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Tampa Bay Region Mass Transportation: Phase II Appendixes

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TAMPA BAY REGIONAL PLANNING COUNCIL

TAMPA BAY REGION MASS TRANSPORTATION

PHASE II

APPENDIXES

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PHASE II

APPENDIXES

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by

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INTRODUCTION

TAMPA BAY REGION, MASS TRANSPORTATION, PHASE II examines mass transit in the five Counties of the Tampa Bay Region. The objectives of the study are to improve Regional mass transportation through a program of short-range actions and to take the initial steps in the long-range process of implementing future transit systems in the Region.

The report consists of three main Parts plus three Appendixes. Parts I, II and III, described briefly below, are published separately as the main body of the report. The three Appendixes, also described briefly below, are contained herein in their entirety.

Part I of the report presents the Transit User Survey, including survey objectives, survey method, experimental evaluation and final results.

Part II briefly summarizes mass transit as it is today in the Tampa Bay Region and describes a Short-Range Improvement Program for Regional mass transit. Recommendations are made with respect to coordination of existing services and facilities, application of new technology and establishment of a Regional Transit Service Corporation.

Part III contains the statement of long-range mass transportation goals and objectives for the Region, along with the specifications for the transportation analysis computer model. A summary of community views and priorities and a postulated long-range evolution of mass transit in the Tampa Bay Region are presented as background for the discussion of mass transportation goals and objectives.

Appendix I contains all of the raw data obtained from the Transit User Survey, as well as a disaggregation of transit rider suggestions for improving bus service. The latter shows how the Region's bus operations compare with one another and how user priorities vary between the different local services.

Appendix II is a summary of vehicle technology applicable to transit equipment, including exhaust emission kits, gas turbine engines, natural gas engines, other engine types, noise reduction and safety devices. The summary addresses bus-related technological innovations presently available, in an advanced stage of development or being given serious attention in the context of a longer time frame.

Appendix III consists of a survey of existing transportation analysis computer programs. Model purpose, underlying theory, operational method, data usage and degree of aggregation are discussed.

APPENDIX I

REGIONAL TRANSIT SURVEY DATA

INTRODUCTION

A one-day transit user survey was conducted on Tuesday, 24 November 1970. Bus riders throughout the Tampa Bay Region were asked to fill out a survey form comprised of a small map of the Region and eleven questions. Questionnaires were distributed on board the buses and respondents were requested to mail the postage-paid forms back to the TBRPC. Approximately 1,200 completed questionnaires were returned to the Council.

The raw data from the survey, some intermediate processed data and a breakdown of transit user suggestions on how to improve Regional bus service are presented below.

RAW DATA

The questionnaire raw or unprocessed data were manually read and aggregated in table form. Separate tables, included herein as Tables I-a through I-f, were developed to organize the data in the following manner:

Table I-a

Rider description in terms of age, retirement status, sex, and main purpose for bus travel as a function of number of round trips per week.

Table I-b

Rider description in terms of age, retirement status, sex and need for additional bus service to obtain a better job, as a function of home location.

Table I-c

Travel description in terms of number of round trips made by bus per week and main purpose for bus travel, as a function of home location.

Table I-d

The distribution of non-work trip purposes for which additional bus service is required, identified as shopping, medical, personal business, social/recreational, school and other (non-work), as a function of home location.

Table I-a. Rider Characteristics and Trip Type Related to Transit Usage

(UNPROCESSED SURVEY COUNT DATA)

4		1				2		3		5	
		AGE				RETIRED		SEX		TRIP TYPE	
ROUND TRIPS PER WEEK	TOTAL NUMBER OF RESPONSES	UNDER 16	16–35	35–60	OVER 60	YES	NO	MALE	FEMALE	WORK	OTHER
1	30	1	8	4	17	16	14	7	19	5	25
2	78	2	3	14	60	58	17	12	50	13	73
3	107	2	6	16	82	78	20	22	60	12	100
4	106	2	7	16	80	73	26	30	58	28	94
5	367	10	91	177	86	56	290	80	238	293	217
6	264	1	38	120	101	60	194	40	184	203	191
7	96	1	17	41	36	22	68	25	63	76	84
8	42	0	11	21	9	8	32	11	25	33	36
9	37	0	10	15	12	7	28	10	24	28	36

NOTE: NUMBERS AT THE TOP IDENTIFY THE SURVEY QUESTION THAT PRODUCED THE DATA.

Table I-b. Rider Characteristics and Need for Job Transportation Related to Home Location

(UNPROCESSED SURVEY COUNT DATA)

6	1				2		3		7	
	AGE				RETIRED		SEX		NEED JOB TRANSPORTATION	
HOME LOCATION	UNDER 16	16–35	35–60	OVER 60	YES	NO	MALE	FEMALE	YES	NO
1										
2										
3				1	1			1		1
4				1		1		1	1	
5	1	2	1	1	2	3	2	3	1	3
6			12	15	11	14	3	23	5	14
7	3	11	14	37	30	39	13	38	9	38
8	2	2	3	19	16	9	7	12	5	13
9	1	2	8	19	18	11	8	17	8	11
10		5	16	25	22	22	14	26	8	27
11		5	23	35	31	33	21	36	16	31
12	8	69	167	236	190	275	113	302	94	326
13	3	70	152	90	52	252	60	223	102	166
14		7	7	7	3	18	5	16	9	12
15			1	1	2	2		4	2	1
16			1	1	1	1		2	1	1
17		3	1			4		3	3	1
18										
19		2	2			4		4	2	2
20	1	3	4	9	9	8	3	11	3	15
21										
22										
23		10	17	14	13	25	2	31	15	13
24		3				3	2	1	3	
25										
26										
27										

NOTE: NUMBERS AT THE TOP IDENTIFY THE SURVEY QUESTION THAT PRODUCED THE DATA.

Table I-c. Transit Usage and Trip Purpose
Related to Home Location

(UNPROCESSED SURVEY COUNT DATA)

6	4									5	
	ROUND TRIPS PER WEEK									TRIP TYPE	
HOME LOCATION	1	2	3	4	5	6	7	8	9	WORK	OTHER
1											
2											
3			1								1
4	1										1
5	1	2	1				1			2	6
6		3	3	1	10	7	1		1	13	21
7	2	8	11	8	20	15	2	3	1	32	59
8	2	4	3	5	2	2			2	7	25
9		1	3	2	12	7	2	2		10	24
10	1	5	5	7	14	9	3			24	35
11	1	5	7	7	19	12	6	1	2	32	49
12	12	36	43	54	244	103	48	18	14	259	286
13	7	15	19	16	111	87	26	15	11	252	223
14	1	2	1		7	4	2	1	3	19	14
15		1			1	2				3	3
16					2					2	1
17					3	1				4	
18											
19				2		2				3	3
20	1	1	1	3	1	6	1	1		7	17
21											
22											
23	1	1	4	5	9	13	4		2	26	30
24					1		2			2	3
25											
26											
27											

NOTE: NUMBERS AT THE TOP IDENTIFY THE SURVEY QUESTION THAT PRODUCED THE DATA.

Table I-d. Reasons Given for Needing New Non-Work Trip Services

(UNPROCESSED SURVEY COUNT DATA)

	6	9				
		NON-WORK TRIP PURPOSE				
HOME LOCATION	SHOPPING	MEDICAL	PERSONAL BUSINESS	SOCIAL/ RECREATIONAL	SCHOOL	OTHER (NON-WORK)
1						
2						
3	1		1	1		
4						
5	1			1		
6	16	8	7	14	1	4
7	35	22	22	23	1	12
8	11	11	7	6	2	4
9	13	10	12	7		8
10	15	16	7	120	1	6
11	31	21	19	16		9
12	141	85	84	98	16	63
13	135	111	109	84	28	62
14	15	7	9	6	3	4
15	2					1
16	1	1	1			
17	2	1	1	1	1	1
18						
19	1	1		1		
20	8	3	2	5		3
21						
22						
23	19	9	14	12	5	10
24	1		1	1		1
25						
26						
27						

NOTE: NUMBERS AT THE TOP IDENTIFY THE SURVEY QUESTION THAT PRODUCED THE DATA.

Table I-e. Indicated Needs for New Work Trip Services

(UNPROCESSED SURVEY COUNT DATA)

HOME LOCATION (QUESTION 6)	POTENTIAL JOB LOCATIONS (QUESTION 8)																										
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
1	2							1				1															
2																											
3																											
4				1			1						1														
5				1		1							1														
6							4	2	1			1															
7	1			1			4	1	2		1	2															
8							2	2				2	1														
9						2	4	3	2	2		1															
10							1	2	2	4	2	5	1														
11				1			4	4	2	6	12	9	3	1							1						
12				1	1		13	19	14	23	40	36	12	3	1					1			2			1	
13	2	2	1	2	3		7	1	2	3	7	22	70	34	4	12	1			1							
14									1			1	2	4		4											
15												1															
16													1	1													
17					1					1			1	1		1		1									
18																											
19												1									1	1	1				
20																				4	1	1	2	1			
21																											
22																											
23							1	1										1		2	2	4	6	2	2	1	
24																							1	1	1	1	
25																											
26																											
27																											

Table I-f. Indicated Needs for New Non-Work Trip Services

(UNPROCESSED SURVEY COUNT DATA)

	DESIRED NON WORK TRIP DESTINATION (QUESTION 10)																											
HOME LOCATION (QUESTION 6)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	*
1	2			1							1	1	2															2
2																												1
3			2					1							1													
4			1	1			1																					
5						1	1	1					1															5
6			1	1		5	7	2	6	2		6	4										1					10
7	1			1		3	16	10	10	2		8	7							1			1					36
8							6	2	2	4	2	4	1										1					11
9						1	9	6	3	2		7																16
10				1			7	3	3	5	1	15	4	1		1							3					24
11							3	4	4	6	17	27	6					1					1				1	37
12	7	1	4	6	2	6	35	22	33	53	43	51	36	4				1		2	4	1	7	1		2	1	285
13	4	4	3	2	4		17	2	13	8	3	46	96	31	9	13	1		1	4		1	6		1			163
14		1					2	1				6	4	2	2	1		1		2								8
15									1																			4
16													1	1														2
17					1							1	1										1					1
18																												
19																												3
20								1				1	1						4	7	3		7					7
21																												4
22																												
23							1			1		6	3					1	2	4	3	8	10	5	10	3	1	13
24																							1		1			
25																												
26																												
27																												

*NO RESPONSE

Table I-e

The distribution of anticipated job locations which cannot be reached by bus at present, as a function of home location.

Table I-f

The distribution of desired destinations for non-work trips which cannot be made by bus at present, as a function of home location.

The data in the body of each of these six tables, identified as unprocessed survey count data, are simply the number of responses in each of the respective tabular categories. No operations have been performed on these data.

Survey question number four asked for the number of round trips made by bus in one week for any purpose. Responses indicating ten or more round trips per week were halved for the purposes of data tabulation and analysis. It was assumed in these instances that the respondent misunderstood the question and thought that one-way trips were being asked for rather than round trips.

Survey question number five listed seven trip purposes for transit riders to choose from. One trip purpose was work, five non-work purposes were listed, and an "other" category was provided. If "other" and/or any of the five non-work trip purposes were checked, that respondent was shown as one entry in the "other" column for trip type in Tables I-a and I-c.

PROCESSED DATA

The most important information resulting from the survey has to do with estimating transit user needs for new bus service, either for work or non-work trips. The following computational steps were necessary in order to obtain the desired estimates:

1. Distribute transit rider population by home area.
2. Compute the percentage of transit riders in each home area needing new services.
3. Compute the total number of transit riders in each home area needing new services.
4. Distribute service desires originating in each home area among the various destinations.

5. Compute the total number of present transit riders needing new service between each Regional origin-destination pair.

Total ridership estimates furnished by each of the transit operators for their respective systems and the distribution of survey responses among the home areas served by each separate transit system were used to compute transit rider population in each home area. Ridership for each transit operator was distributed among the home areas served by that operator in the same manner as the survey responses were distributed. This process implies that survey sampling was uniform across all areas served by the operator. In those areas served by more than one transit system, the portions of each system ridership estimated to reside in a given home area were summed to obtain total transit rider population for that area.

The percentage of transit riders in each home area needing new services for work trips was determined on the basis of responses to survey question number seven. The corresponding percentage for non-work trips was obtained by means of the responses to survey question number ten.

The total number of transit riders in each home area needing new work or non-work bus services was then obtained by applying the sample percentages in step number 2 to the population estimates in step number 1.

The survey produced a distribution of desired destinations in association with each of the 27 home areas identified on the questionnaire map. These data are shown in Table I-e for work trips and Table I-f for non-work trips. This sample distribution was used to apportion the service desires originating in each home area, as computed in step 3, among the various destinations.

The total number of transit riders needing new service between the various Regional origin-destination pairs was then determined by summing the indicated needs in each direction between each pair. The results of this final step are shown in Table I-g.

USER SUGGESTIONS

Survey question number eleven asked for suggestions on how to improve bus service in the five Counties of the Tampa Bay Region. An attempt was made to categorize the responses and the results of that effort are shown in Table I-h.

Figures I-a through I-g show the relative importance of the various suggestions within each of the separate bus riderships of the Region. Figures I-h through I-s show how the riderships compare with one another in terms of relative sensitivity to each of the individual suggestions for improvement.

Table I-g. Estimated Portions of Present Transit Ridership Needing New Services

FOR NON-WORK TRIPS

ZONAL PAIR	NO. OF RIDERS		ZONAL PAIR	NO. OF RIDERS
1–12	75		11–11	103
1–13	29		11–12	628
2–13	29		11–13	58
3–12	43		12–12	550
4–12	65		12–13	721
5–13	29		12–14	89
6–7	25		12–20	25
6–12	78		12–21	43
7–7	55		12–23	94
7–8	60		13–13	695
7–9	55		13–14	255
7–12	405		13–15	65
7–13	147		13–16	94
8–11	33		13–20	31
8–12	255		13–23	52
9–12	372		20–23	29
9–13	94		22–23	25
10–11	38		23–23	31
10–12	601		23–24	26
10–13	66		23–25	31

FOR WORK TRIPS

ZONAL PAIR	NO. OF RIDERS		ZONAL PAIR	NO. OF RIDERS
5–13	28		12–12	361
7–11	29		12–13	285
7–12	141		12–14	40
7–13	53		12–15	46
8–12	200		13–13	525
9–12	143		13–14	275
10–11	40		13–15	30
10–12	240		13–16	97
10–13	25		14–14	39
11–11	73		14–16	46
11–12	456		23–23	27
11–13	71			

NOTE: ESTIMATED RIDERSHIP VALUES BELOW 25 HAVE BEEN OMITTED.

Table I-h. Transit Rider Suggestions for Improving Bus Service

(Tabulation of Responses to Survey Question Number 11)

Rider Suggestion for Improving Bus Service	Clearwater Transit	Cities Transit	Gulf Beach-Pinellas Park	Gulf Coast	Tampa Transit	St. Petersburg Municipal Transit	State DOT Demonstration	Total
More service on Sundays and holidays	25	16	0	2	54	4	29	130
More evening and early morning service	17	6	4	0	42	0	18	87
More frequent service	11	19	18	2	95	3	115	263
Closer adherence to schedules	2	4	2	0	25	0	10	43
More convenient transfers	8	3	0	3	25	0	32	71
More complete area coverage	13	6	7	7	30	6	32	101
More conscientious and polite drivers	0	7	3	0	19	0	10	39
Improved bus equipment	9	13	5	0	27	0	19	73
Increased use of Minibuses	1	4	3	0	11	0	18	37
Improved waiting accommodations	0	2	1	0	22	0	12	37
Lower fares	10	2	4	0	30	0	23	69
Present service is generally good	2	4	2	4	3	4	43	62

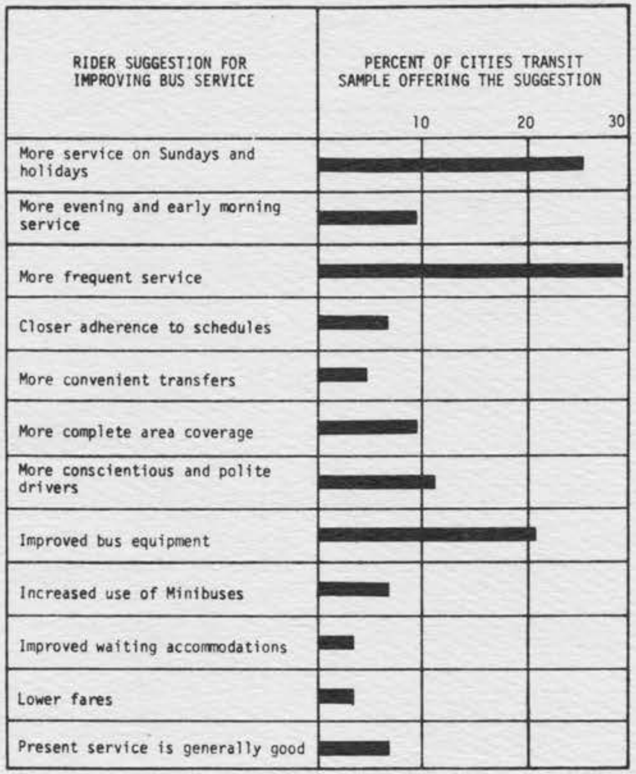

Figure I-a. Cities Transit User Priorities

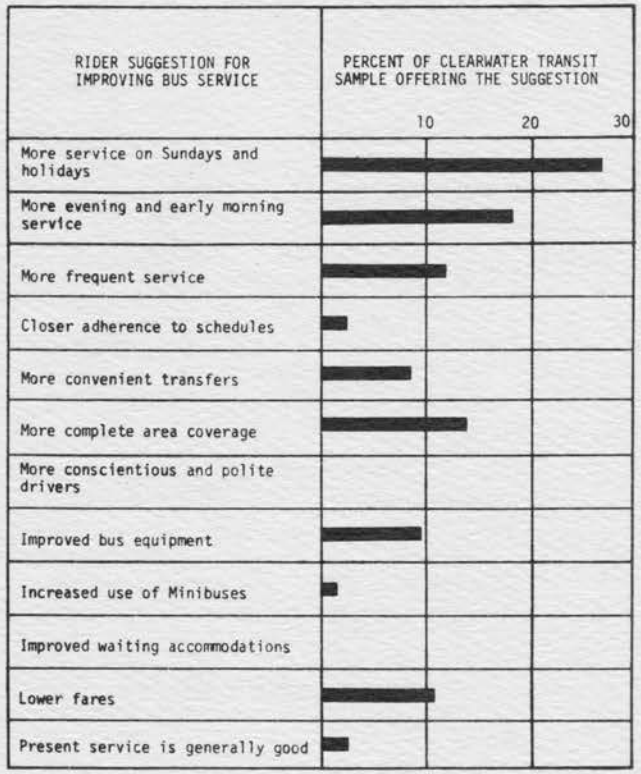

Figure I-b. Clearwater Transit User Priorities

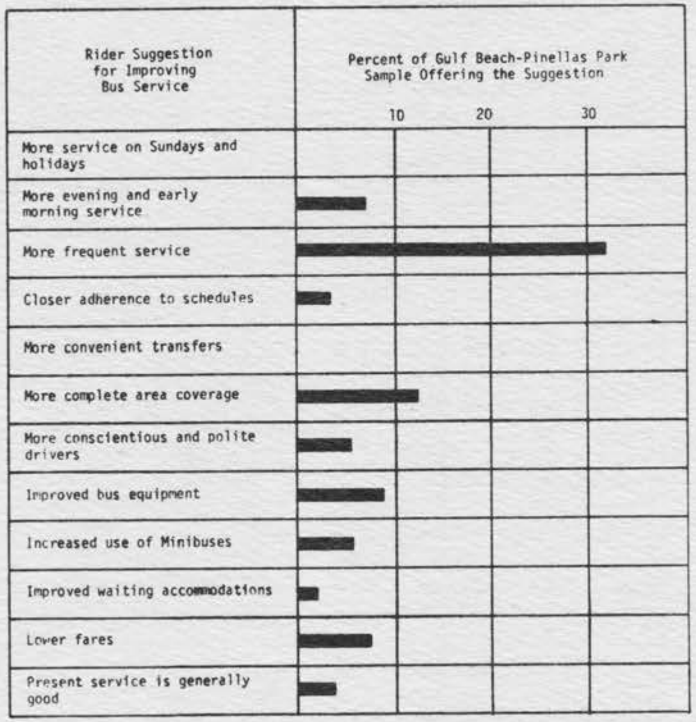

Figure I-c. Gulf Beach-Pinellas Park Transit User Priorities

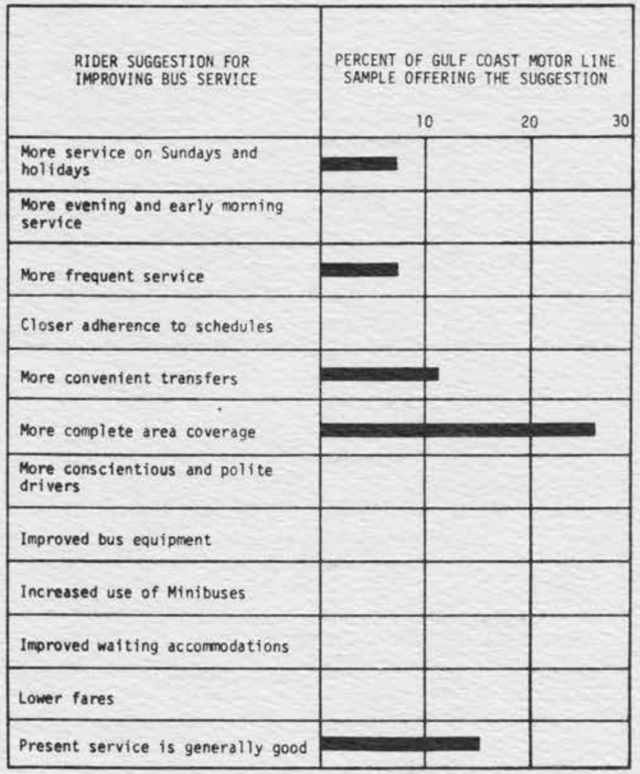

Figure I-d. Gulf Coast Motor Line User Priorities

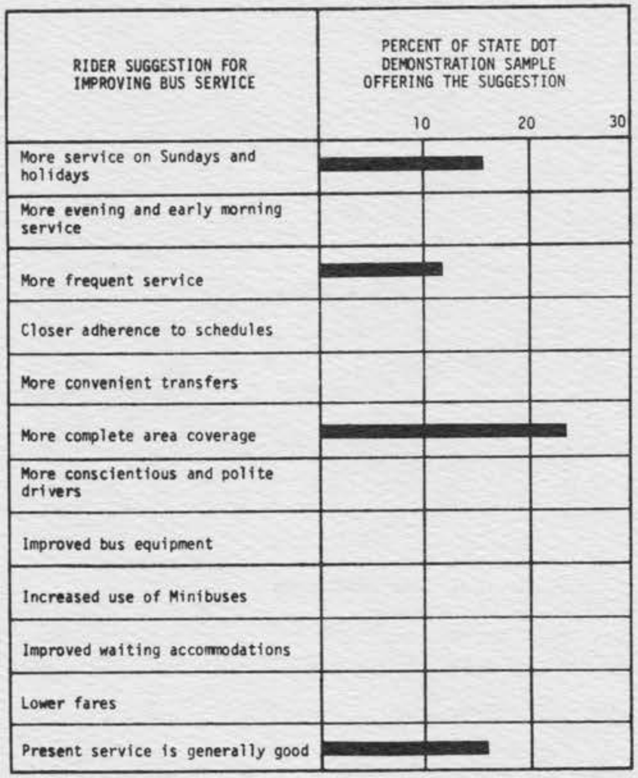

Figure I-e. State DOT Demonstration User Priorities

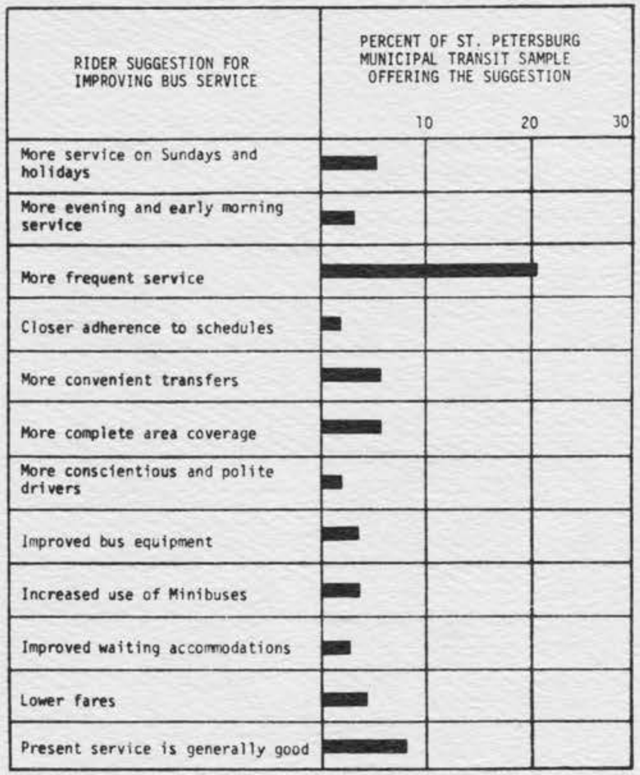

Figure I-f. St. Petersburg Municipal Transit User Priorities

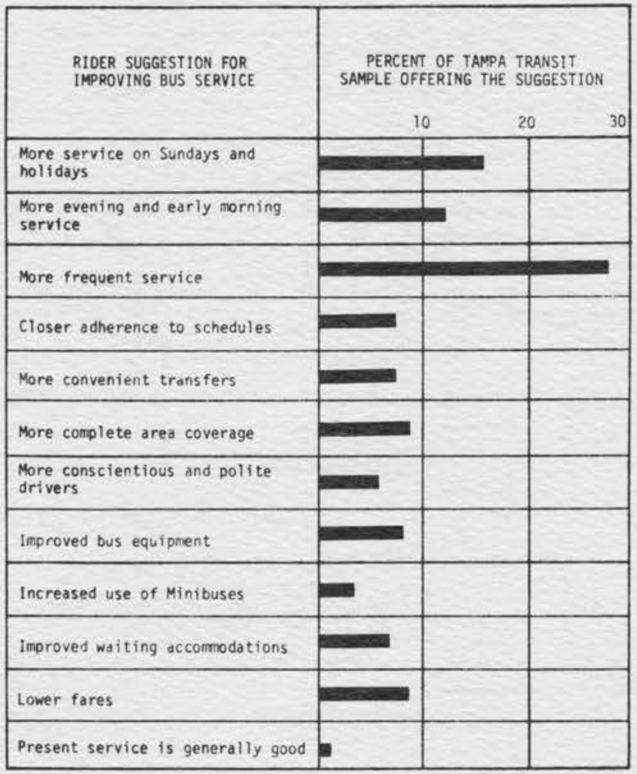

Figure I-g. Tampa Transit User Priorities

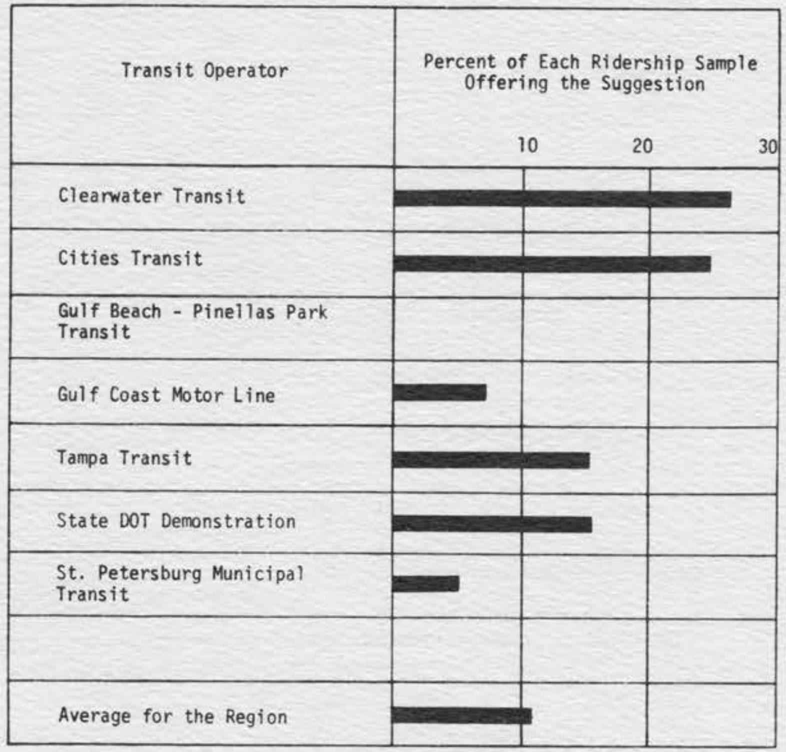

Figure I-h. Ridership Comparisons on Suggestions for More Sunday and Holiday Service

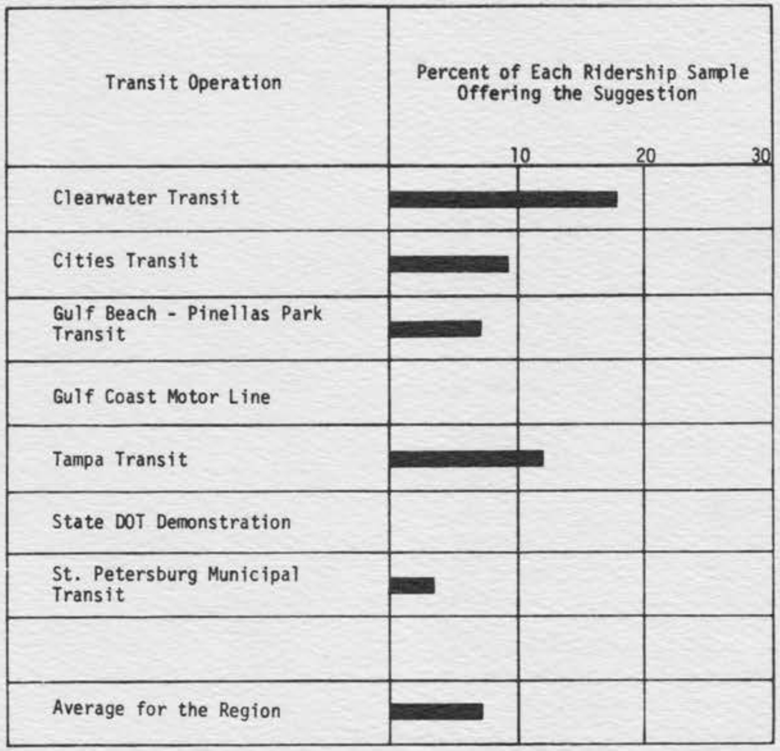

Figure I-i. Ridership Comparisons on Suggestions for More Evening and Early Morning Service

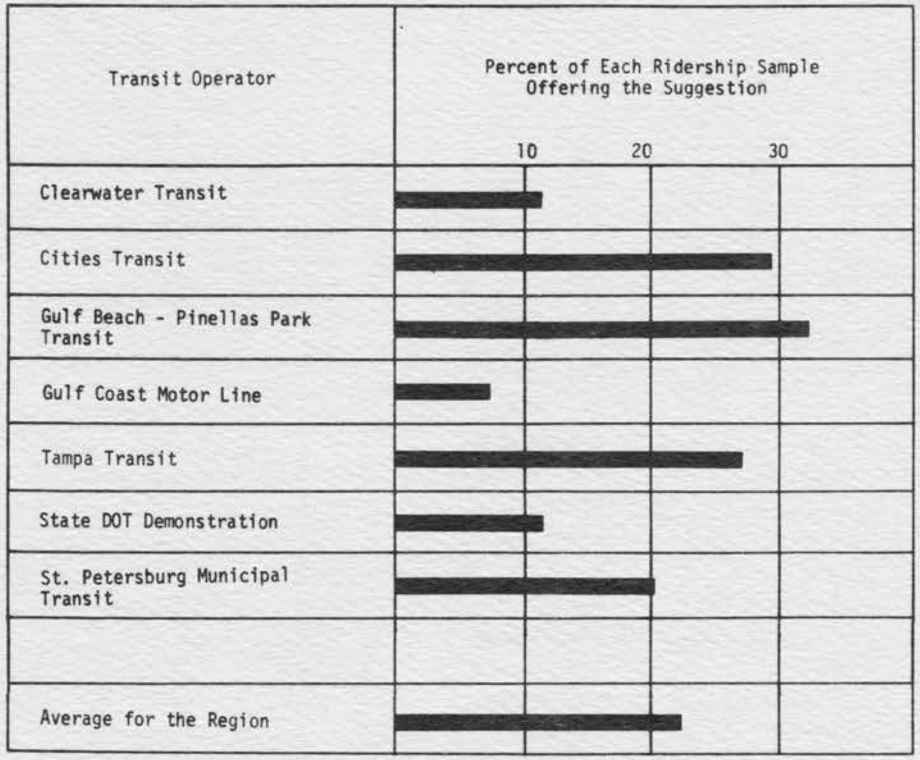

Figure I-j. Ridership Comparisons on Suggestions for More Frequent Service

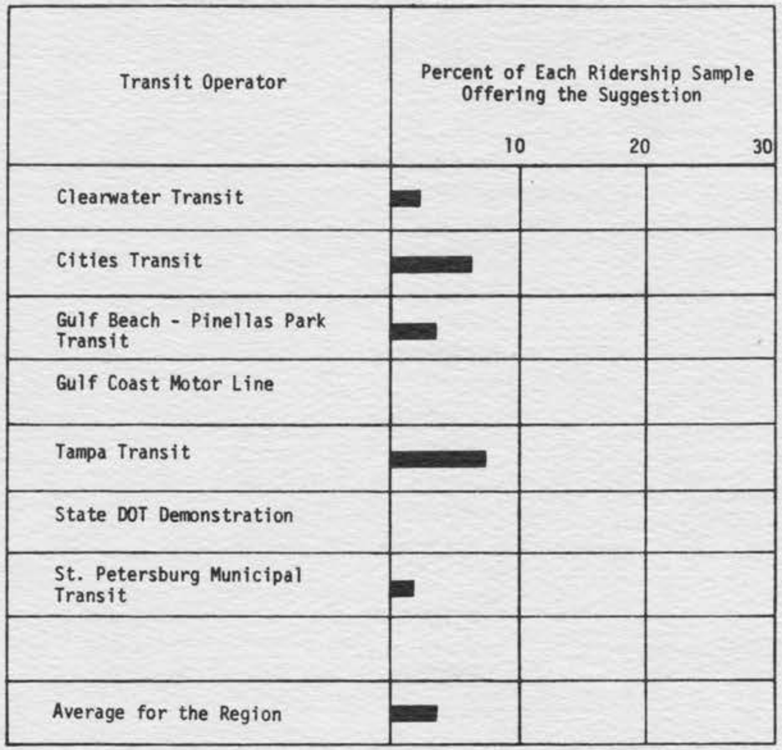

Figure I-k. Ridership Comparisons on Suggestions for Closer Adherence to Schedules

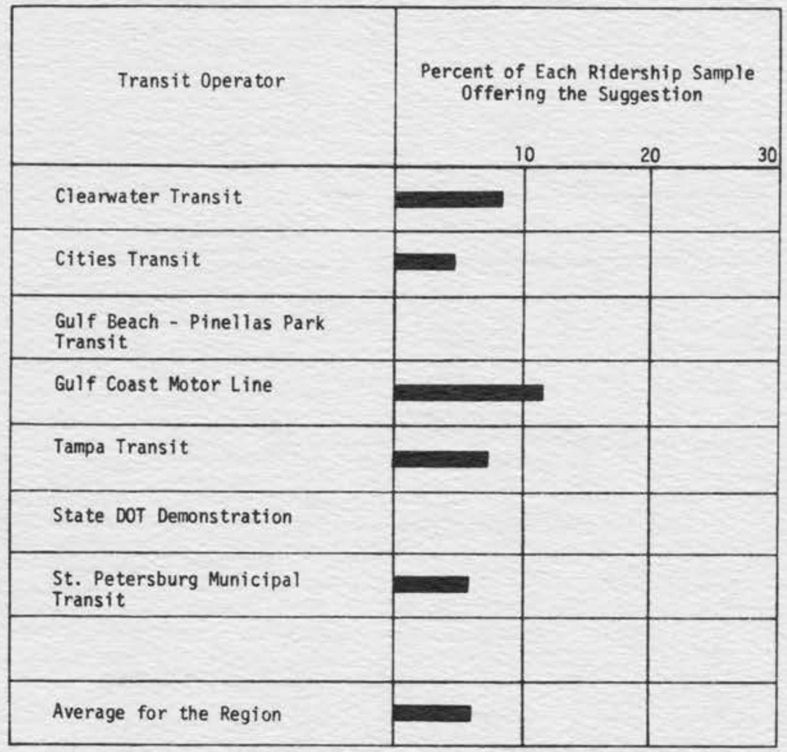

Figure I-l. Ridership Comparisons on Suggestions for More Convenient Transfers

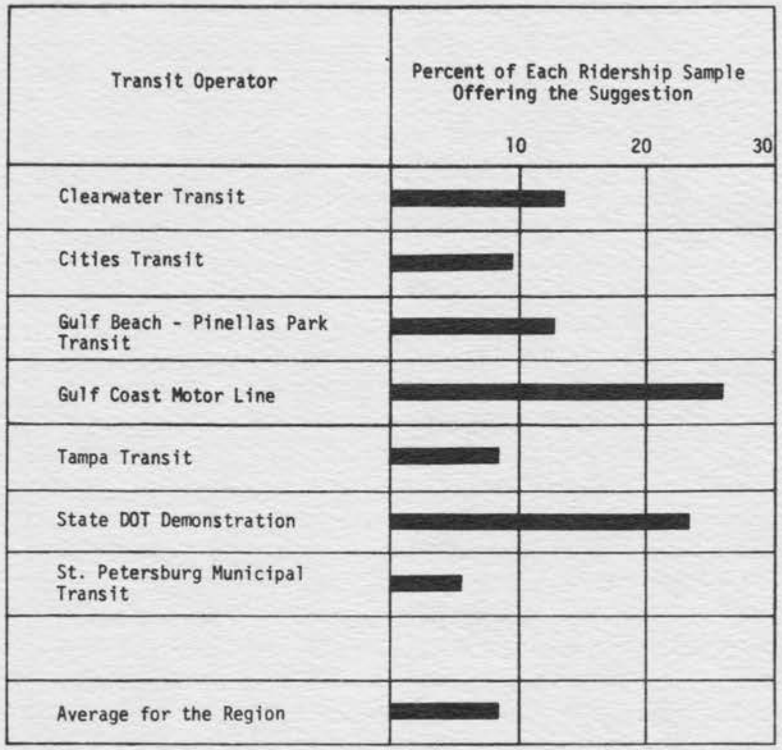

Figure I-m. Ridership Comparisons on Suggestions for More Complete Area Coverage

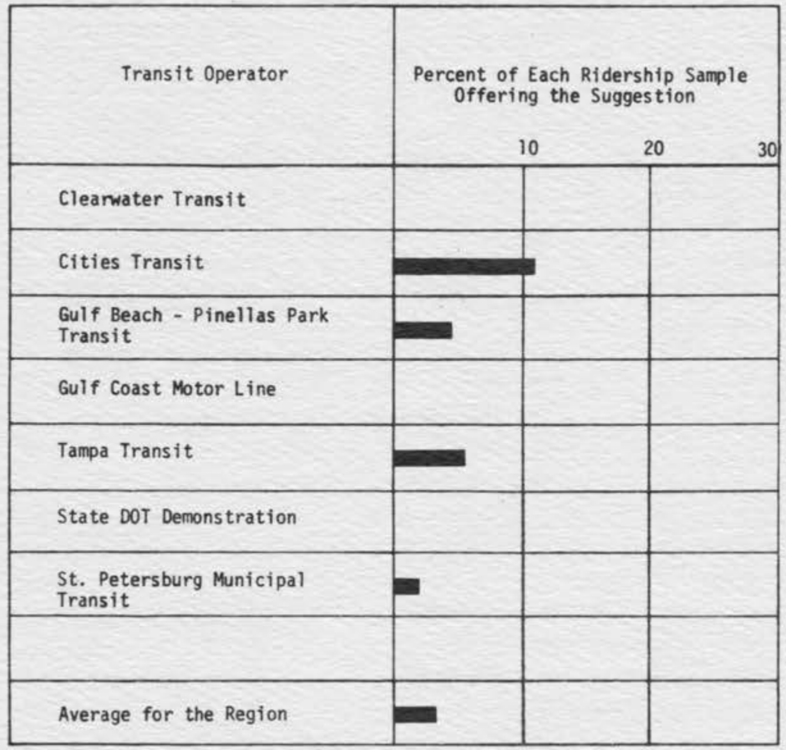

Figure I-n. Ridership Comparisons on Suggestions for More Conscientious and Polite Drivers

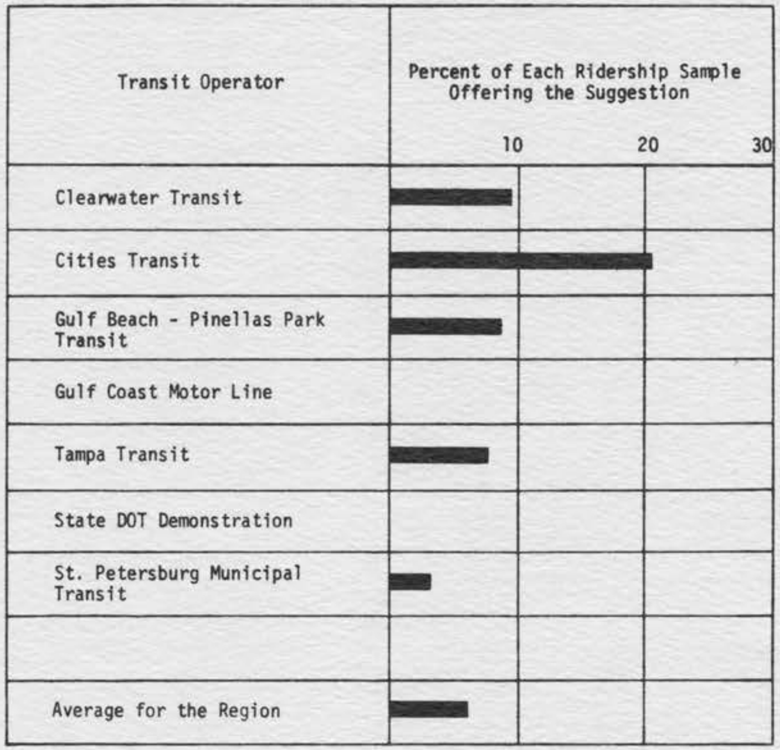

Figure I-o. Ridership Comparisons on Suggestions for Improved Bus Equipment

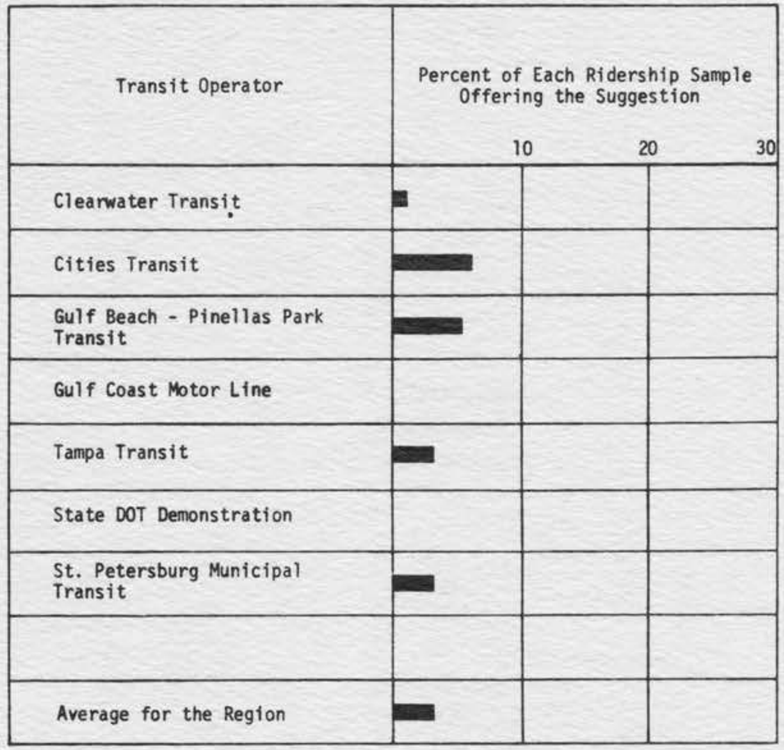

Figure I-p. Ridership Comparisons on Suggestions for Increased Use of Minibuses

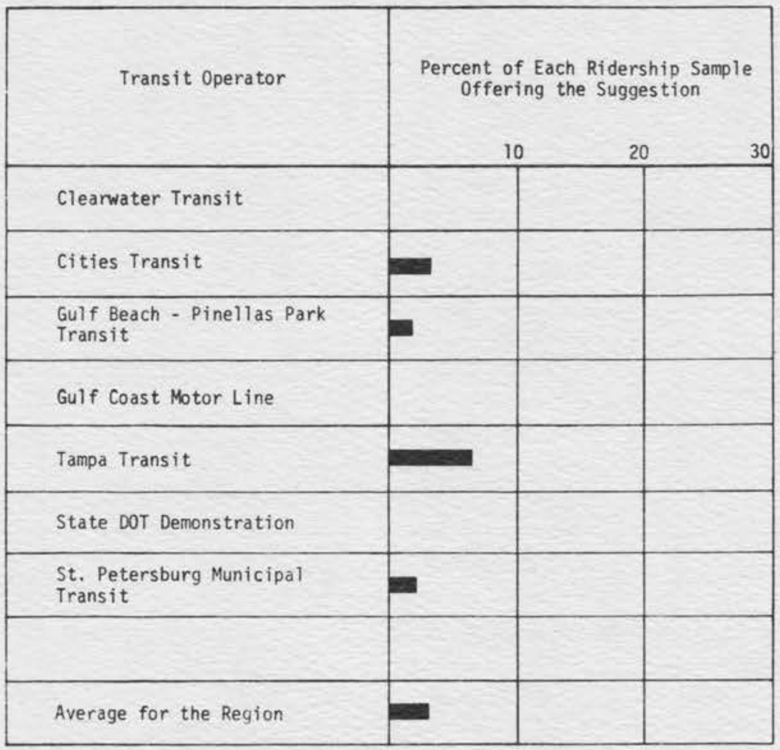

Figure I-q. Ridership Comparisons on Suggestions for Improved Waiting Accommodations

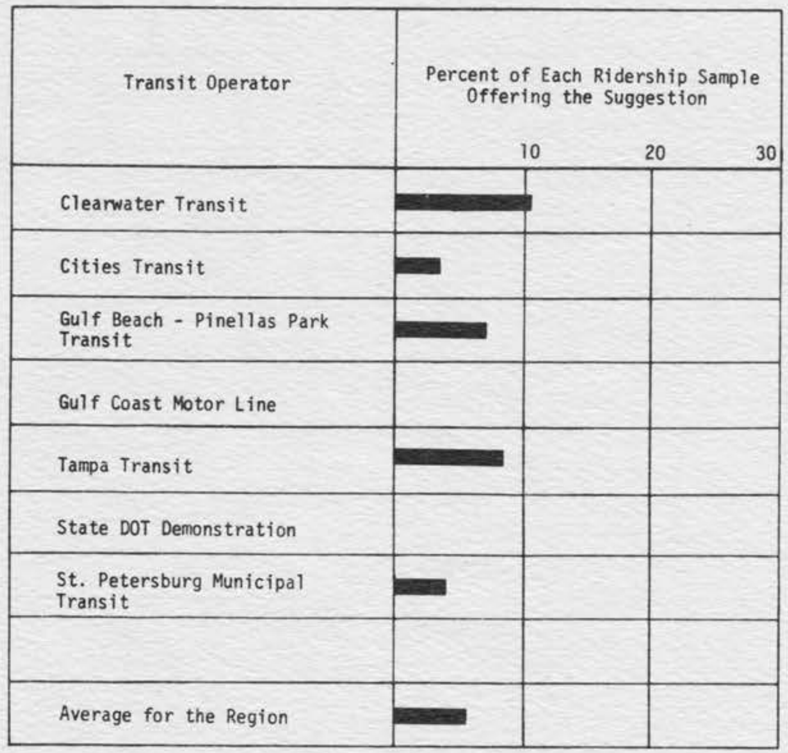

Figure I-r. Ridership Comparisons on Suggestions for Lower Fares

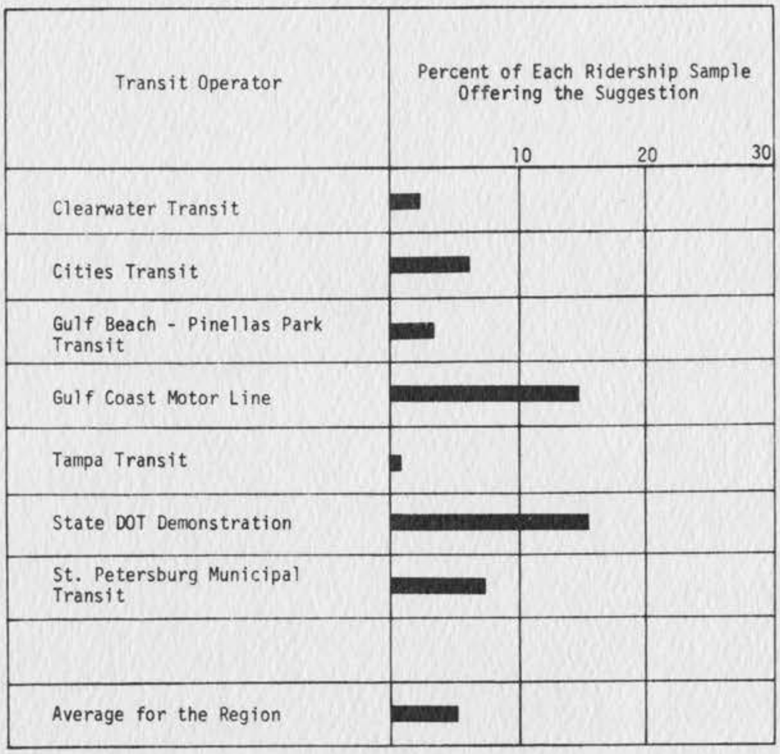

Figure I-s. Ridership Comparisons on the Comment that Present Service Is Generally Good

Generally speaking, more service on Sundays and holidays and more frequent service rank high among user suggestions for all the riderships. Cities Transit riders are particularly sensitive to the poor condition of their system's bus equipment. By far the most important issue as far as Gulf Beach-Pinellas Park riders are concerned is more frequent service. The most important improvement as far as Gulf Coast Motor Line and State DOT Demonstration Project riders are concerned is to have more complete area coverage. Clearwater Transit and Cities Transit patrons place greater emphasis on the need for more Sunday and holiday service than the other riderships in the Region. A greater percentage of Clearwater patrons suggested more evening and early morning service compared with the Region's other riderships, with Tampa Transit ranking second. The greatest percentage of riders commenting that present service is generally good occurred in the Gulf Coast Motor Line and State DOT Demonstration Project riderships.

APPENDIX II

VEHICLE TECHNOLOGY

INTRODUCTION

A literature survey was conducted to examine the spectrum of bus and bus-related technological innovations presently available, in an advanced stage of development or being given serious attention in the context of a longer time frame. A discussion of the potential applicability of these innovations in the Tampa Bay Region is presented in the main body of this report. The results of the technological survey are summarized below.

EXHAUST EMISSION KIT

General Motors Corporation has developed an exhaust emission kit which is currently being installed and tested on several buses in Washington, D. C. The kit is not readily visible when viewed from the exterior of the bus. It incorporates two vents (one intake and one exhaust) which are mounted on each side of the bus rear window and can be made to blend in very effectively. The kit contains several other components, most of which are installed in the engine compartment. These components include such items as filters, special muffler and associated parts. The Washington Metropolitan Area Transportation Commission is monitoring the effectiveness of the devices, and officials state that preliminary performance data indicates the emissions from buses equipped with kits will meet the new city air pollution code. Interestingly, a by-product of this kit, which includes some special engine mounts, is a two-db drop in interior bus noise level.

GAS TURBINE ENGINES

It is being widely predicted that gas turbine engines will be one of the earliest replacements for gasoline and diesel engines in order to meet national air pollution requirements. Significant progress is being made in the use of gas turbine engines for trucks and buses. Ford, GMC, International Harvester and others have test versions of their turbine engines presently installed in trucks and buses. GMC has publicly shown its gas turbine application for buses --- the GTX Turbine Experimental Bus.

Some recent emission test results under the California Driving Cycle are shown in Table II-a.

Table II-a. Vehicle Power Plant Emission Data

Engine Type	Emission (Grams per Mile)		
	Carbon Monoxide	Unburned Hydrocarbons	Nitrogen Dioxide
1960 Otto	80	11	6
1970 Otto	23	2.2	6
Diesel	5	3.5	4
Gas Turbine	2.4	0.2	1
Steam	2.8	0.6	1
Stirling	1.0	0.1	2.6

These and other similar data support the contention that gas turbines are likely to replace diesels and gasoline engines for certain applications in the near time frame. The significant reduction in carbon monoxide and hydrocarbons between the 1960 and 1970 versions of the Otto cycle gasoline engine is probably attributable to such things as the oxy-catalyst exhaust device which is reputed to reduce these emissions without serious increases in back pressures, and special emission reburning cycles and control valves.

GAS TURBINE TRENDS

High fuel consumption per BHP hour has been an everpresent problem for gas turbine researchers. The problem is less severe for higher horsepower engines (300 - 400 HP); however, smaller size engines have experienced unacceptable fuel consumption. Considerable attention is being given to the problem of developing smaller gas turbine engines, such as would be more appropriate for urban bus applications.

WILLIAMS RESEARCH CORPORATION

The Williams Research Corporation is presently developing an 80-HP turbine which is 250 pounds lighter than the Chrysler automotive turbine of 10 years ago. The Williams turbine, shown in Figure II-a, is unique not only because of its small size and low weight, but also because it

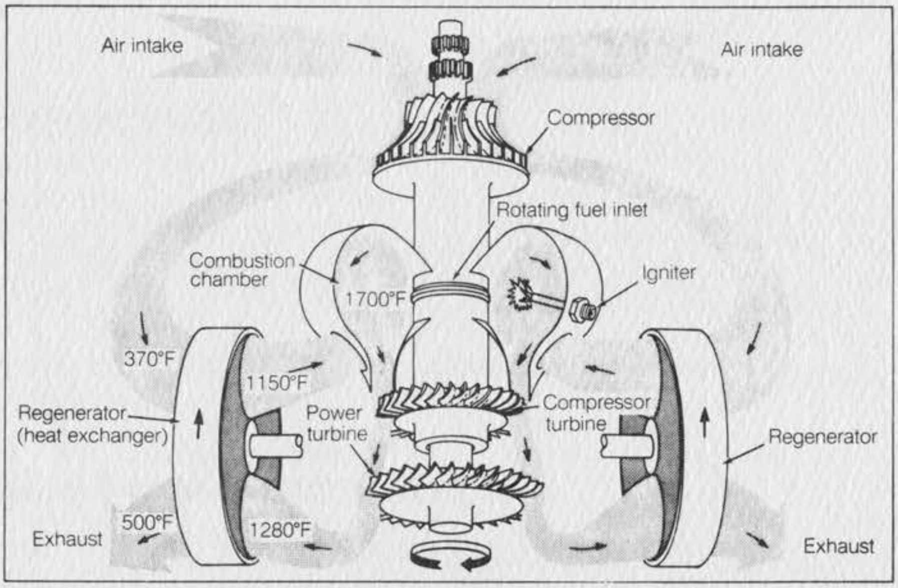

Figure II-a. Williams Gas Turbine

includes a pair of rotary heat exchangers which will provide reduced fuel consumption compared with earlier turbines. The Williams turbine will be installed in an American Motors Hornet for experimental use in New York City traffic.

FORD MOTOR COMPANY

The Ford Motor Company has built a new plant in Ohio to manufacture its second generation turbine which has sustained 250,000 miles of operation in trucks and in a Trailways bus. These turbines will be in the 225 to 335 HP range, and they will be much smaller and lighter than comparable diesels with the same power rating.

LEAR MOTORS CORPORATION

William Lear, President of Lear Motors Corporation, has combined his steam development efforts with his turbine capabilities to produce the organic turbine system which is shown in Figure II-b. The intended application of this system is for a compact, light, efficient bus for city operations. The bus design utilizes a steam turbine to drive an alternator, and brushless electric drive motors, one at each wheel.

LTV AEROSPACE CORPORATION

The Dallas Public Transit Board has received an award from the Department of Transportation to develop and test a Rankine cycle turbine system using toluol as the working fluid. The working fluid is condensed and expanded within a closed system, and is used to drive a turbine which in turn supplies power to the wheels. The project is to be managed by LTV Aerospace Corporation, with Sundstrand's Aviation Division subcontracting to develop an engine suitable for a 25-passenger transit bus. The DOT grant covers feasibility testing only.

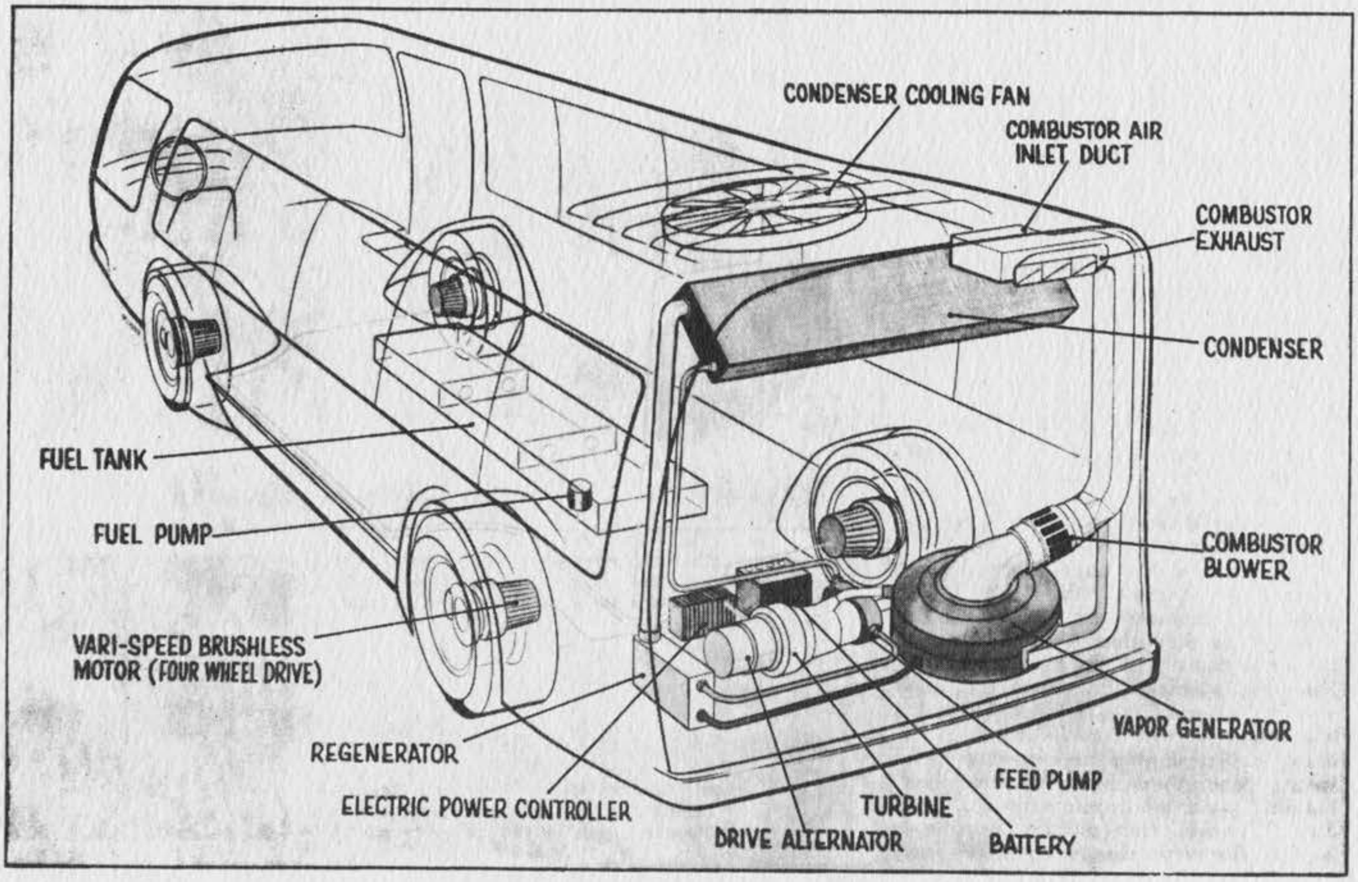

Figure II-b. Lear Vapordyne Power System

NATURAL GAS ENGINES

Several development efforts have been undertaken in recent years to compare the performance, including emission levels, of converted diesel engines running on liquified natural gas (LNG) versus standard diesel fueled diesel engines. Not only did the results indicate a fuel savings with LNG, but emission pollutant levels also dropped appreciably. As a result of such tests and LNG industry marketing efforts, there has been considerable activity in conversion to LNG. For example:

1. At present, Milwaukee's entire taxicab fleet is running on propane.

2. In 1968, Chicago had 1,500 buses equipped to operate on propane.

3. Orlando has engaged in a program of converting its fleet of service vehicles to propane.

4. The Washington Gas Light Company is operating four or five service vehicles on compressed natural gas (no test results have been made public yet).

5. The U.S. Post Office in Washington, D. C., is operating several postal vehicles on compressed natural gas (the Post Office maintains its own natural gas compressing facility).

OTHER ENGINE TYPES

The engine types discussed below are all being actively pursued, but in each case, availability is much further away than for the engines discussed above, and their potential for public transit vehicle applications, if any, will be much more difficult to realize.

ELECTRIC STORAGE BATTERY

Since 1929, many articles have appeared predicting the future of electrically powered vehicles. Today, a considerable amount of money is being spent on the development of such vehicles. The Department of Housing and Urban Development is sponsoring research into the application of electric storage battery power for buses. A $150,000 grant has been given to the National Academy of Science for the first phase of a "new bus design."

The concensus is that small, low-speed, short-trip vehicles will remain the principal application of electric storage battery propulsion power for some time to come. Experimental vehicles of this type include the "StaRRcar," "Renault-Dauphine," "Commucar," "Mini," "Scamp," "Trident," and "Honda Z."

STEAM

There are many problems associated with steam engines for modern applications that remain unresolved. These include:

1. Water as a working fluid freezes

2. Enormous condensers are required

3. Boilers are complex and expensive

4. Control remains a major problem

Regardless of the general pessimism surrounding steam engines, however, the Federal Government is very interested in steam propulsion for vehicles and has engaged William Lear in the application of the steam engine to a bus. Mr. Lear's efforts have apparently been directed at fitting a 300-HP steam system to a bus manufactured by Flxible Bus Company.

FUEL CELL

Other than small fuel cells developed for the military and the Apollo Program, there has been little effort devoted to the industrial application of fuel cells. The essential problem is high cost directly related to such items as platinum catalysts, inefficient electrolytes and inefficient fuels. The primary application of fuel cells, assuming costs can be reduced, is for power sources at remote sites, oil rigs and meteorological stations. The military uses fuel cells as small field power sources for radios.

WANKEL ENGINE

Curtiss Wright Corporation and GMC have arrangements with the German NSU Company for marketing activities in the United States. However, in view of the Wankel engine's poor emission characteristics due to its combustion chamber design (i.e., surface to volume ratio is very high), it is doubtful whether this engine can be competitive in the low exhaust emission environment that the vehicle industry must survive in.

NOISE REDUCTION

Most of the attention given to vehicle noise reduction has been directed at the engine and exhaust system.

The Danes have developed a new exhaust system which is reported to be very efficient in reducing exhaust noise. It has been adopted for the 500 buses that comprise the Copenhagen bus transportation system. Essentially, the components of the exhaust system consist of a two-chamber muffler with reflectors in the first stage and absorption material in the second. Presumably, there has been no serious increase in exhaust system back pressure.

Another engine noise attenuation effort has been underway for some time by a British firm, CAV Ltd., which has addressed diesel engine noise reduction by analyzing engine configurations and structure shapes. This effort has resulted in a 5 dba reduction in noise through the use of sandwich type metal/rubber panels for large flat surfaces, and the use of silicone rubber protected slots for isolating thick covers on the engine exterior. Currently, the CAV people are predicting another 5 dba reduction in noise through the control of piston slap and timing gear impact.

SAFETY

One interesting safety device for buses (conceived and developed by the Miami Transit Company) provides a "dead man" control system similar to that employed by the railroads for many years. The device consists of a specially designed bus driver safety seat which incorporates a sensor. The sensor is activated if the driver falls or becomes unseated for some reason. The sensor triggers a circuit which activates the air brake system bringing the bus to a smooth gradual stop without locking the wheels.

Another development which will, when finalized, contribute to increased vehicle safety is the energy absorbing bumper system. The insurance companies, in conjunction with the National Highway Safety Bureau, are working on bumper standards which will require that cars must be able to withstand a 5-mph impact (Florida is calling for 10-mph capability). The automobile companies (and presumably, bus manufacturers) are currently surveying the field of candidates. These include:

1. The Tayco Shock Absorber - a liquid spring design incorporating a silicone oil which can be compressed to 85 percent of its original volume. This system is similar to railroad between-car bumpers which originally employed coil spring recoil devices.

2. The Menasco Shock Absorber - similar to the Tayco device except instead of using a compressible oil, a highly compressible silicone rubber filler is used. The advantage here is reduced maintenance without leakage problems.

3. The Tor-Shok Shock Absorber - unique component is a helically wound coil spring which is caused to react as a series of tori as it rolls inside out under the movement of telescoping tubes.

APPENDIX III

SURVEY OF TRANSPORTATION MODELS

INTRODUCTION

Specifications for the TBR transportation systems analysis model are presented in the main body of this report. To aid in the development of those specifications, a comprehensive survey of existing transportation analysis computer programs was employed to act as a point of departure and a library of available modeling technology.

Thirty-four transportation and traffic models were reviewed and classified according to purpose, underlying theory, operational method, data usage and degree of aggregation. A bibliography of the thirty-four models is given at the end of this appendix.

MODEL PURPOSES

Four major purposes were identified for the thirty-four models surveyed:

land use allocation
population distribution
transportation analysis
economic analysis

LAND USE ALLOCATION

Many of the models surveyed were designed to allocate land in conjunction with the planning of a related transportation system. Simple models have been developed to deal only with the allocation of residential land, and more general models have been developed to provide for the allocation of land in several different categories, such as residential, industrial, commercial, public function, public open space and governmental.

The Chicago Area Transportation Study (Reference 7 in the bibliography) is an example of a general land use model. It was used to forecast population and manufacturing employment by zone for the year 1980. It also sought to determine the quantity of land in each zone that would be used for such purposes as housing, commercial, public open space, manufacturing, transportation and streets. Then, interzonal travel demands could be determined and transportation requirements identified.

POPULATION DISTRIBUTION

Another common purpose among the transportation models surveyed was distribution of present and future population. This was frequently combined with the allocation of land uses.

Some models produce a population distribution described by number of people as a function of distance from city center. Others determine area densities, given land use, employment and population distribution data. Still others attempt to compute density by means of systematic correlations with income, housing, land use and age distribution. Policy-makers can then examine the effect of their decisions by using these models and perturbating the independent variables to determine effect on population densities.

TRANSPORTATION ANALYSIS

This, of course, was the most common objective of the models surveyed. Transportation analysis and land use allocation are usually interdependent, and the interdependency can be accounted for internally within a single model or externally through separate evaluation. Several of the very large, multi-purpose urban planning models surveyed included transportation analysis and land use allocation within a single model. These models allocate land uses within the various zones, compute traffic volume between zonal pairs, project changes in the transportation system in response to the computed traffic volumes, and complete an initial loop by estimating the impact on land use patterns due to the projected changes in the transportation system. Older models were found to usually trace through this circular path only once, while later models usually cycle through the loop several times.

ECONOMIC ANALYSIS

A number of the models perform some sort of economic analysis in support of transportation analysis. In some cases the analysis is provided by externally inputting cost/benefit data, in other cases a sub-model is used to produce economic input for a general model, and a few large models perform economic analysis within the primary model. In the first case, economic data is treated as a given input, and the model computes dependent planning variables, such as population, land use or transportation. The second case involves a multistage process to calculate the planning variables. In the third case, the model accepts as input all the exogenous variables that determine employment, retail trade levels and personal incomes.

MODEL THEORY

Transportation systems models can be conveniently sorted into two classes with respect to underlying theory: behavioral and growth forces.

BEHAVIORAL

Economic models based on the concepts of rational choice, market behavior and equilibrium combine to create the general class of behavioral models. The Penn-Jersey Transportation Study (Reference 20 in the bibliography) is an example of a behavioral model that predicts residential distribution. It is based on assumed behavior of individuals renting or buying a house, regarding the percentage of annual income they would be willing to spend on housing and transportation, and on the assumed behavior of land owners regarding their objective to allocate land to that group of households able to pay the highest price for it.

Other behavioral models use observed travel and/or trip distribution patterns to represent certain decision-making processes. These models, based on the concept of general preferences, relate behavior as evidenced by a choice or preference to such factors as income, household activity patterns and transportation descriptors, including taste norms of transit and non-transit users.

GROWTH FORCES

Models based on growth forces depend on a knowledge of social forces rather than on individual behavior in making calculations and generating projections.

The purest example of this type of model is the very useful social physics model. The theory of social physics derives from an analogy between social phenomenon and Newtonian physics, specifically, gravitational forces. In physics, the force of physical attraction between two bodies is directly proportional to the product of their masses and inversely proportional to the square of the distance between them. Similarly, the force of social attraction between two population centers is assumed to be directly proportional to the product of their populations and inversely proportional to some power of the distance separating them.

Another theory in this class is the intervening opportunities theory, which states that the probability of a trip originating in one zone and finding a destination in another zone is proportional to the possible trip destinations in the other zone and to the number of intervening trip destinations previously considered. Spatial separation for the intervening opportunities model is measured not in absolute travel time, cost, or distance, but in the number of intervening destinations or opportunities.

Accessibility models are another way of quantifying the opportunity or potential for interaction. Accessibility is a measure of the intensity of the possibility for interaction rather than just a measure of the ease of interaction.

Two growth force concepts that find frequent use in transportation analysis models are the so-called modified and simple trend. The two are mathematically similar; both analyze historical data to determine behavioral and growth trends. Normally, regression equations are used to describe the observed behavior. With the trend concept, the model is tested, calibrated and refined using historical data, and then used directly to forecast or project future occurrences. The modified trend concept projects historical trends in the light of new behavior patterns or additional external variables.

OPERATIONAL METHOD

Operational methods used in the surveyed models and the manner in which they may be classified are shown in Figure III-a. An operational method is defined here to be the method utilized to process exogenous inputs into a meaningful product or output. A large model will often employ submodels to internally generate data needed as inputs for successive stages of the model. Thus, a single model may actually employ several operational methods.

The two basic operational methods are identified in Figure III-a as optimizing and non-optimizing. Optimizing models can be further classified as linear or dynamic models; and non-optimizing models can be subdivided into simulation, algorithmic, heuristic and statistical models.

OPTIMIZING MODELS

Optimizing models are mathematically closed form. They seek to find a single "best" or "optimum" solution to the system problem by optimizing an objective function subject to constraints defined within the model. Optimization normally consists of maximizing or minimizing the objective function as appropriate, and the objective function is usually related to such parameters as cost, profit, fare, effort, utility, benefit or some unit of physical output. The use of such a model presupposes the existence of some optimization criteria, and since the model focuses on a single goal, it tends to present a rather simplistic view of the total problem.

LINEAR MODELS

The Penn-Jersey Regional Growth Model (Reference 20 in the bibliography), which allocates households to available land, is an example of an optimizing linear programming model. The model seeks to locate households in such a way as to maximize their aggregate rent-paying ability. The objective function in this case is the summation of individual rent-paying abilities. There are two constraints imposed on the system. All

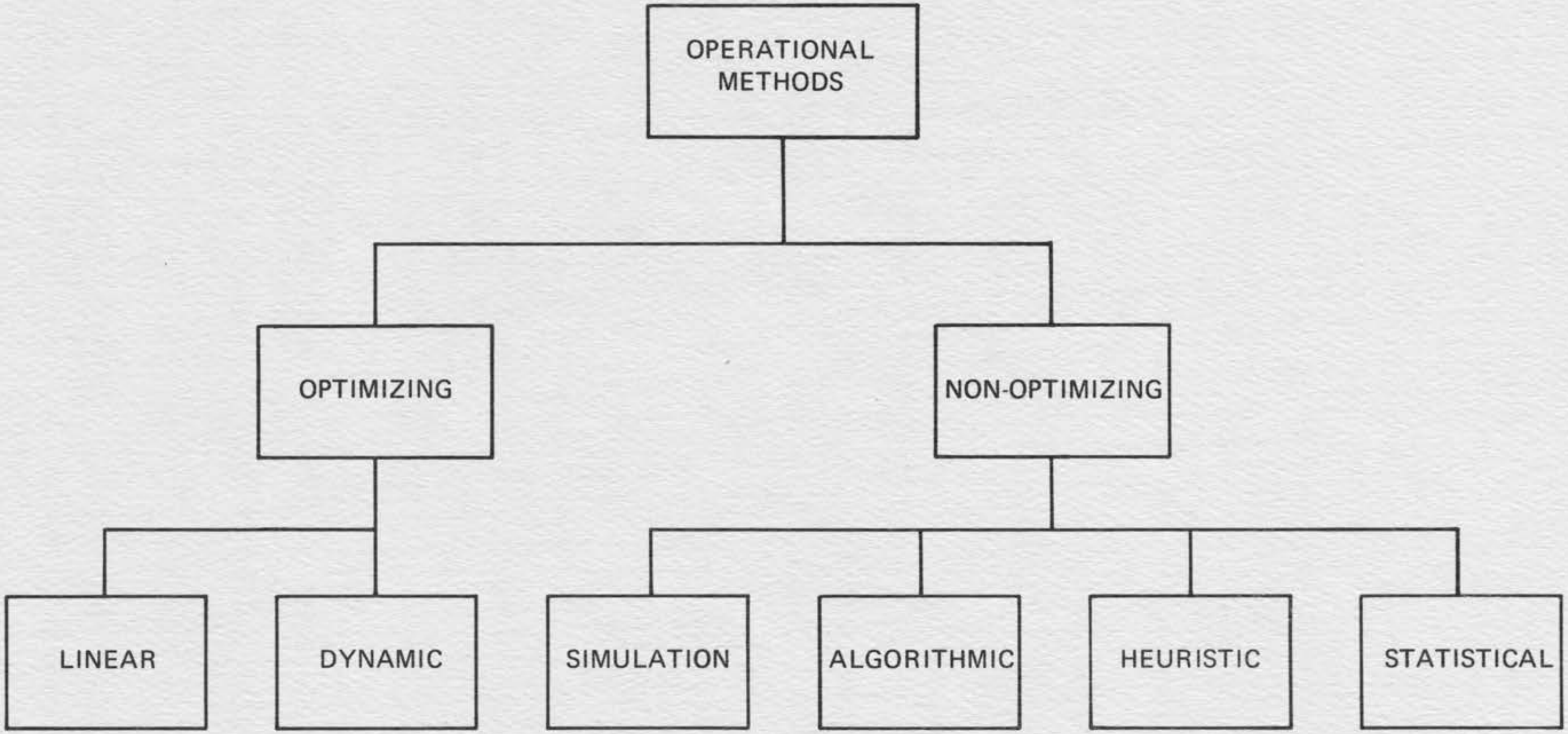

Figure III-a. Operational Methods for Mathematical Modeling households must be located and the total land used in each zone must not exceed the land made available.

DYNAMIC MODELS

The second optimizing technique makes use of dynamic programming and has the potential for removing the two primary restrictions inherent in linear programming. This class of mathematical procedures is capable of handling both discrete and nonlinear objective functions and constraint relationships. To date, this technique has received little use in transportation system modeling.

NON-OPTIMIZING MODELS

In the case of non-optimizing techniques, the modeling objective is to symbolically represent the real system and analyze its behavior under a variety of conditions. Model builders frequently settle for this more easily obtainable objective (compared with the objective of optimization) because often it is the only practical approach available in analyzing large complex systems with intractable relationships that defy any reasonable form of optimizing solution. The model becomes a tool for testing and experimenting with alternative system configurations, fare policies, service policies, financing arrangements, regional conditions and other similar considerations.

SIMULATION MODELS

Simulation models are powerful tools for producing conditional forecasts. Usually, a simulation model consists of four major components: status variables, exogenous variables, functional relations, and output. Status variables describe the state of activity within the system area at the beginning of the period to be simulated. Exogenous variables describe behavior or conditions outside the area. And, functional relations describe interrelationships between internal components of the simulation model. Functional relations are used to predict the changes which will occur during the simulated period as a result of the exogenous factors acting on the status variables. The model's output describes the activity state at the end of the simulated period. The simulation model is well suited for observing the behavior of a proposed transportation system in response to hypothetical policy changes, new planning strategies or revised development forecasts.

ALGORITHMIC MODELS

Algorithmic models are replicative, closed-form analytic systems requiring no human judgment in their operational process. Given the algorithmic system, any operator can locate the inputs, initiate the processing of the input data, and the technique will iterate to a solution. The solution will not be optimal unless the model builder has defined the computational procedures in such a way that the technique will locate the optimum solution. Given the same inputs, the outputs of the model will always be the same. It is only when the inputs are changed that the output of the model will vary.

Algorithmic models include gravity models, opportunity models, modal split models, abstract mode models and traffic models. These are all well known in the transportation field and represent some of the fundamental building blocks for large transportation analysis models.

HEURISTIC MODELS

Heuristic models may be defined as non-optimizing, open-form analytic models which are non-replicative. Their operation depends partly on human judgment and partly on their mathematical procedures. The model will perform computations on the input data up to the point where a human decision is necessary. At some number of points during the exercise of the model, a judgment in the form of a decision from the operator is required. A heuristic model will only arrive at a solution if this constant interaction between the model and its operator occurs. The final output of a heuristic model is thus dependent on the individual operating it. Given the same inputs, it is very likely that the model output will differ significantly from one individual to the next. The Chicago Area Transportation Model (Reference 7 in the bibliography) is an example of a heuristic model.

STATISTICAL MODELS

The commonly used technique for statistical modeling is multiple regression analysis. This is another modeling method frequently used in the construction of transportation analysis computer models. Statistical models account for the effect of random variations by virtue of the procedures used in handling independent inputs to the model. Parameters describing the behavior of input variables are determined at a single point in time, and the models are static. In the case of a multiple regression equation, these parameters are the regression coefficients.

DEGREE OF AGGREGATION

The transportation system models surveyed utilized varying degrees of aggregation. The extent to which a model-builder can disaggregate depends on the availability and quality of data, storage and process limitations of the computational method used, the objectives of the model, and the precision of the analytical routines. Theoretically, the basic unit of aggregation should be the smallest unit which forms a meaningful and homogeneous sub-metropolitan community. For the most part, behavioral models tend to be more disaggregated than growth-forces models.

Model aggregation can be thought of in terms of space aggregation or population aggregation.

Space aggregation refers to the size of the planning zone or land area used for allocation purposes in a transportation model. Some models may use city blocks as their basic unit while others use square miles or even larger units. The objectives of the model determine the degree of space aggregation. The more complex models demand a greater degree of disaggregation in order to achieve their objectives.

Population aggregation refers to stratification in terms of descriptors such as income level, household size, and car ownership. Often it is found that the degree of population stratification is related to the degree of space aggregation. The greater the disaggregation of space, the greater the degree of population stratification.

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