,'VEHICLE'),4X,'RUNNING',5X,
     1 'FUEL',11X,'EMISSIONS(GRAMS)'/8X,'CAPACITY',
     2 4X,'REQUIRED',5X,'MILES',2(6X,'HOURS'),4X,'CONSUMED',7X,'CO',7X,
     3 'HC',7X,'NOX'/8X,8(1H-),4X,8(1H-),4X,7(1H-),3(4X,7(1H-)),3X,
     4 26(1H-)/)
      DO 120 IV=1,NVTYP
```

FIGURE D-2 (Continued)

```
      IF(IVTYP(IV).EQ.0) GO TO 120
      VMTOT(IV)=VMPHR(IV)*PROLEN*DEDHED(IV)
      VHTOT(IV)=VHPHR(IV)*PROLEN*DEDHED(IV)
      RNTOT(IV)=RNPHR(IV)*PROLEN*DEDHED(IV)
      FLTOT(IV)=FUELHR(IV)*PRDLEN*DEDHED(IV)
      COTOT(IV)=COPHR(IV)*PROLEN *DEDHED(IV)
      HCTOT(IV)=HCPHR(IV)*PROLEN *DEDHED(IV)
      NOXTOT(IV)=NOXPHR(IV)*PROLEN*DEDHED(IV)
      WRITE(OUP,2210)CAPY(IV),NVTOT(IV),VMTOT(IV),VHTOT(IV),RNTOT(IV),
     1 FLTOT(IV),COTOT(IV),HCTOT(IV),NOXTOT(IV)
2210  FORMAT(7X,I7,4X,I8,2X,4F11.1,2(2X,3F9.1))
  120 CONTINUE
C
C  ******************************
C  ANNUAL OPERATIONS AND COSTS
C  ******************************
C
      WRITE(OUP,2220)
2220  FORMAT(//2X,'ANNUAL SUMMARY OF OPERATIONS AND COSTS'//9X,'VEHICLE'
     1,1X,3(4X,'VEHICLE'),22X,        'ANNUAL COST ($''S)'/8X,'CAPACITY'
     2,6X,'FLEET',6X,    'MILES',6X,'HOURS',7X,'DRIVER',4X,'VEH-OPS',3X,
     3 'MAINT&OVH',4X,'DEPREC',6X,'TOTAL'/8X,8(1H-),4X,8(1H-),4X,7(1H-),
     4 4X,7(1H-),5X,5(1H-)/)
      DO 130 I=1,NVTYP
      IF(IVTYP(I).EQ.0) GO TO 130
      IF(DAYPER(I).EQ.OFFPK(I)) GO TO 2230
C
C  CALCULATIONS FOR PEAK PERIOD
C  (PPLU=PEAK PERIOD LABOR USAGE OR THE PARTICIPATION RATE OF DRIVERS
C   IN THE MORNING AND EVENING SERVICE AS APPROPRIATE)
C
      APF=250.
      VDEPHR   =OFRATO(I)*CDEPR(I)/(APF *DAYHRS)+(1-OFRATO(I))*CDEPR(I)/
     1 (APF *PRCLEN)
      CLABHR=CLABOR(I)
      IF(I.GE.5) CLABHR=((1-OFRATO(I)) *8./(PPLU(I)*PROLEN)+OFRATO(I))*
     1 CLABOR(I)
      GO TO 2240
C
C  CALCULATIONS FOR OFF-PEAK PERIOD
C
2230  CONTINUE
      APF=300.
      VDEPHR   =CDEPR(I)/(APF * DAYHRS)
      CLABHR=CLABOR(I)
2240  CONTINUE
      AVM(I)=VMTOT(I)*APF
      AVH(I)=VHTOT(I)*APF
```

FIGURE D-2 (Continued)

```
      PERDEP=VDEPHR    *PROLEN
      PERDRV = CLABHR * BPPH(I) * VHTOT(I)
      FLEET(I)=NVTOT(I)*SIZFAC(I)+.5
      ACDEPR(I)=PERDEP    *APF*FLEET(I)
      ACDRV(I)=PERDRV    *APF
      ACOPS(I)=(CPGAL(I)*FLTOT(I) +VMTOT(I)*(CTIRE(I)+COIL(I)))*APF
      ACOVHD(I)=(CINS(I)+CADMIN(I)+CMAINT(I) +CADVTF(I)+CDISPA(I)+
     1 CTXLIC(I))*FLEET(I)*PROLEN/DAYHRS
      ACTOT(I)=ACDRV(I)+ACOPS(I)+ACDEPR(I)+ACOVHD(I)
      WRITE(OUP,2300) CAPY(I),FLEET(I),AVM(I),AVH(I),
     1            ACDRV(I),ACOPS(I),ACOVHD(I),ACDEPR(I),ACTOT(I)
2300  FORMAT(7X,I7,4X,I8,2X,2F11.0,1X,5F11.0)
  130 CONTINUE
C
C  ******************************************
C  ROUTE OPERATIONS PER HOUR AND TOTAL COST
C  ******************************************
C
      WRITE(OUP,2310) DAYPER
2310  FORMAT(//2X,'AVERAGE',1X,2A4,1X,'HOUR OPERATIONS AND COSTS'//9X,
     1 'VEHICLE',1X,4(4X,'VEHICLE'),22X,'HOURLY COST ($''S)'/8X,'CAPACIT
     2Y',6X,'FLEET',6X,'MILES',6X,'HOURS',6X,'TRIPS',7X,'DRIVER',4X,
     3 'VEH-OPS',3X,'MAINT&OVH',4X,'DEPREC',6X,'TOTAL'/8X,8(1H-),5X,
     4 7(1H-),3(4X,7(1H-)),5X,5(1H-)/)
      DO 140 I=1,NVTYP
      IF(IVTYP(I).EQ.0) GO TO 140
      HRVM=VMPHR(I)*DEDHED(I)
      HRVH=VHPHR(I)*DEDHED(I)
      HRDRV=ACDRV(I)/(APF*PROLEN)
      HROPS=ACOPS(I)/(APF*PROLEN)
      HROVHD=ACOVHD(I)/(APF*PROLEN)
      HRDEPR=ACDEPR(I)/(APF*PROLEN)
      HRCOST= ACTOT(I)/(APF*PROLEN)
      WRITE(OUP,2320)CAPY(I),FLEET(I),HRVM,HRVH,TRIPS(I),HRDRV,HROPS,
     1 HROVHD,HRDEPR,HRCOST
2320  FORMAT(7X,I7,4X,I8,1X,2F11.1,1X,F10.1,2X,5F11.1)
  140 CONTINUE
C
C  ***********************************************
C  COSTS PER VEHICLE MILE AND PER VEHICLE HOUR
C  (FOR COMPARISONS WITH EXISTING DATA ONLY)
C  ***********************************************
      WRITE(OUP,2330) DAYPER
2330  FORMAT(//2X,'AVERAGE',1X,2A4,1X,'COSTS PER VEHICLE MILE AND PER VE
     1HICLE HOUR'//9X,12X,'COSTS PER VEHICLE-MILE ($''S)',28X,
     2 'COSTS PER VEHICLE-HOUR ($''S)'/3X,2(6X,'DRIVER',4X,'VEH-OPS',3X,
     3 'MAINT&OVH',4X,'DEPREC',6X,'TOTAL')/3X,2(5X,5(1H-))/)
      DO 145 I=1,NVTYP
```

FIGURE D-2 (Continued)

```
      IF(IVTYP(I).EQ.0) GO TO 145
      DRVPVM=ACDRV(I)/AVM(I)
      OPSPVM=ACOPS(I)/AVM(I)
      OVHPVM=ACOVHD(I)/AVM(I)
      DEPPVM=ACDEPR(I)/AVM(I)
      COSPVM=ACTOT(I)/AVM(I)
      DRVPHR=ACDRV(I)/AVH(I)
      OPSPHR=ACOPS(I)/AVH(I)
      OVHPHR=ACOVHD(I)/AVH(I)
      DEPPHR=ACDEPR(I)/AVH(I)
      COSPHR=ACTOT(I)/AVH(I)
      WRITE(OUP,2340) DRVPVM,OPSPVM,OVHPVM,DEPPVM,COSPVM,
     1 DRVPHR,OPSPHR,OVHPHR,DEPPHR,COSPHR
 2340 FORMAT(4X,5F11.2,1X,5F11.2)
  145 CONTINUE
      N=N +1
      GO TO 82
  150 CONTINUE
      STOP
      END
```

FIGURE D-2 (Continued)

A set of input data cards should be supplied as follows:

1. Title (single card);
2. Service time for vehicle types (single card);
3. General vehicle data (six cards);
4. Cost rates (six cards);
5. Cost related ratios (six cards);
6. Speed by type of roadway (six cards); and
7. Route designation (six cards).

Card type 1 is required, but may be replaced by a blank card. Card types 2 and 7 must be supplied by the program user to designate a specific route service. Card types 3, 4, 5, and 6 must be supplied with the program, but values shown in the following pages may be used as a default value. One single card each of types 1 and 2 is required, but types 3, 4, 5, and 6 require six cards of each. Card type 7 also requires six cards, but blank cards can replace service modes not being considered.

The format of each card is described in Figures D-3 through D-9. Note that a scale is provided with card images to show the column location of each variable within each card type.

```
----*---10----*---20----*---30----*---40----*---50----*---60----*---70----*---80
       ******* JACKSONVILLE TEST FOR JITNEYS *******
```

Variable	Columns	Format	Comments
TITLE	1-80	20A4	Title of the project

FIGURE D-3

CARD TYPE 1: TITLE CARD

```
----*----10----*----20----*----30----*----40----*----50----*----60----*----70----*----80

5    6        PEAK   13
```

Variable	Columns	Format	Comments
PRDLEN	1-5	F5.1	Period length of this simulation (hours)
NVTYP	6-10	I5	Number of vehicle types (6 specified)
DAYPER	12-20	2A4	Period of day; either P E A K or O F F - P E A K
DAYHRS	21-25	F5.1	Total daily hours of system operation

FIGURE D-4

CARD TYPE 2: SERVICE TIME FOR VEHICLE TYPES

```
----*---10----*---20----*---30----*---40----*---50----*---60----*---70----*---80
```

```
 6 GAS    60  351   72   35  840  174 118 093 079 070 063 058 055 055 058
 5 GAS    60  533   48   30  840  174 118 093 079 070 063 058 055 055 058
11 GAS    60  453   42   26  840  183 123 098 083 073 066 064 064 069 076
14 GAS    60  453   42   26  840  183 123 098 083 073 066 064 064 069 076
20 DSL    46  142   23  102  180  183 103 078 068 064 063 053 044 050 057
45 DSL    46  317   44  209  440  446 251 193 167 156 154 095 108 123 139
```

Variable	Columns	Format	Comments
CAPY (I)	1-4	I4	Passenger seating capacity of vehicle[a]
FLTYP (I)	6-8	A3	Fuel type; G A S or D S L
CPGAL (I)	11-15	F5.2	Cost per gallon of fuel (cents)
CORAT (I)	16-20	F5.1	Carbon monoxide emission rate 19.6 mph
HCRAT (I)	21-25	F5.1	Hydrocarbons emission rate at 19.6 mph
NOXRAT (I)	26-30	F5.1	Nitrogen oxides emission rate at 19.6 mph
FPHR (I)	31-35	F5.3	Fuel consumption rate at idle (gal/veh-hour)
FPVM (I, J)	37-76	10F4.3	Fuel consumption rate at speeds from 5 to 50 mph in 5 mph increments (gal/veh-mile)

[a]Seating capacity of vehicle also identifies service-mode e.g., 14 identifies stand-dispatched jitney van with 14 passenger capacity, excluding the driver.

FIGURE D-5

CARD TYPE 3: GENERAL VEHICLE DATA

```
----*----10----*----20----*----30----*----40----*----50----*----60----*----70----*----80
```

150	3	2	540	400	0	200	240	0	40
300	6	2	900	962	120	500	100	0	70
300	17	8	1200	1200	120	500	100	150	85
300	17	8	1350	1400	120	500	100	150	85
650	20	3	3400	2000	9853	9369	514	3256	1000
650	27	3	5667	3839	9853	9369	514	3256	2672

Variable	Columns	Format	Comments[a]
CLABOR (I)	1-8	F8.2	Cost of labor per working hour
CTIRE (I)	9-16	F8.3	Cost of tires per vehicle-mile
COIL (I)	17-24	F8.3	Cost of oil per vehicle-mile
CDEPR (I)	25-32	F8.0	Annual cost of capital depreciation per vehicle
CINS (I)	33-40	F8.0	Annual cost of insurance per vehicle
CADMIN (I)	41-48	F8.0	Annual cost of administration per vehicle
CMAINT (I)	49-56	F8.0	Annual cost of maintenance and its related overhead per vehicle
CADVTF (I)	57-64	F8.0	Annual cost of advertising and traffic per vehicle
CDISPA (I)	65-72	F8.0	Annual cost of dispatching per vehicle
CTXLIC (I)	73-80	F8.0	Annual cost of taxes and licenses per vehicle

[a]all costs are in dollars

FIGURE D-6

CARD TYPE 4: COST RATES

```
----*---10----*---20----*---30----*---40----*---50----*---60----*---70----*---80

100  100  100  100   50
110  100  100  100   78
150  100  100  100   78
150  100  100  100   78
115  110  114  100   50
115  110  114  100   50
```

Variable	Columns	Format	Comments
SIZFAC (I)	1-5	F5.2	Size-factor to increase operating vehicles to fleet size required for service, including maintenance and shift needs.
DEDHED (I)	6-10	F5.2	Deadheading required by vehicles to go from garage to point of revenue operation.
BPPH (I)	11-15	F5.2	Base paid hour to platform hours (applies to transit only)
PPLU (I)	16-20	F5.2	Peak period labor usage or probability of using peak period labor for 8 hours.
OFRATO (I)	21-25	F5.2	Off-peak to peak period vehicle ratio.

FIGURE D-7

CARD TYPE 5: COST-RELATED RATIOS

```
----*----10----*----20----*----30----*----40----*----50----*----60----*----70----*----80

 15   18    0   33   18   22   24   35   20   25   28   44
 13   15    0   33   16   19   21   33   18   22   26   44
 12   13    0   33   14   17   19   35   16   20   24   44
 12   13    0   33   14   17   19   35   16   20   24   44
  9   10   13   25   11   14   16   30   13   17   21   35
  8    9   12   25   10   13   15   30   12   16   20   35
```

Variable	Columns	Format	Comments
SPEED (I, K)	1-80	16F5.0	Speed by type of roadway - First four columns are CBD collector, arterial, buslane and expressway. - Second four columns are fringe local, collector, arterial and expressway. - Third four columns are local, collector, arterial and expressway. - Fourth four columns are left blank for other uses, including one single average speed for entire route length.

FIGURE D-8

CARD TYPE 6: SPEED TYPE OF ROADWAY

```
----*---10----*---20----*---30----*---40----*---50----*---60----*---70----*---80

blank card
blank card
JITNEY-ST 1A3 70
JITNEY-ST 1A4 70
blank card
FULBUS-TR 1A6 24
```

Variable	Columns	Format	Comments
MODLIN	1-12	3A4	Service mode and line to be served, used for identification only.[a]
VTYP	13	I1	Vehicle types designated as 1 thru 6 for service modes specified in footnote a.
FREQ	14-16	F3.1	Vehicles per hour serving route for the specified time period by service-mode.
DIST	17-80	16F4.1	Distance traveled through each roadway type by service mode.

[a]Service mode pre-specified as: auto, 5-seat cruising jitney, 11-seat stand-dispatched jitney, 14-seat stand-dispatched jitney, 20-seat transit mini-bus, 45-seat transit bus. Line to be served is any alphameric designation set by the planner for the route under study.

FIGURE D-9

CARD TYPE 7: ROUTE DESIGNATION

APPENDIX E

OFF-PEAK TO PEAK RATIO

Capital and drivers are two primary components of public transportation costs that are essentially fixed over short spans of time. These are related to the vehicle fleet required during peak periods. Since peak period demand is usually higher than off-peak demand, the fleet required to provide peak period service is significantly higher than the fleet required for off-peak service. Thereby, the total daily cost should consider the difference in capital and driver costs required between the two periods. Additional costs incurred during peak periods include labor costs for drivers who remain idle during off-peak periods and the total daily depreciation of those vehicles used only during peak hours. Techniques to account for those factors have been incorporated in the Corridor model (56,66,67).

Labor Costs

In allocating daily labor costs between peak and off-peak periods half time split shifts were used to account for extra drivers required during peak hours based on four-hour split shifts. Under this assumption, a driver would work for both peak periods and be idle for only two of his eight working hours. This is an intermediate assumption between when all drivers must be paid for continuous eight hour shifts and when extra drivers may be hired on an hourly basis to meet fluctuation in demand over the operating period. Figure E-1 depicts the above condition and assumptions.

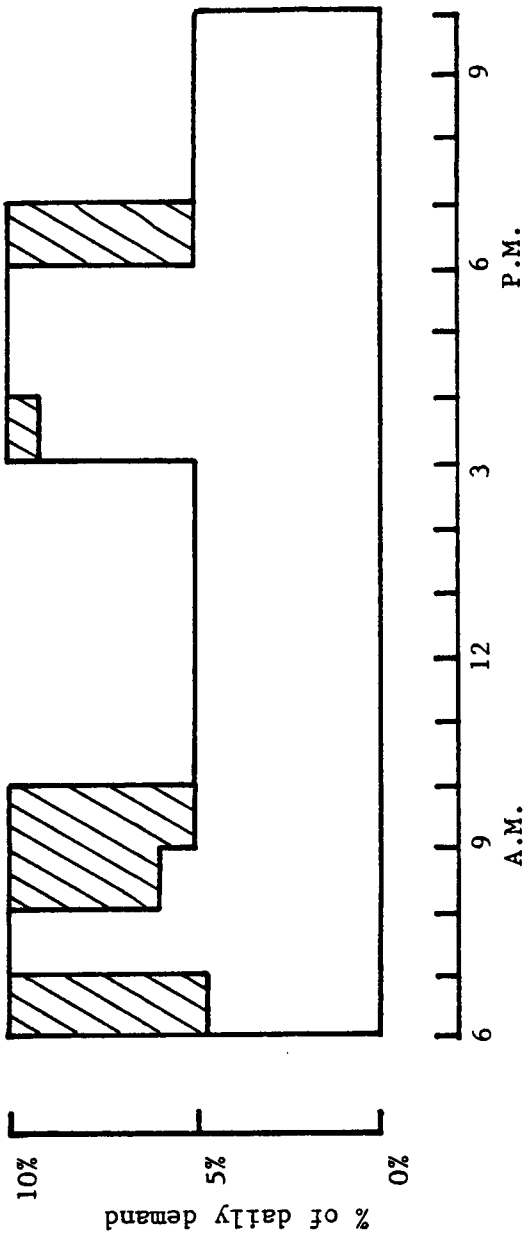


FIGURE E-1

FULL-TIME WORKERS WITH SPLIT SHIFTS PERMITTED

Under this assumption, total labor cost per day can be defined as:

$$L = (N_p - N_o) * W * 8 + N_o * W * T_d \qquad (E\ 1)$$

where: N_p is vehicle fleet required during peak periods,

N_o is vehicle fleet required during off-peak periods,

W is hourly wage, and

T_d is total daily hours of operation

or, $L = L_p + L_a$

where: L_p is peak period labor cost and,

L_o is off-peak period labor cost.

Thus, $L_p = (N_p - N_o) * W * 8 + N_o * W * T_p$

where: T_p is peak period hours of operations.

Another useful relationship is based on labor cost per vehicle-hour; for peak periods this is:

$$LPHR_p = L_p / (N_p * T_p).$$

Combining with above definition, peak period labor cost is:

$$LPHR_p = \left[\left(1 - \frac{No}{N_p}\right) \frac{8}{T_p} + \left(\frac{No}{N_p}\right) \right] W \qquad (E\text{-}2)$$

Labor cost per off-peak period vehicle-hours is:

$$LPHR_o = L_o / (N_o * T_o) = W. \qquad (E\text{-}3)$$

Relationships E-2 and E-3 were used in the Corridor program and were modified as required for computer representation.

Capital Costs

Under this assumption total capital cost pending is defined as:

$$C = N_o * VC + (N_p - N_o) * VC$$

where: VC is daily capital cost per vehicle.

When, T_p is operating time during peak periods and,

T_o is operating times during off-peak periods,

the time of daily operations is:

$$T = T_p + T_o.$$

Total cost per day is also,

$$C = C_p + C_o$$

where, C_p is total capital cost required for operations during peak periods and,

C_o is total capital cost required for operation during off-peak periods.

$$\text{Then, } C_o = N_o * VC * \frac{To}{T} \qquad \text{(E-4)}$$

$$\text{and } C_p = N_o * VC * \frac{Tp}{T} + (N_p - N_o) * VC \qquad \text{(E-5)}$$

Relationships E-4 and E-5 may be better visualized through the use of Figure E-2.

Another useful relationship is based on capital cost per vehicle-hour; for peak periods there is:

$$CPHR_p = C_p / (N_p * T_p) \quad \text{or,}$$

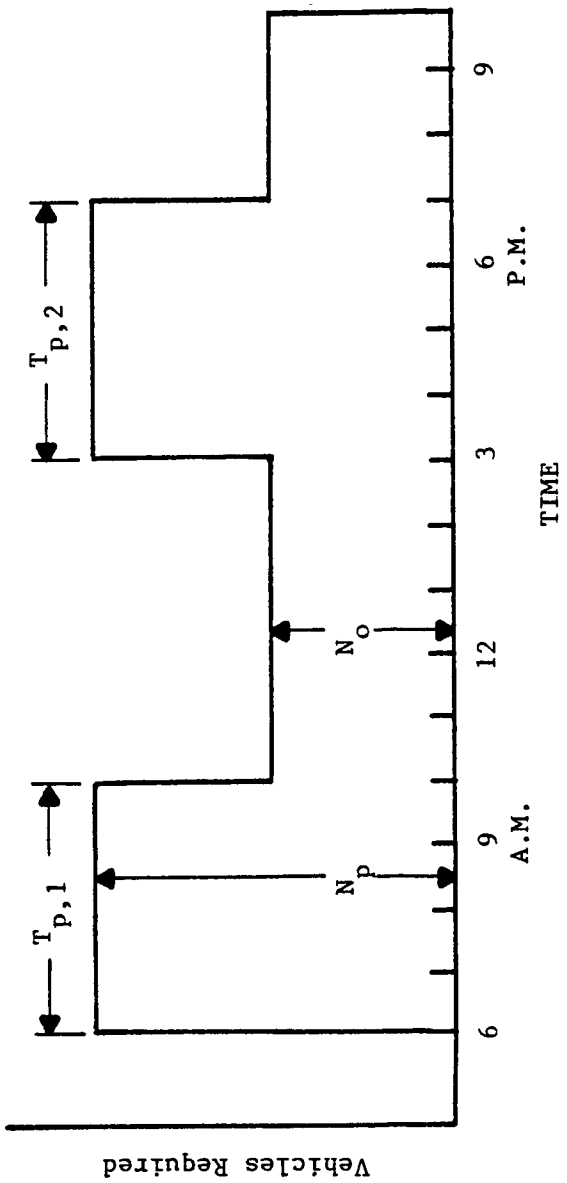
$$= \frac{No}{Np} * \frac{VC}{T} + (1 - \frac{No}{Np}) * \frac{VC}{Tp}, \qquad \text{(E-6)}$$

and for off-peak periods this is

$$CPHR_o = C_o / (N_o * T_o) \text{ or,} \qquad \text{(E-7)}$$

$$= \underline{VC} / T.$$

Relationships E-6 and E-7 were used in the Corridor programs and were modified as required for computer representation.



Note: $T_p = T_{p,1} + T_{p,2}$

FIGURE E-2

TIME VERSUS VEHICLE REQUIREMENTS

APPENDIX F

MANUAL PROCEDURE FOR ESTIMATING JITNEY COSTS

This supplementary procedure is provided as an alternate to the computer program corridor to estimate jitney costs. The procedure follows the logic used by the program, but simplifies several assumptions and deletes various iterative computations. It disregards computations used for determining fuel consumption, pollutant emissions, passenger trip time and special considerations required for bus transit evaluation. However, the manual procedure provides the planner additional understanding of the Corridor program estimates and the alternative to prepare cost estimates without use of a computer.

The following explanation makes use of the Jacksonville Scenario described in Chapter 6. The assumption is made that the Jacksonville Transportation Authority (JTA) is considering to reduce its operating deficit and jitneys are to be investigated as a substitute for JTA Route 30. This route provides service connecting downtown Jacksonville with a residential area. Buses traverse approximately 10.4 miles from the CBD to the residential route-end or 1.0 miles of CBD collector streets, 3.6 miles of fringe collector streets, 4.3 miles of residential collector streets and 1.5 miles of residential local streets. Peak period service is provided for 5 hours and off-peak service for 8 hours every weekday. Jitneys would essentially serve the same route and the same periods. Saturday and Sunday service will also be provided, but at a reduced level.

As explained in Chapter 6, 11-seat jitney vans can provide equal or better service operating at a frequency of 7 runs per hour during peak periods and 4.7 runs per hour during off-peak. Jitneys will operate from a stand during peak and off-peak hours but may resort to cruising during peak demand periods. Base jitney data including item costs will be obtained from Table 6-2 (p. 144). The steps following describe the procedure to estimate annual cost of operating jitneys for the above service.

Step 1--Determine Round Trip Time and Average Speed

Trip time is needed to determine vehicular and manpower requirements. Trip time is obtained by dividing distance traveled by speed for each segment traveled. Average speed is obtained by multiplying segment speed by distance and then dividing by the sum of distance. Speed values by type of roadway traveled are taken from Table 6-2.

Vehicular round trip time is,

$$VRTT = \sum_{i=1}^{n} DIST_i * 2. * 60. / SPEED_i$$

where: VRTT is round trip time in minutes,

DIST is distance of one-way segments in miles, and

SPEED is in miles per hour for each segment traveled.

Then,

VRTT = (1.0 * 120./12.) + (3.6 * 120./17.) +
(4.3 * 120./20.) + (1.5 * 120./16.)

= 10.0 + 25.4 + 25.8 + 11.3

= 72.5 minutes for round trip

And average speed is,

$$AVSP = \frac{\sum_{i=1}^{n} DIST_i * SPEED_i}{\sum_{i=1} DIST_i}$$

$$= \frac{1.0 * 12. + 3.6 * 17. + 4.3 * 20. + 1.5 * 16.}{1.0 + 3.6 + 4.3 + 1.5}$$

= 17.6 miles per hour

Step 2--Determine Vehicles Required in Operation

The required number of jitney vehicles will vary by time of day, according to demand. However, this can be approximated by specifying vehicles required during peak and off-peak hours.

This can be represented by,

OVEH (period) = VRTT * FREQ/60.

where: OVEH is operating vehicles by period, and

FREQ is service frequency in vehicles per hour.

Then,

OVEH (peak) = 72.5 * 7./60.

= 8.4

, and round up

= 9 jitney vans.

Also,

OVEH (off-peak) = 72.5 * 7./60.

= 5.7

, and rounded up

= 6 jitney vans.

Step 3--Determine Vehicle-Miles and Vehicle-Hours per Period

Vehicle-miles and vehicle-hours together with the vehicle fleet size are the basic variables used to compute costs. All are specified by period of the day.

VM (period) = RTDIS * FREQ * PRDLEN

where: VM is vehicle-miles traveled during a selected period,
RTDIS is route round trip distance, and
PRDLEN is period length in hours.

Then,

VM (peak) = (10.4 * 2.) * 7. * 5.
= 728 vehicle-miles,

and,

VM (off-peak) = (10.4 * 2.) * 4.7 * 8.
= 782 vehicle-miles.

In a similar manner,

VH (period) = OVEH * PRDLEN

where: VH is vehicle-hours, and
OVEH and PRDLEN are described above.

It follows that,

VH (peak) = 8.4 * 5.
= 42 vehicle-hours

and,

VH (off-peak) = 5.7 * 8.
= 45.6 vehicle-hours.

Step 4--Determine Fleet Size Requirements

The fleet size is determined by multiplying operating vehicle required by an adjustment factor that considers maintenance, operator's time off and service requirements. An adjustment factor of 1.5 is suggested for stand dispatched jitneys (see Table 6-2, p. 144).

FVEH (period) = OVEH * FF

where: FVEH is fleet vehicles required,

FF is fleet factor, and

OVEH is described above.

VITA

Carlos R. Bonilla was born in San German, Puerto Rico on September 14, 1944. He attended grade school in various cities within Puerto Rico and was graduated from Central High School in Santurce in July 1960. The following month he entered the Mayaguez campus of The University of Puerto Rico, and in December 1966 he completed the requirements for a Bachelor of Science in Civil Engineering.

In March 1967 he entered the U.S. Army as a Second Lieutenant. In July 1968 he was assigned to military duties in Turkey and in March 1969 was promoted to Captain. In August 1969 he was assigned to Seneca Army Depot in New York state as Assistant Chief for the Storage and Supply Division.

In August 1970 he joined the Puerto Rico Ports Authority as a Planning Engineer. In January 1972 he entered the Graduate School of The Pennsylvania State University in State College under fellowship from the Puerto Rico Ports Authority. In March 1973 he received a Master of Engineering in Civil Engineering. He resumed work with the Puerto Rico Ports Authority in planning and coordination of projects related to ports and airports.

In December 1973 he was assigned as the Technical Director for Puerto Rico of the 1974 National Transportation Study, and a member of the Technical Committee of the Puerto Rico Airport System Plan.

In November 1974 he was transferred to the Puerto Rico Department of Transportation and Public Works and assigned the duties of Acting Chief of the Planning Office for the Rapid Transit Area.

In January 1976 he entered the Graduate School of The University of Tennessee, Knoxville. From January 1976 to October 1979 he was also a research assistant at the Transportation Center of The University of Tennessee. He received the Doctor of Philosophy degree with a major in Civil Engineering in December 1980.

Since May 1979 he has been working with the Dade County Transportation Administration as a Senior Program Analyst. He is also the Assistant Chief of the Planning Support Branch.

The author is a member of the Transportation Research Board, the American Society of Civil Engineers, the Institute of Transportation Engineers, the Puerto Rico Engineers Society, Phi Kappa Phi and Chi Epsilon. He is a certified Professional Engineer in Puerto Rico.

He is married to the former Elsie A. Roure of San Juan, Puerto Rico, and has three children, Carlos, Gerardo and David.