

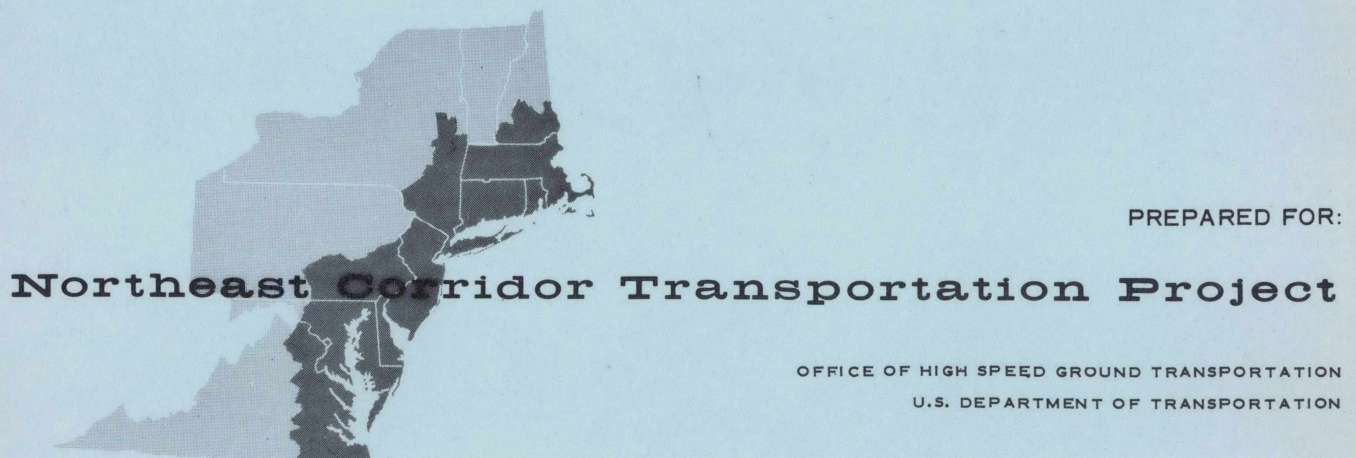


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Frank J. Macklin
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NORTHEAST CORRIDOR TRANSPORTATION FACTS AND STATISTICS

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WASHINGTON, D.C.



PREPARED FOR:

Northeast Corridor Transportation Project

OFFICE OF HIGH SPEED GROUND TRANSPORTATION
U.S. DEPARTMENT OF TRANSPORTATION

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16. Abstract <p>The material presented in this document is meant to provide the reader with basic information on the intercity transportation system and other select regional characteristics of the Northeast Corridor. Primary attention is given to the status of the existing transportation system and the magnitude and characteristics of system usage.</p> <p>The data presented herein are derived from many sources and have been aggregated, expanded, and updated where necessary to achieve a common base. The original data source has been identified wherever possible.</p> <p>Only the most reliable sources have been used in this report, however, in some cases data on important areas are available only in the form of estimates or representative figures. In these cases the tables and charts are marked as estimated or typical.</p>			
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This volume is one of a set of 17 reports supporting the Northeast Corridor Transportation Project Report of December 1969 (NECTP-209). As a set, the 17 reports provide detailed information on Corridor transportation and cover descriptions of the Corridor, its problems and prospects, project methodology, descriptions of alternative systems, and the cost analysis techniques upon which the findings of the main report are based. Included in the document set are:

DESCRIPTION OF THE NORTHEAST CORRIDOR (NEC): TRANSPORTATION PROBLEMS AND PROSPECTS	REPORT NUMBER
NEC Transportation: Problems and Prospects	NECTP-210
Status of the Transportation System and Plans for Improving Intercity Transportation in the NEC	-211
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PREFACE

The primary function of the Northeast Corridor Transportation Project is to determine the intercity transportation facility requirements of the Northeast Corridor and to evaluate the potential effectiveness of alternative transportation systems in meeting these needs.

This report, entitled Northeast Corridor Transportation Facts and Statistics, is one report in a series concerning the current progress of the Northeast Corridor Transportation Project. It contains information on transportation service being provided to Corridor residents as well as data descriptive of the Corridor itself.

The report is organized in four major sections plus an Appendix. Section I, The Introduction, provides a brief history of the Northeast Corridor Transportation project plus basic socioeconomic and geographic data pertaining to the Corridor.

Section II provides background information on intercity transportation modes serving the Northeast Corridor. It is based largely on data developed from preliminary tabulations of the Northeast Corridor Travel Survey sponsored by the Office of High Speed Ground Transportation and conducted by the Bureau of the Census. The section also contains estimates of intercity travel that have been developed from numerous secondary sources.

Section III describes transportation service in the Corridor. The level of service to and between major metropolitan areas as well as service to and between rural portions of the region are defined in terms of frequency, travel time and travel cost. Access characteristics for common carrier terminals are provided so that trip comparisons can be made between paired community centers. The extent of transportation facilities are graphically depicted and trends in the usage of these facilities are provided.

Section IV presents a listing of the major transportation planning agencies in the Corridor specifically listing Federal Highway Administration Regional Offices, State Supported Transportation Planning Programs in the Region and State Aviation agencies.

The Appendix contains miscellaneous transportation data for other than the Corridor region or related to specific elements of individual modal travel. It also contains a bibliography of reports published by the Office of High Speed Ground Transportation and the Northeast Corridor Transportation Project.

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I. INTRODUCTION

Background and Composition of The Northeast Corridor Transportation Project

In June 1962, Senator Claiborne Pell of Rhode Island introduced into the Congress a resolution (S.J. Res. 194, 87th Congress, 2nd Session) which would have authorized the District of Columbia and eight Northeastern States to "...enter into a compact to establish a multi-state authority to construct and operate a rail passenger transportation system within the area..." Senator Pell requested that the Administration consider the transportation problem which had prompted his resolution. The President responded by directing that an interagency task force be assembled "...to survey available information, to identify issues and to estimate the time, expense and staff required to prepare such proposals as may be appropriate." The interagency task force reported to the President on December 10, 1962, recommending that a "...comprehensive analysis of transportation problems in the Northeastern Megalopolis..." to determine the needs for transportation service to 1980 and beyond for both passengers and freight be carried on by the U. S. Department of Commerce.

Work began on the Washington-Boston study in June 1963 with funds which had been previously appropriated by Congress for transportation research in the Commerce Department. In September 1964 the study was given formal project status as the Northeast Corridor Transportation Project, first, in the Office of the Secretary of Commerce and, in April 1965, in the Office of the Under Secretary of Commerce for Transportation.*

The presidential directive left the determination of both the geographic limit of the study region and the study approach up to the Project staff. Late in 1965 a preliminary description of an area system for the study was prepared which is still in use to date.** The description established the

* In April 1967 the Project was transferred to its present location within the Department of Transportation.

** Description of the Area System for the Northeast Corridor Transportation Project, NECTP Technical Report #2, December 1965.

areal extent and the jurisdictional make-up of the Northeast Corridor Transportation Project Region (see Figures I.1 and I.2). The furthest limits of the region were obtained by establishing a cordon line outside of which there was a noticeable decline in population density and within which there were evidences of strong economic or transportation connectivities among the communities.

The region which resulted contained nearly 39 million people in 1960 and 43 million people in 1966, as reported in Table I.1; while the forty-one Standard Metropolitan Statistical Areas (SMSA's) contained 88% and 87% of the reported Corridor population for the respective years (see Table I.2 and Figure I.3).

The major political divisions of the Corridor region are: the entire states of Connecticut, Delaware, New Jersey, Massachusetts and Rhode Island; portions of Maryland, New Hampshire, New York, Pennsylvania and Virginia; and the District of Columbia. The next level of political division accounts for 165 counties and independent cities. These latter jurisdictions were used to form the basic statistical unit for the study termed the "district." In most cases a Corridor district is a single county or independent city. Districts were then aggregated into larger units called super-districts, and the latter were further aggregated into market-areas. These three areal classifications were selected as the most convenient areas for use by the set of Northeast Corridor transportation models as data-base, analysis, and reporting units respectively. The delineation of these three areal systems are depicted in Figures I.4, and I.5. There are a total of 131 data-base districts which aggregate into 40 super-district analysis units which in turn aggregate into 10 market-area reporting units.* Appendix Table A lists the entire 165 local jurisdictions comprising the Corridor region along with its assigned district, super-district and market-area code names.

* Market-areas were delineated for the "core" set of super-districts lying astride the main spinal transportation network between Boston and Washington and not for the remaining "fringe" areas of the Corridor region.

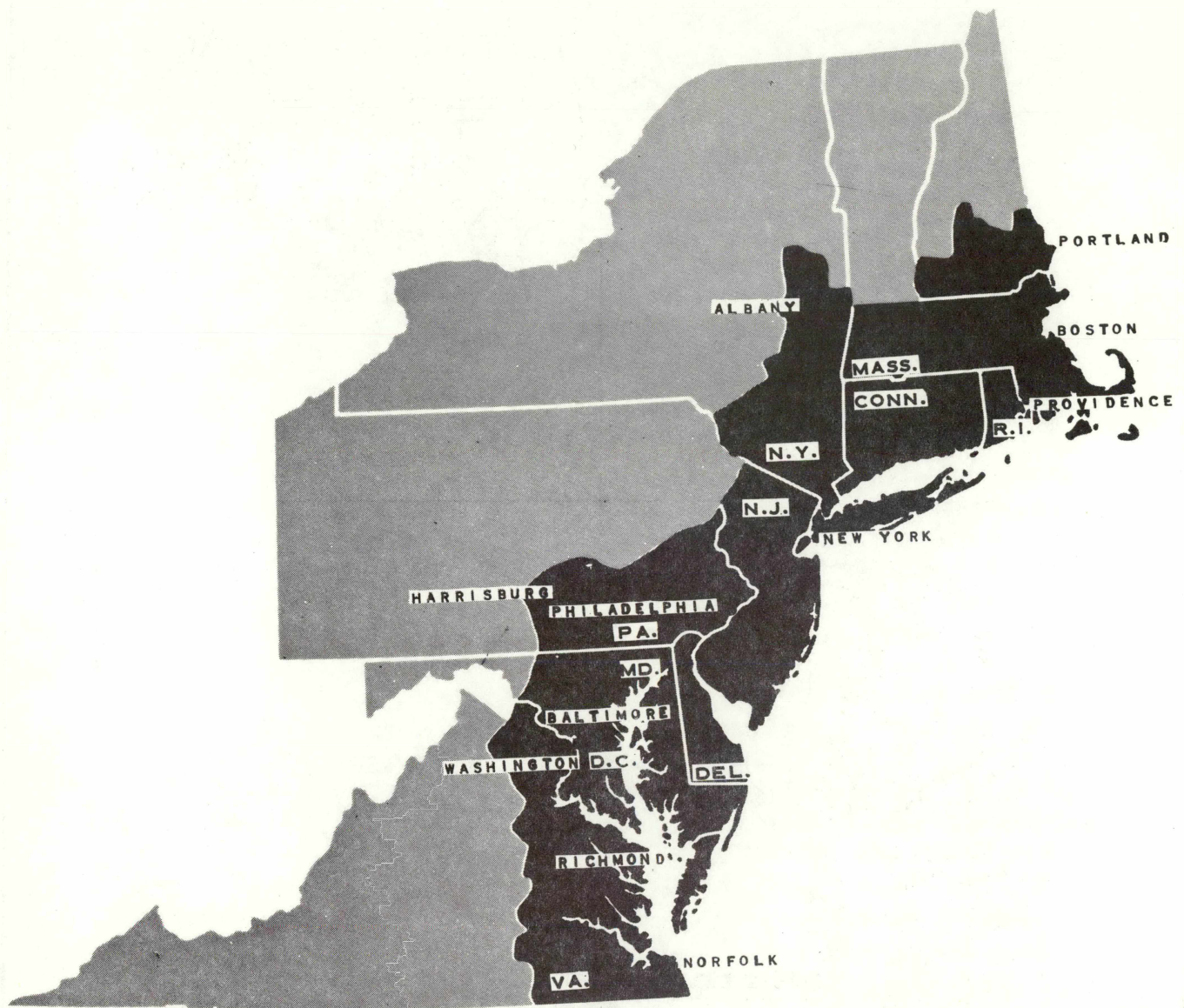


FIGURE I.1

NORTHEAST CORRIDOR TRANSPORTATION PROJECT REGION

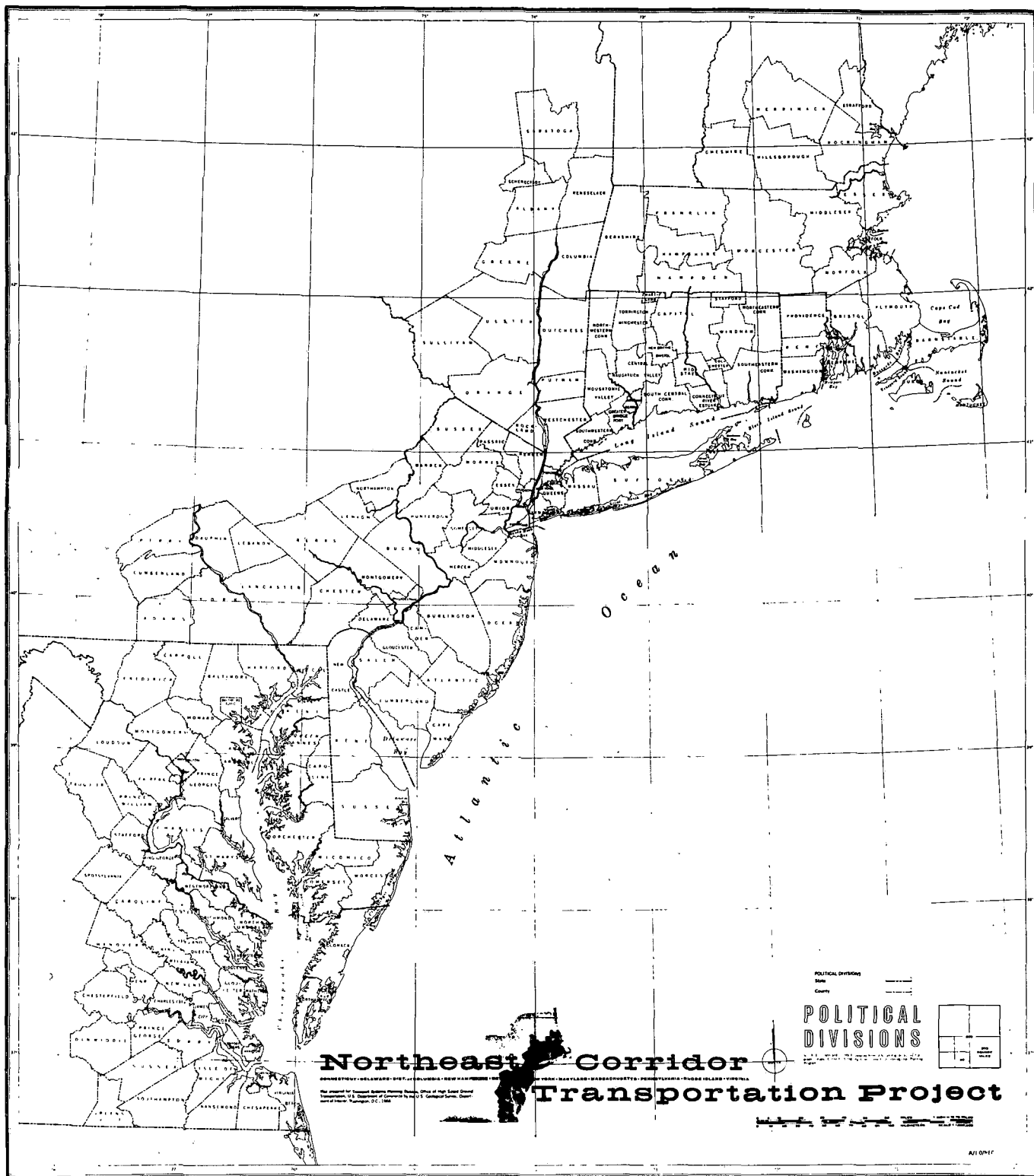


FIGURE I.2

LOCAL JURISDICTIONS WITHIN THE NORTHEAST CORRIDOR STUDY REGION

TABLE I.1

1960 POPULATION COUNT AND 1966 ESTIMATES
FOR THE NORTHEAST CORRIDOR STATES

STATE	1960 CENSUS OF POPULATION	1966 ESTIMATE OF POPULATION
CONNECTICUT	2,535,200	2,876,000
DELAWARE	446,300	514,000
DISTRICT OF COLUMBIA	764,000	806,000
MARYLAND*	2,904,900	3,475,100
MASSACHUSETTS	5,148,600	5,403,000
NEW HAMPSHIRE*	448,100	512,100
NEW JERSEY	6,066,800	6,911,000
NEW YORK*	11,986,400	12,894,800
PENNSYLVANIA*	5,327,000	5,678,000
RHODE ISLAND	859,500	898,000
VIRGINIA*	2,317,300	2,739,800
NORTHEAST CORRIDOR	38,804,100	42,717,800

* The population refers to the portion of the state that is within the Northeast Corridor.

SOURCE: Census of Population reported in County and City Data Book 1967, Estimates of the Population of Counties, July 1, 1966, Series P-25, U.S. Department of Commerce, Bureau of the Census.

TABLE I.2

1960 POPULATION AND 1965 POPULATION ESTIMATES OF STANDARD
METROPOLITAN STATISTICAL AREAS (SMSA) IN THE NORTHEAST CORRIDOR

<u>SMSA as of Jan. 15, 1968</u>	<u>1960 SMSA Population*</u>	<u>Estimated 1965 SMSA Population**</u>	<u>Percent Change</u>
Albany-Schoenectady-Troy, N.Y.	657,503	697,000	6.0
Allentown-Bethlehem-Easton, Pa., N.J.	492,168	515,000	4.4
Atlantic City, N.J.	160,880	179,000	11.3
Baltimore, Md.	1,803,745	1,962,800***	8.8
Boston, Mass.	2,595,481	2,605,452	0.4
Bridgeport, Conn.	337,983	358,800	5.9
Brockton, Mass.	149,458	172,185	15.2
Fall River, Mass.-R.I.	138,156	144,066	4.3
Fitchburg-Leominster, Mass.	90,158	91,750	1.8
Harrisburg, Pa.	371,653	391,000	5.2
Hartford, Conn.	549,249	610,800	11.2
Jersey City, N.J.	610,734	619,000	1.3
Lancaster, Pa.	278,359	288,000	3.5
Lawrence-Haverhill, Mass.-N.H.	199,136	213,196	7.1
Lowell, Mass.	164,243	179,953	9.6
Manchester, N.H.	102,861	110,792	7.8
Meriden, Conn.	51,850	54,000	4.1
New Bedford, Mass.	143,176	147,145	2.8
New Britain, Conn.	129,397	142,200	9.9
New Haven, Conn.	320,836	351,600	9.6
New London-Groton-Norwich, Conn.	170,980	189,300	10.7
New York, N.Y.	10,694,632	11,366,000	6.3
Newark, N.J.	1,689,420	1,851,000	9.6
Newport News-Hampton, Va.	224,503	271,000	20.7
Norfolk-Portsmouth, Va.	578,507	637,000	10.1
Norwalk, Conn.	96,756	112,200	16.0
Paterson-Clifton-Passaic, N.J.	1,186,873	1,307,000	10.1
Philadelphia, Pa.-N.J.	4,342,897	4,659,000	7.3
Pittsfield, Mass.	76,772	77,615	1.1
Providence-Pawtucket, Warwick, R.I.-Mass.	821,101	860,717	4.8
Reading, Pa.	275,414	283,000	2.8
Richmond, Va.	436,044	484,000	11.1
Springfield-Chicopee-Holyoke, Mass.-Conn.	493,999	494,204	0.0
Stamford, Conn.	178,409	201,900	13.2
Trenton, N.J.	266,392	296,000	11.1
Vineland-Millville-Bridgeton, N.J.	106,850	124,500***	16.5
Washington, D.C.-Md.-Va.	2,076,610	2,612,000***	25.6
Waterbury, Conn.	185,548	203,300	9.6
Wilmington, Del.-N.J.-Md.	414,565	468,000	12.9
Worcester, Mass.	328,898	337,372	2.6
York, Pa.	290,242	307,000	5.6
TOTAL	34,302,438	36,975,847	7.8

*Source: Standard Metropolitan Statistical Areas; May 1967 as amended by errata sheet of Jan. 15, 1968.

**The 1965 estimates with the exception of New England are from the Current Population Reports, Series P-25, No. 371. Department of Commerce, Bureau of the Census; January 31, 1969. For New England the following sources were used:

Connecticut - Connecticut Department of Health, July 1, 1965;
New Hampshire - Department of Resources and Economic Development, September 1, 1965;

Rhode Island - Statewide Comprehensive Transportation and Land Use Planning Program, October 1, 1965;

Massachusetts - Office of the Secretary of the Commonwealth, January 1, 1965.

***As of July 1, 1966.

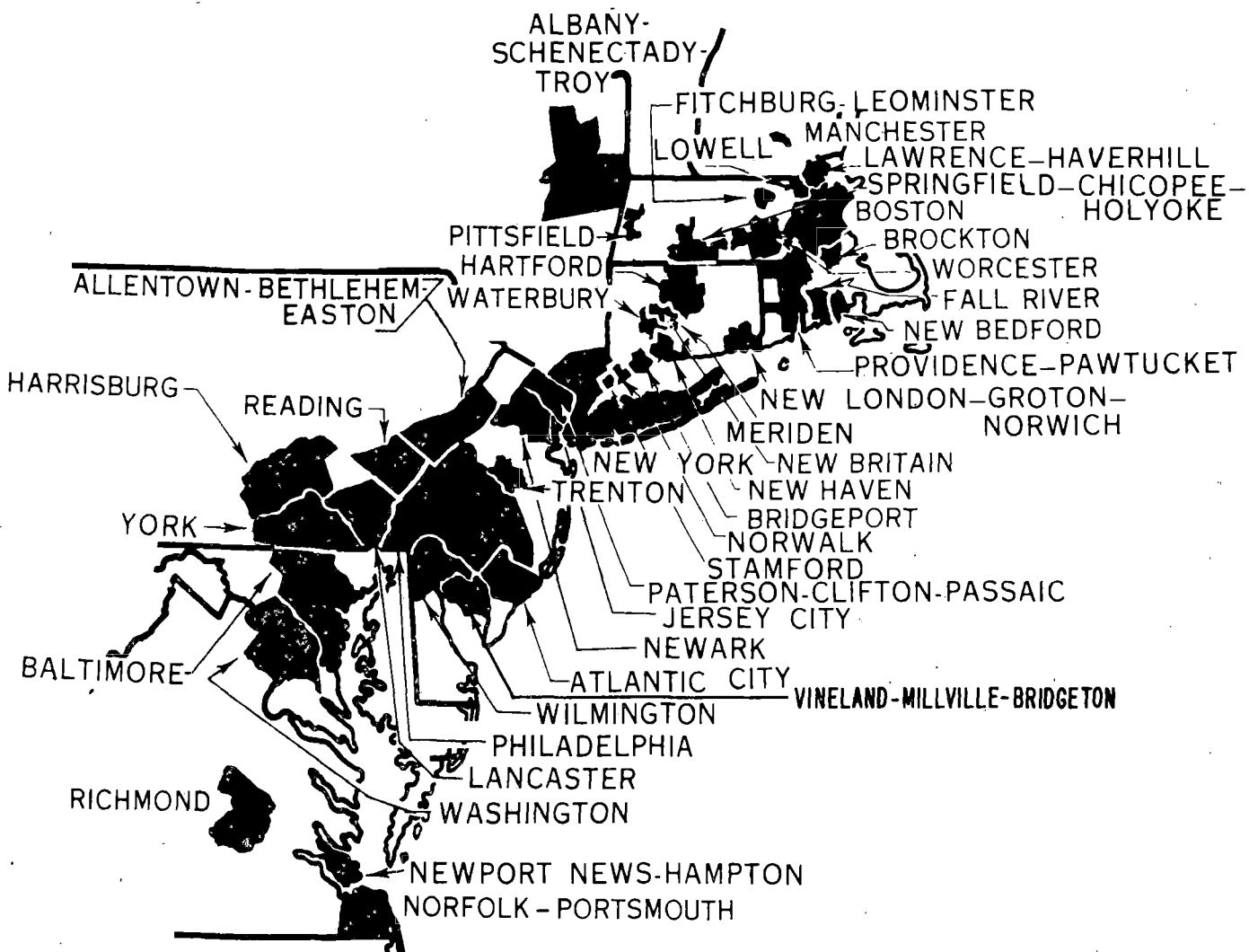


FIGURE I.3

STANDARD METROPOLITAN STATISTICAL AREAS
IN THE NORTHEAST CORRIDOR REGION

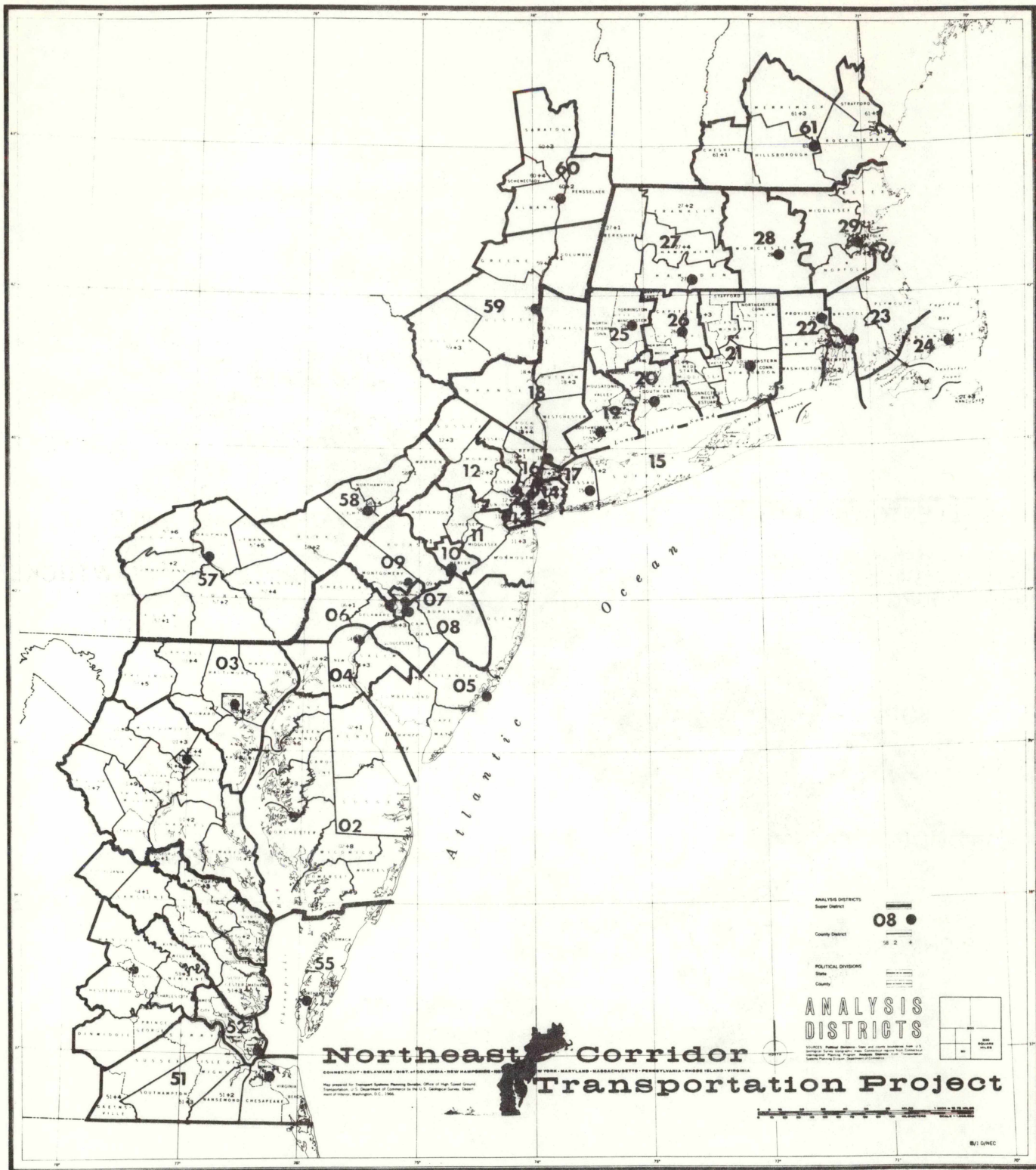


FIGURE I.4
NORTHEAST CORRIDOR
DATA BASE DISTRICTS AND
SUPERDISTRICT ANALYSIS UNITS



FIGURE I.5
NORTHEAST CORRIDOR MARKET AREA
REPORTING UNITS

During the time preliminary research was underway and the Project's approach was being formulated*, it became apparent that in order to adequately evaluate alternative ways in which the transportation needs of the Northeast Corridor could be met, additional specific information was needed, including technological and cost data for both current high speed ground systems and possible new systems. Legislation was therefore introduced into the 89th Congress which resulted in the High Speed Ground Transportation Act of October 1965. This Act authorized the Secretary of Commerce to undertake research and development in high speed ground transportation, to contract for demonstrations in high speed ground transportation and to collect and collate transportation data, statistics, and other information.

Although the demonstration projects described in the legislative background were to be in the Northeast Corridor (see Figure I.6, Map of Demonstration line and stops), the single area of greatest regional population density and transportation congestion, the High Speed Ground Transportation program was designed to have national significance. The information and experience gained in the Corridor could be expected to have general application in other highly urbanized regions of the nation. Planners, builders and operators of urban and interurban transportation systems throughout the United States would then have available to them the new technology coming out of high speed ground transportation research and development, as well as the data obtained in testing public acceptance of improved rail service. The systems engineering, costing, and system simulation and evaluation techniques to be developed for analyzing alternative transportation systems for the Northeast Corridor would also be available for application in other regions of the nation.

* "Study Design," NECTP Technical Paper #5, July 1966.

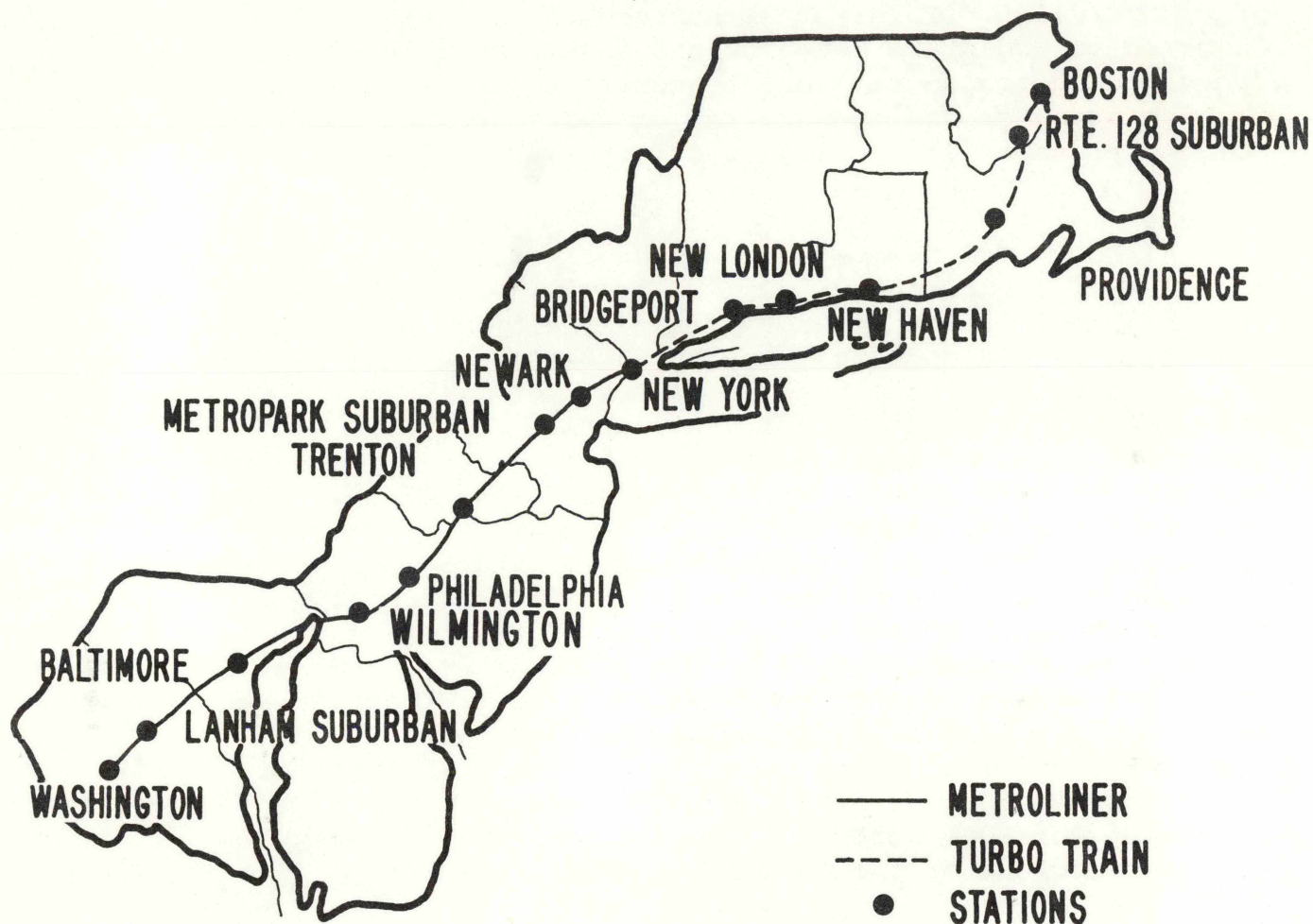


FIGURE I.6
 ROUTES AND CURRENT STATION STOPS
 FOR THE DEMONSTRATION OF NEW RAIL EQUIPMENT
 IN THE NORTHEAST CORRIDOR REGION

II. BACKGROUND OF INTERCITY TRANSPORTATION IN THE NORTHEAST CORRIDOR

Intercity Travel in the Northeast Corridor - 1968

Table II.1 contains estimates of the annual number of person trips between major metropolitan areas in the Northeast Corridor for calendar year 1968. Data are provided for the total travel demand and for the percentage using auto, air, bus, and rail. The values shown represent total one way person trips in both directions between each pair of communities.

The original data used to develop these estimates came from many sources, some of which date back to 1960. The raw data has been aggregated, expanded, and updated, where necessary, to achieve a common base where comparisons between the modes are possible.

The original data sources are often a small sample survey of the total universe they represent and, as a result, are subject to sampling errors. In addition, the adjustment of the data to a common base requires modifying assumptions which may further effect the reliability of any given data observation. However, it is believed that the information presented in this report is a reasonable representation of the actual conditions, although it is subject to revision if and when more reliable data sources are uncovered.

The data in Table II.1 may differ from previously published materials since it represents actual origins and destinations rather than terminal-to-terminal volumes. For instance, a portion of the air trips between terminals in New York and Washington have origins and destinations outside the metropolitan areas of New York and Washington. The data have been modified to eliminate movements through Corridor terminals of persons not having their actual trip origins or destinations in the paired Metropolitan areas.

The data shown represent trips between the metropolitan areas of each city, which in general comprise the standard metropolitan statistical area (SMSA), as defined by the Bureau of Budget. In some cases market areas smaller than SMSA's were used when paired metropolitan areas were adjacent to one another (e.g., Providence-Boston and Washington-Baltimore), so that the reported volumes would be more representative of intercity travel. In these latter cases outlying portions of paired SMSA's which were in close proximity to one another were eliminated as origins or destinations for this table.

TABLE II.1

1968 INTERCITY TRAVEL BETWEEN SELECTED
NORTHEAST CORRIDOR METROPOLITAN AREAS

Metropolitan Areas (SMSA unless otherwise noted)	Estimated Annual Number of Person Trips In Both Directions (All Modes)	Percent Carried by Each Mode				
		Air	Auto	Bus	Rail	Total
<u>BOSTON</u> - <i>MU</i>						
Providence*	7,990,000	**	93	4	3	100%
New London	590,000	**	85	3	12	100%
Hartford/Springfield	4,320,000	1	91	8	**	100%
New Haven	640,000	**	72	19	9	100%
Bridgeport/Stamford	420,000	7	70	3	20	100%
New York/Newark <i>184</i>	<i>5,165,000</i>	46	42	7	<u>5</u>	100%
Trenton	<i>19,125</i> 83,000	14	78	1	7	100%
Philadelphia <i>279</i>	939,000	34	61	3	2	100%
Wilmington	105,000	11	82	4	3	100%
Baltimore <i>369</i>	255,000	38	53	7	2	100%
Washington <i>399</i>	<i>1,010,000</i>	51	42	4	3	100%
	<i>21,517</i>	<i>3402,930</i>			<i>773,490</i>	
<u>PROVIDENCE</u> -						
New London	365,000	**	89	3	8	100%
Hartford/Springfield	780,000	**	90	10	**	100%
New Haven	270,000	1	75	13	11	100%
Bridgeport/Stamford	94,000	**	58	6	36	100%
New York/Newark	1,240,000	19	54	14	13	100%
Trenton	21,000	5	78	2	15	100%
Philadelphia	205,000	19	73	4	4	100%
Wilmington	23,000	13	74	5	8	100%
Baltimore	64,000	21	72	2	5	100%
Washington	167,000	40	51	3	6	100%
	<i>3,229</i>					

* Less than SMSA (See Page II.1)

** Less Than 1%

*** Not Considered Intercity Travel for Purposes of This Report

TABLE II.1 (Continued)

1968 INTERCITY TRAVEL BETWEEN SELECTED
NORTHEAST CORRIDOR METROPOLITAN AREAS

Metropolitan Areas (SMSA unless otherwise noted)	Estimated Annual Number of Person Trips In Both Directions (All Modes)	Percent Carried by Each Mode				
		Air	Auto	Bus	Rail	Total
<u>NEW LONDON -</u>						
Hartford/Springfield	460,000	**	96	4	**	100%
New Haven	1,080,000	**	94	2	4	100%
Bridgeport/Stamford	155,000	**	92	2	6	100%
New York/Newark	650,000	**	70	5	25	100%
Trenton	67,000	**	97	**	3	100%
Philadelphia	130,000	10	80	4	6	100%
Wilmington	5,000	**	50	20	30	100%
Baltimore	18,000	3	67	9	21	100%
Washington	55,000 2,620	46	36	7	11	100%
<u>HARTFORD/SPRINGFIELD -</u>						
New Haven *	1,840,000	**	87	2	11	100%
Bridgeport/Stamford	1,860,000	**	97	1	2	100%
New York/Newark	3,280,000	6	71	13	10	100%
Trenton	38,000	1	91	1	7	100%
Philadelphia	290,000	18	72	7	3	100%
Wilmington	27,000	11	82	3	4	100%
Baltimore	70,000	29	64	4	3	100%
Washington	240,000	42	50	5	3	100%

* Less than SMSA (See Page II.1)

** Less Than 1%

*** Not Considered Intercity Travel for Purposes of This Report

TABLE II.1 (Continued)

1968 INTERCITY TRAVEL BETWEEN SELECTED
NORTHEAST CORRIDOR METROPOLITAN AREAS

Metropolitan Areas (SMSA unless otherwise noted)	Estimated Annual Number of Person Trips In Both Directions (All Modes)	Percent Carried by Each Mode				
		Air	Auto	Bus	Rail	Total
<u>NEW HAVEN -</u>						
Bridgeport/Stamford	***	-	-	-	-	-
New York/Newark	3,140,000	**	69	7	24	100%
Trenton	31,000	4	82	3	11	100%
Philadelphia	310,000	1	87	6	6	100%
Wilmington	11,000	5	73	4	18	100%
Baltimore	39,000	5	77	5	13	100%
Washington	98,000	15	65	7	13	100%
	3629					
<u>BRIDGEPORT/STAMFORD-</u>						
New York/Newark	***	-	-	-	-	-
Trenton	40,000	**	88	1	11	100%
Philadelphia	110,000	14	60	3	23	100%
Wilmington	15,000	**	67	3	30	100%
Baltimore	37,000	11	66	2	21	100%
Washington	100,000	39	36	4	21	100%
	302,					
<u>NEW YORK/NEWARK</u>						
Trenton	2,790,000	**	46	3	51	100%
Philadelphia	14,660,000	1	73	7	19	100%
Wilmington	1,290,000	**	76	7	17	100%
Baltimore	1,960,000	12	56	16	16	100%
Washington	5,315,000	36	45	10	9	100%
	26,015					
		2,295,200	16,454,950	2,045,300	5,101,950	25,897,400

* Less than SMSA (See Page II.1)

** Less Than 1%

*** Not Considered Intercity Travel for Purposes of This Report

1968 INTERCITY TRAVEL BETWEEN SELECTED
NORTHEAST CORRIDOR METROPOLITAN AREAS
$$\Sigma = 78,293$$

** Less Than 1%

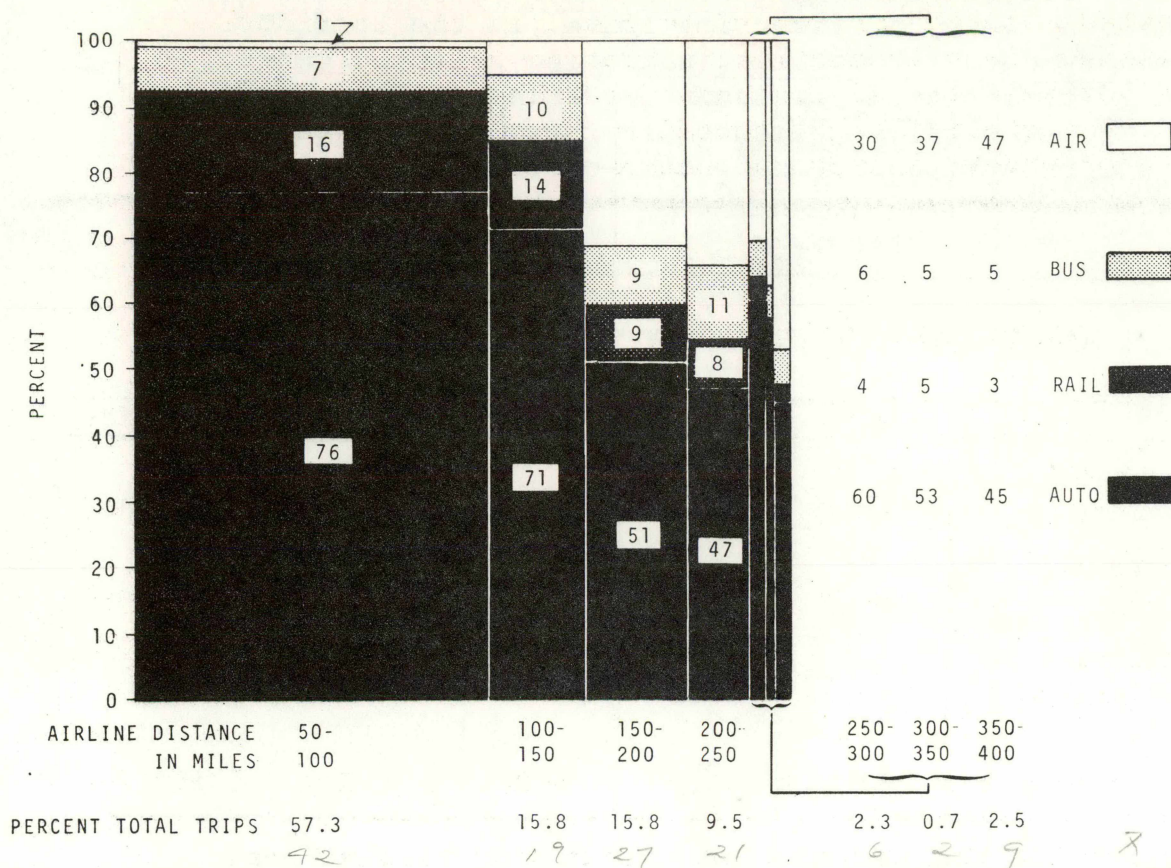
*** Not Considered Intercity Travel for Purposes of This Report

9.2M/yr
between " places N of Md. val line
and " S " " "

25,000/day

FIGURE II.1

MODE CHOICE VS. INTERCITY AIRLINE DISTANCE 1968



NOTE: Band widths are proportional to total trips in each distance category

The data listed in Table II.1 have been aggregated to indicate the mode used based upon the airline distance between cities in the Corridor. It may be noted that the auto mode is predominant but its use decreases with increased distance. Rail is the most heavily used common carrier mode for trips under 150 miles, while air transportation is little used for this length trip. It is only for trips greater than 150 miles that the air mode claims the largest share of the common carrier market; in general, this share increases with increased travel distance.

Characteristics of Intercity Passenger Travel in the Corridor

For the past two years, the Northeast Corridor Transportation Project and the U. S. Bureau of the Census have conducted a survey of intercity travel in the Corridor. Preliminary data tabulations indicating selected characteristics of this travel are shown in Tables II.2 through II.5. The statistics presented in these tables provide a basis for understanding the nature of travel in the Corridor.

TABLE II.2

MODES USED FOR INTERCITY TRIPS (PERCENT)*

	Auto	Air	Bus	Rail	All Modes
Northeast Corridor	74.0	10.8	4.7	10.5	100.0
New York-Boston	41.6	46.7	6.7	5.0	100.0
New York-Washington	45.2	35.8	10.3	8.7	100.0
Total United States	87.0	3.9	5.9	3.2	100.0

Sources: Data abstracted from Preliminary Tabulations, Northeast Corridor 1968 Travel Survey; and compiled from selected origin-destination travel surveys.

Table II.2 compares intercity travel, by mode, for the Corridor, for selected paired cities within the Corridor and for the nation. Intercity travel in the Corridor is significantly different from that in the country as a whole, with considerably more reliance on the common carrier modes. Proportionately there are three times as many air and rail trips in the Corridor as in the nation, while bus travel is only slightly below the national average.

Travel between two of the major cities in the Corridor differs considerably from total travel in the Corridor. Travel from New York City to both Boston and Washington is primarily by the common carrier modes, with air transport the overwhelming choice of travelers.

* The data shown represents person-trips, not person-miles of travel. The latter would take into account the average length of each trip and would considerably alter the data for the common carrier modes, especially for the total United States. (See Appendix C)

TABLE II.3

TRAVEL MODE SELECTED FOR NORTHEAST CORRIDOR INTERCITY
TRIPS BY FAMILY INCOME GROUP - 1968

FAMILY INCOME GROUP	MODE OF INTERCITY TRAVEL (PERCENT OF TRIPS)				
	AUTO	AIR	BUS	RAIL	TOTAL
UNDER \$4,000	64.8	3.1	10.6	21.5	100.0
4,000 - 7,499	77.3	2.7	9.9	10.1	100.0
7,500 - 9,999	80.5	5.4	4.6	9.5	100.0
10,000 - 14,999	78.3	10.0	2.8	8.9	100.0
15,000 - 24,999	75.1	13.9	2.5	8.5	100.0
25,000 AND OVER	45.0	41.8	0.8	12.4	100.0
ALL LEVELS	74.0	10.8	4.7	10.5	100.0

SOURCE: Data abstracted from preliminary tabulations of the 1968 Northeast Corridor Travel Survey.

Table II.3 indicates the modal split of Northeast Corridor travelers by income group. Families in the lower income categories make considerably greater use of the bus and rail modes than do those in higher brackets. As incomes rise, the use of air transportation increases while the use of bus transportation becomes relatively insignificant. Rail transportation is patronized by families in all income brackets, with the greatest percentage of use being in the lowest and the highest income brackets. Auto transportation is by far the favorite overall intercity transportation mode, and only for families with incomes greater than \$25,000 does it account for less than one-half of total travel.

TABLE II.4

TRIP PURPOSE OF NORTHEAST CORRIDOR INTERCITY
TRAVELERS BY MODE - 1968

PRIMARY TRIP PURPOSE	MODE OF INTERCITY TRAVEL (PERCENT OF TRIPS)				
	AUTO	AIR	BUS	RAIL	ALL MODES
BUSINESS	20.0	74.0	13.4	37.1	27.3
VISIT FRIENDS OR RELATIVES	41.8	10.9	29.1	30.1	36.5
OTHER PLEASURE	24.8	6.9	40.9	21.1	23.2
PERSONAL OR FAMILY AFFAIRS	10.5	4.3	9.7	8.1	9.7
STUDENT GOING TO SCHOOL	2.9	3.9	6.9	3.6	3.3
TOTAL	100.0	100.0	100.0	100.0	100.0

SOURCE: Data abstracted from preliminary tabulations of
the 1968 Northeast Corridor Travel Survey.

Table II.4 delineates Northeast Corridor intercity travel by trip purpose. Personal or social trips account for 80 percent of auto, 87 percent of bus, and 63 percent of rail travel. Air travel, on the other hand, is oriented toward business trips, which account for three out of every four trips made by that mode. Rail transport is used extensively for all trip purposes although business travel is the single most important category.

TABLE II.5

MODE USED FOR NORTHEAST CORRIDOR INTERCITY
TRAVEL BY SIZE OF FAMILY TRAVELING - 1968

FAMILY GROUP SIZE*	MODE OF INTERCITY TRAVEL (PERCENT OF TRIPS)				
	AUTO	AIR	BUS	RAIL	TOTAL
1 PERSON	50.6	23.1	7.3	19.0	100.0
2 PERSONS	81.1	4.6	4.4	9.9	100.0
3 OR 4 PERSONS	92.4	2.4	2.6	2.6	100.0
5 OR MORE	97.7	0.6	1.0	0.7	100.0
ALL GROUP SIZES	74.0	10.8	4.7	10.5	100.0

*Family group size refers to the members of a family traveling together; unrelated individuals traveling together are not considered as a family group. Therefore, the data presented in this table do not include charter group travel, except for cases in which each member of a charter group might report his own particular trip.

SOURCE: Data abstracted from preliminary tabulations of the 1968 Northeast Corridor Travel Survey.

The extensive use of the auto for trips with more than one group member is shown in Table II.5. For family groups of two or more, almost 90 percent of all travel is by automobile. For individual travelers, air travel is the preferred common carrier mode, although rail travel is extensively used also. As the size of the family group increases, the use of common carrier modes decreases significantly although there is little preference shown between common carrier modes for groups of three or more. The heavy use of the auto by larger family groups probably reflects, the factor of lower cost per person with each additional passenger, while common carrier travel cost per person decreases only slightly for each additional family member under existing fare structures.

III. TRANSPORTATION SERVICE IN THE NORTHEAST CORRIDOR

III.1 Transportation Service Characteristics

Section III.1 includes a series of tables which provide data on the level of transportation service available between selected paired cities in the Northeast Corridor.

The tables have been grouped in the following manner:

- . Between large population centers in the southern half of the Corridor including New York;
- . Between large population centers in the northern half of the Corridor including New York;
- . Between northern and southern population centers in the Corridor (not involving New York);
- . Between small population centers and large population centers within the Corridor; and
- . Between small population centers in the Corridor.

The data in Table III.1 are meant to indicate the varying levels of service provided specific Corridor travelers and to point out the differences in service available to persons residing in large metropolitan centers in contrast to those living in smaller cities or in rural areas . The smaller cities that have been chosen are representative of many similar communities. Other cities in the same population range would provide equally good examples.

The data are based upon schedules, fares and service levels that were in effect in calendar year 1968. They do not include Metroliner or Turbo Train service introduced in 1969 nor do they include the increased fares that were instituted by all of the common carriers in 1969.

The data are for typical intercity trips under normal travel conditions. As such, certain of the times (and costs) could be lower under ideal conditions or higher under adverse conditions.

In several instances there is no service provided by one or more modes. In such cases it is indicated by the letters "N/S" (no service) in the appropriate column. Likewise, where information is not available or considered unreliable, it is indicated by an "N/A" (not available).

TABLE III.1
1968 TRANSPORTATION SERVICE CHARACTERISTICS
NEW YORK - WASHINGTON

Service Characteristic	Auto	Air			Bus			Rail		
		N	D	T	N	D	T	N	D	T
Distance	225	215			225				225	
Daily Frequency of Service.....		138			75	5			26	
Travel Times-Minutes Scheduled Terminal-Terminal.....	260	60			250				230	
Estimated Center City to Center City.....	270	140			295				280	
Travel Costs										
Operating Cost.....	6.75									
Coach Fare.....		17.85			9.15				10.75	
First Class Fare...		22.05							19.90	
Tolls.....	4.45									
Annual Person Trips.. (Thousands) <i>5315</i> <i>11,427,250 x 10³ pers mi</i>	2,400	1,905			550			460		

Common Carrier Access and Terminal Characteristics	Air		Bus		Rail	
	New York	Wash	New York	Wash	New York	Wash
Driving Time to Center City-Minutes	35	20	13	12	13	14
Fares to Center City						
Cab.....	4.25	2.25	1.00	.75	1.00	.75
Limousine.....	1.50	1.35	-	-	-	-
Transit.....	-	-	.20	.30	.20	.30
Terminal Times-Minutes						
Access.....	15	15	15	10	15	15
Egress.....	10	10	9	7	7	7
Terminal Parking Cost (Daily).....	2.00	2.50	-	-	-	-

N - Non-Stop Service
D - Direct Service
T - Transfer Involved

21 para on ff pages $\Sigma = 59,223,000$ annual pers trips
III.3
 $\Sigma = 5,434 B$ pers mi

TABLE III.1
1968 TRANSPORTATION SERVICE CHARACTERISTICS
NEW YORK - BALTIMORE

Service Characteristic	Auto	Air			Bus			Rail		
		N	D	T	N	D	T	N	D	T
Distance	191	185			191				185	
Daily Frequency of Service.....		57	3		46	22			26	
Travel Times-Minutes Scheduled Terminal-Terminal.....	215	50			210				188	
Estimated Center City to Center City.....	225	135			250				232	
Travel Costs										
Operating Cost.....	5.73									
Coach Fare.....		16.80			7.90				8.75	
First Class Fare...		18.90			-				16.65	
Tolls.....	3.95									
Annual Person Trips.. (Thousands) <i>2025</i> <i>37,462.5</i>	1,150	240			320			315		

Common Carrier Access and Terminal Characteristics	Air		Bus		Rail	
	New York	Balt	New York	Balt	New York	Balt
Driving Time to Center City-Minutes	35	20	12	7	12	10
Fares to Center City						
Cab.....	4.25	4.00	1.00	1.00	1.00	1.00
Limousine.....	1.50	1.60	-	-	-	-
Transit.....	-	-	.20	.30	.20	.30
Terminal Times-Minutes						
Access.....	18	20	15	10	15	14
Egress.....	10	10	9	7	7	8
Terminal Parking Cost (Daily).....	2.00	2.25	-	-	-	1.50

N - Non-Stop Service
D - Direct Service
T - Transfer Involved

TABLE III.1
1968 TRANSPORTATION SERVICE CHARACTERISTICS
NEW YORK - PHILADELPHIA

Service Characteristic	Auto	Air			Bus			Rail		
		N	D	T	N	D	T	N	D	T
Distance	93	95			93				91	
Daily Frequency of Service.....		62			40	107			46	
Travel Times-Minutes Scheduled Terminal-Terminal.....	120	35			115				97	
Estimated Center City to Center City.....	130	176			161				144	
Travel Costs										
Operating Cost.....	2.79									
Coach Fare.....		10.50			3.95				4.25	
First Class Fare...		11.55							8.15	
Tolls.....	2.65									
Annual Person Trips.. (Thousands) 14660 1392700	10,700	130			1,090			2,740		

Common Carrier Access and Terminal Characteristics	Air		Bus		Rail	
	New York	Phil	New York	Phil	New York	Phil
Driving Time to Center City-Minutes	35	26	12	12	12	12
Fares to Center City						
Cab.....	4.25	4.00	1.00	.70	1.00	1.00
Limousine.....	1.50	1.75	-	-	-	-
Transit.....	-	-	.20	.25	.20	.25
Terminal Times-Minutes						
Access.....	18	20	15	12	15	14
Egress.....	10	10	9	7	7	7
Terminal Parking Cost (Daily).....	2.00	2.00	-	-	-	1.50

N - Non-Stop Service
D - Direct Service
T - Transfer Involved

TABLE III.1
1968 TRANSPORTATION SERVICE CHARACTERISTICS
PHILADELPHIA - WASHINGTON

Service Characteristic	Auto	Air			Bus			Rail		
		N	D	T	N	D	T	N	D	T
Distance	136	120				136			134	
Daily Frequency of Service.....		74	4	-	3	64	-		27	
Travel Times-Minutes Scheduled Terminal- Terminal.....	175	43				190			130	
Estimated Center City to Center City.....	185	119				233			179	
Travel Costs										
Operating Cost.....	4.08									
Coach Fare.....		12.60				5.35			6.50	
First Class Fare...		15.75				-			12.00	
Tolls.....	1.80									
Annual Person Trips.. (Thousands) 2460 295,200	1,640	170			250			400		

Common Carrier Access and Terminal Characteristics	Air		Bus		Rail	
	Phil	Wash	Phil	Wash	Phil	Wash
Driving Time to Center City-Minutes	26	20	12	12	12	15
Fares to Center City						
- Cab.....	4.00	2.25	.70	.75	1.00	.75
Limousine.....	1.75	1.35	-	-	-	-
Transit.....	-	-	.25	.30	.25	.30
Terminal Times-Minutes						
Access.....	20	18	12	10	14	15
Egress.....	10	10	7	7	7	8
Terminal Parking Cost (Daily).....	2.00	2.50	-	-	1.50	-

N - Non-Stop Service
D - Direct Service
T - Transfer Involved

TABLE III.1

1968 TRANSPORTATION SERVICE CHARACTERISTICS

PHILADELPHIA - BALTIMORE

Service Characteristic	Auto	Air			Bus			Rail		
		N	D	T	N	D	T	N	D	T
Distance	97	91			97				94	
Daily Frequency of Service.....		26	-		21	43	-		27	
Travel Times-Minutes Scheduled Terminal-Terminal.....	125	35			130				89	
Estimated Center City to Center City.....	135	111			168				133	
Travel Costs										
Operating Cost.....										
Coach Fare.....	2.91	10.50			3.60				4.50	
First Class Fare...		10.50				-			8.65	
Tolls.....	1.30									
Annual Person Trips.. (Thousands) 1794 163254	1,345	9			190			250		

Common Carrier Access and Terminal Characteristics	Air		Bus		Rail	
	Phil	Balt	Phil	Balt	Phil	Balt
Driving Time to Center City-Minutes	26	20	12	7	12	10
Fares to Center City						
Cab.....	4.00	4.00	.70	1.00	1.00	1.00
Limousine.....	1.75	1.60	-	-	-	-
Transit.....	-	-	.25	.30	.25	.30
Terminal Times-Minutes						
Access.....	20	20	12	10	14	14
Egress.....	10	10	7	7	7	8
Terminal Parking Cost (Daily).....	2.00	2.25	-	-	1.50	1.50

N - Non-Stop Service
D - Direct Service
T - Transfer Involved

TABLE III.1
1968 TRANSPORTATION SERVICE CHARACTERISTICS
WASHINGTON - BALTIMORE

Service Characteristic	Auto	Air			Bus			Rail		
		N	D	T	N	D	T	N	D	T
Distance	39	30			39				40	
Daily Frequency of Service.....		38			145				37	
Travel Times-Minutes Scheduled Terminal- Terminal.....	55	20			55				42	
Estimated Center City to Center City.....	65	90			92				89	
Travel Costs										
Operating Cost.....	1.17									
Coach Fare.....		6.30			1.75				2.00	
First Class Fare...		6.30			-				5.00	
Tolls.....										
Annual Person Trips.. (Thousands) 6948 20 8490	6,120	18			480			330		

Common Carrier Access and Terminal Characteristics	Air		Bus		Rail	
	Wash	Balt	Wash	Balt	Wash	Balt
Driving Time to Center City-Minutes	20	20	12	7	15	10
Fares to Center City						
Cab.....	2.25	4.00	.75	1.00	.75	1.00
Limousine.....	1.35	1.60	-	-	-	-
Transit.....	-	-	.30	.30	.30	.30
Terminal Times-Minutes						
Access.....	18	20	10	10	15	14
Egress.....	10	10	7	7	8	8
Terminal Parking Cost (Daily).....	2.50	2.25	-	-	-	1.50

N - Non-Stop Service
D - Direct Service
T - Transfer Involved

TABLE III.1
1968 TRANSPORTATION SERVICE CHARACTERISTICS
NEW YORK - BOSTON

Service Characteristic	Auto	Air			Bus			Rail		
		N	D	T	N	D	T	N	D	T
Distance	215	184			215				230	
Daily Frequency of Service.....		162	18		27	31			26	
Travel Times-Minutes Scheduled Terminal- Terminal.....	270	55			265				270	
Estimated Center City to Center City.....	280	139			207				317	
Travel Costs										
Operating Cost.....	6.45									
Coach Fare.....		16.80			8.45				11.58	
First Class Fare...		19.95							13.95	
Tolls.....	2.65									
Annual Person Trips.. (Thousands) <i>5165</i> <i>950,360</i>	2,150	2,410			345			260		

Common Carrier Access and Terminal Characteristics	Air		Bus		Rail	
	New York	Boston	New York	Boston	New York	Boston
Driving Time to Center City-Minutes	35	24	12	12	12	12
Fares to Center City						
Cab.....	4.25	2.50	1.00	.75	1.00	1.10
Limousine.....	1.50	1.25	-	-	-	-
Transit.....	-	.35	.20	.25	.20	.25
Terminal Times-Minutes						
Access.....	15	15	15	10	15	15
Egress.....	10	10	9	7	7	7
Terminal Parking Cost (Daily).....	2.00	2.25	-	-	-	2.00

N - Non-Stop Service
D - Direct Service
T - Transfer Involved

TABLE III.1
1968 TRANSPORTATION SERVICE CHARACTERISTICS

NEW YORK - HARTFORD

Service Characteristic	Auto	Air			Bus			Rail		
		N	D	T	N	D	T	N	D	T
Distance	110	101				101			109	
Daily Frequency of Service.....		36			14	55	-		28	
Travel Times-Minutes Scheduled Terminal-Terminal.....	150	40				155			160	
Estimated Center City to Center City.....	160	131				195			202	
Travel Costs										
Operating Cost.....	3.30									
Coach Fare.....		10.50				5.15			6.22	
First Class Fare...		11.55				-			8.59	
Tolls.....	1.50									
Annual Person Trips* (Thousands) <i>3285</i> <i>331,785</i>	2,340	215			400			330		

Common Carrier Access and Terminal Characteristics	Air		Bus		Rail	
	New York	Hart	New York	Hart	New York	Hart
Driving Time to Center City-Minutes	35	26	12	7	12	7
Fares to Center City						
Cab.....	4.25	6.50	1.00	1.00	1.00	1.00
Limousine.....	1.50	1.50	-	-	-	-
Transit.....	-	-	.20	.25	.20	.25
Terminal Times-Minutes						
Access.....	18	20	15	10	15	14
Egress.....	10	10	9	7	7	7
Terminal Parking Cost (Daily).....	2.00	1.75	-	-	-	1.50

N - Non-Stop Service
D - Direct Service
T - Transfer Involved

*Includes Springfield, Mass.

TABLE III.1
1968 TRANSPORTATION SERVICE CHARACTERISTICS
NEW YORK - PROVIDENCE

Service Characteristic	Auto	Air			Bus			Rail		
		N	D	T	N	D	T	N	D	T
Distance	177	143			177				186	
Daily Frequency of Service.....		38			10	15			26	
Travel Times-Minutes Scheduled Terminal-Terminal.....	210	45			210				216	
Estimated Center City to Center City.....	220	127			250				258	
Travel Costs										
Operating Cost.....	5.31									
Coach Fare.....		13.65			7.30				9.39	
First Class Fare...		15.75							11.76	
Tolls.....	1.10									
Annual Person Trips.. (Thousands) <i>1245</i> <i>1780.35</i>	675	235			175			160		

Common Carrier Access and Terminal Characteristics	Air		Bus		Rail	
	New York	Prov	New York	Prov	New York	Prov
Driving Time to Center City-Minutes	35	18	12	7	12	7
Fares to Center City						
Cab.....	4.25	4.00	1.00	.60	1.00	.60
Limousine.....	1.50	1.50	-	-	-	-
Transit.....	-	-	.20	.30	.20	.30
Terminal Times-Minutes						
Access.....	18	20	15	10	15	14
Egress.....	10	10	9	7	7	7
Terminal Parking Cost (Daily).....	2.00	1.50	-	-	-	1.50

N - Non-Stop Service
D - Direct Service
T - Transfer Involved

TABLE III.1
1968 TRANSPORTATION SERVICE CHARACTERISTICS
HARTFORD - BOSTON

Service Characteristic	Auto	Air			Bus			Rail		
		N	D	T	N	D	T	N	D	T
Distance	102	91			102					124
Daily Frequency of Service.....		19	3		18	7				4
Travel Times-Minutes Scheduled Terminal-Terminal.....	115	31			115					235
Estimated Center City to Center City.....	125	111			152					277
Travel Costs										
Operating Cost.....	3.06									
Coach Fare.....		10.50			5.60					10.60
First Class Fare...		11.55								
Tolls.....	1.65									
Annual Person Trips * (Thousands) 4320 393120	3,930	27			360			3		

Common Carrier Access and Terminal Characteristics	Air		Bus		Rail	
	Hart	Boston	Hart	Boston	Hart	Boston
Driving Time to Center City-Minutes	26	24	7	12	7	12
Fares to Center City						
Cab.....	6.50	2.50	1.00	.75	1.00	1.10
Limousine.....	1.50	1.25	-	-	-	-
Transit.....	-	.35	.25	.25	.25	.25
Terminal Times-Minutes						
Access.....	20	18	10	10	14	15
Egress.....	10	10	7	7	7	7
Terminal Parking Cost (Daily).....	1.75	2.25	-	-	1.50	2.00

N - Non-Stop Service
D - Direct Service
T - Transfer Involved

* Includes Springfield, Mass.

TABLE III.1
1968 TRANSPORTATION SERVICE CHARACTERISTICS
HARTFORD - PROVIDENCE

Service Characteristic	Auto	Air			Bus			Rail		
		N	D	T	N	D	T	N	D	T
Distance	70	67				70				150
Daily Frequency of Service.....		28				8				12
Travel Times-Minutes Scheduled Terminal-Terminal.....	110	24				120				226
Estimated Center City to Center City.....	120	98				152				262
Travel Costs										
Operating Cost.....	2.10									
Coach Fare.....		9.45				3.95				3.41
First Class Fare... (Tolls).....		9.45				-				
Annual Person Trips.. (Thousands) 778 52126	700	3			75			Neg		

Common Carrier Access and Terminal Characteristics	Air		Bus		Rail	
	Hart	Prov	Hart	Prov	Hart	Prov
Driving Time to Center City-Minutes	26	18	7	7	7	7
Fares to Center City						
Cab.....	6.50	4.00	1.00	.60	1.00	.60
Limousine.....	1.50	1.50	-	-	-	-
Transit.....	-	-	.25	.30	.25	.30
Terminal Times-Minutes						
Access.....	20	20	10	10	14	14
Egress.....	10	10	7	7	7	7
Terminal Parking Cost (Daily).....	1.75	1.50	-	-	1.50	1.50

N - Non-Stop Service
D - Direct Service
T - Transfer Involved

TABLE III.1
1968 TRANSPORTATION SERVICE CHARACTERISTICS
PROVIDENCE - BOSTON

Service Characteristic	Auto	Air			Bus			Rail		
		N	D	T	N	D	T	N	D	T
Distance	45	49			45				44	
Daily Frequency of Service.....		20			62				44	
Travel Times-Minutes Scheduled Terminal-Terminal.....	60	24			55				54	
Estimated Center City to Center City.....	70	97			92				97	
Travel Costs										
Operating Cost.....	1.35									
Coach Fare.....		8.40			1.25				2.37	
First Class Fare...		8.40							4.74	
Tolls.....	0									
Annual Person Trips.. (Thousands) 7990 391510	7,400	5			350			235		

Common Carrier Access and Terminal Characteristics	Air		Bus		Rail	
	Prov	Boston	Prov	Boston	Prov	Boston
Driving Time to Center City-Minutes	18	24	7	12	7	12
Fares to Center City						
Cab.....	4.00	2.50	.60	.75	.60	1.10
Limousine.....	1.50	1.25	-	-	-	-
Transit.....	-	.35	.30	.25	.30	.25
Terminal Times-Minutes						
Access.....	20	18	10	10	14	15
Egress.....	10	10	7	7	7	8
Terminal Parking Cost (Daily).....	1.50	2.25	-	-	1.50	2.00

N - Non-Stop Service
D - Direct Service
T - Transfer Involved

TABLE III.1
1968 TRANSPORTATION SERVICE CHARACTERISTICS
BOSTON - WASHINGTON

Service Characteristic	Auto	Air			Bus			Rail		
		N	D	T	N	D	T	N	D	T
Distance	437	399				437			457	
Daily Frequency of Service.....		56	2			14	31		8	
Travel Times-Minutes Scheduled Terminal-Terminal.....	540	70				565			531	
Estimated Center City to Center City.....	550	141				607			580	
Travel Costs										
Operating Cost.....	13.11									
Coach Fare.....		28.35				17.60			23.13	
First Class Fare...		34.65				-			34.42	
Tolls.....	7.60									
Annual Person Trips.. (Thousands) <i>1010</i> <i>402,990</i>	425	520			35			30		

Common Carrier Access and Terminal Characteristics	Air		Bus		Rail	
	Boston	Wash	Boston	Wash	Boston	Wash
Driving Time to Center City-Minutes	24	20	12	12	12	15
Fares to Center City						
Cab.....	2.50	2.25	.75	.75	1.10	.75
Limousine.....	1.25	1.35	-	-	-	-
Transit.....	.35	-	.25	.30	.25	.30
Terminal Times-Minutes						
Access.....	18	18	10	10	15	15
Egress.....	10	10	7	7	7	8
Terminal Parking Cost (Daily).....	2.25	2.50	-	-	2.00	-

N - Non-Stop Service
D - Direct Service
T - Transfer Involved

TABLE III.1
1968 TRANSPORTATION SERVICE CHARACTERISTICS
BOSTON - BALTIMORE

Service Characteristic	Auto	Air			Bus			Rail		
		N	D	T	N	D	T	N	D	T
Distance	398	369				398			417	
Daily Frequency of Service.....		12	2	14		6	40		8	
Travel Times-Minutes Scheduled Terminal- Terminal.....	495	60				525			481	
Estimated Center City to Center City.....	505	134				562			525	
Travel Costs										
Operating Cost.....	11.94									
Coach Fare.....		26.25				15.85			21.23	
First Class Fare...		31.50							31.01	
Tolls.....	7.10									
Annual Person Trips.. (Thousands) <i>253</i> <i>93,357</i>	135	95			18			5		

Common Carrier Access and Terminal Characteristics	Air		Bus		Rail	
	Boston	Balt	Boston	Balt	Boston	Balt
Driving Time to Center City-Minutes	24	20	12	7	12	10
Fares to Center City						
Cab.....	2.50	4.00	.75	1.00	1.10	1.00
Limousine.....	1.25	1.60	-	-	-	-
Transit.....	.35	-	.25	.30	.25	.30
Terminal Times-Minutes						
Access.....	18	20	10	10	15	14
Egress.....	10	10	7	7	7	8
Terminal Parking Cost (Daily).....	2.25	2.25	-	-	2.00	1.50

N - Non-Stop Service
D - Direct Service
T - Transfer Involved

TABLE III.1
1968 TRANSPORTATION SERVICE CHARACTERISTICS
BOSTON - PHILADELPHIA

Service Characteristic	Auto	Air			Bus			Rail		
		N	D	T	N	D	T	N	D	T
Distance	304	279					304		323	
Daily Frequency of Service.....		39	3	-		2	43		8	
Travel Times-Minutes Scheduled Terminal-Terminal.....	390	60					430		384	
Estimated Center City to Center City.....	400	140					473		431	
Travel Costs										
Operating Cost.....	9.12									
Coach Fare.....		22.05					12.45		16.78	
First Class Fare...		25.20							22.74	
Tolls.....	5.80									
Annual Person Trips.. (Thousands) <i>939</i> <i>261,981</i>	570	325			30			14		

Common Carrier Access and Terminal Characteristics	Air		Bus		Rail	
	Boston	Phil	Boston	Phil	Boston	Phil
Driving Time to Center City-Minutes	24	26	12	12	12	12
Fares to Center City						
Cab.....	2.50	4.00	.75	.70	1.10	1.00
Limousine.....	1.25	1.75	-	-	-	-
Transit.....	.35	-	.25	.25	.25	.25
Terminal Times-Minutes						
Access.....	18	20	10	12	15	14
Egress.....	10	10	7	7	7	7
Terminal Parking Cost (Daily).....	2.25	2.00	-	-	2.00	1.50

N - Non-Stop Service
D - Direct Service
T - Transfer Involved

TABLE III.1
1968 TRANSPORTATION SERVICE CHARACTERISTICS
HARTFORD - WASHINGTON

Service Characteristic	Auto	Air			Bus			Rail		
		N	D	T	N	D	T	N	D	T
Distance	342		314			342			338	
Daily Frequency of Service.....		6	12	-	0	4	19		2	4
Travel Times-Minutes Scheduled Terminal-Terminal.....	405		103			455			412	
Estimated Center City to Center City.....	415		179			492			456	
Travel Costs										
Operating Cost.....	10.26									
Coach Fare.....			24.15			15.15			17.14	
First Class Fare...			28.35			-			27.16	
Tolls.....	5.80									
Annual Person Trips.. (Thousands) * 238	120	99			11			8		
74732										

Common Carrier Access and Terminal Characteristics	Air		Bus		Rail	
	Hart	Wash	Hart	Wash	Hart	Wash
Driving Time to Center City-Minutes	26	20	7	12	7	15
Fares to Center City						
Cab.....	6.50	2.25	1.00	.75	1.00	.75
Limousine.....	1.50	1.35	-	-	-	-
Transit.....	-	-	.25	.30	.25	.30
Terminal Times-Minutes						
Access.....	20	18	10	10	14	15
Egress.....	10	10	7	7	7	8
Terminal Parking Cost (Daily).....	1.75	2.50	-	-	1.50	-

N - Non-Stop Service
D - Direct Service
T - Transfer Involved

*Includes Springfield, Mass.

TABLE III.1
1968 TRANSPORTATION SERVICE CHARACTERISTICS

HARTFORD - BALTIMORE

Service Characteristic	Auto	Air			Bus			Rail		
		N	D	T	N	D	T	N	D	T
Distance	304		283			304			298	
Daily Frequency of Service.....		1	7	11		3	19		2	4
Travel Times-Minutes Scheduled Terminal- Terminal.....	360		93			415			362	
Estimated Center City to Center City.....	370		168			447			401	
Travel Costs										
Operating Cost.....	9.12									
Coach Fare.....			21.00			13.20			15.87	
First Class Fare...			24.15						23.97	
Tolls.....	5.30									
Annual Person Trips.. (Thousands) * 70 19,810	45	20			3			2		

Common Carrier Access and Terminal Characteristics	Air		Bus		Rail	
	Hart	Balt	Hart	Balt	Hart	Balt
Driving Time to Center City-Minutes	26	20	7	7	7	10
Fares to Center City						
Cab.....	6.50	4.00	1.00	1.00	1.00	1.00
Limousine.....	1.50	1.60	-	-	-	-
Transit.....	-	-	.25	.30	.25	.30
Terminal Times-Minutes						
Access.....	20	20	10	10	14	14
Egress.....	10	10	7	7	7	8
Terminal Parking Cost (Daily).....	1.75	2.25	-	-	1.50	1.50

N - Non-Stop Service
D - Direct Service
T - Transfer Involved

* Includes Springfield, Mass.

TABLE III.1
1968 TRANSPORTATION SERVICE CHARACTERISTICS
HARTFORD - PHILADELPHIA

Service Characteristic	Auto	Air			Bus			Rail		
		N	D	T	N	D	T	N	D	T
Distance	207		195				207		202	
Daily Frequency of Service.....		14	2			1	22		2	4
Travel Times-Minutes Scheduled Terminal-Terminal.....	265	46					320		226	
Estimated Center City to Center City.....	275	128					358		267	
Travel Costs										
Operating Cost.....	6.21									
Coach Fare.....		17.85					9.45		11.40	
First Class Fare...		19.95							15.60	
Tolls.....	4.00									
Annual Person Trips.. (Thousands)* <i>290</i> <i>56,550</i>	210	52			19			9		

Common Carrier Access and Terminal Characteristics	Air		Bus		Rail	
	Hart	Phil	Hart	Phil	Hart	Phil
Driving Time to Center City-Minutes	26	26	7	12	7	12
Fares to Center City						
Cab.....	6.50	4.00	1.00	.70	1.00	1.00
Limousine.....	1.50	1.75	-	-	-	-
Transit.....	-	-	.25	.25	.25	.25
Terminal Times-Minutes						
Access.....	20	20	10	12	14	14
Egress.....	10	10	7	7	7	7
Terminal Parking Cost (Daily).....	1.75	2.00	-	-	1.50	1.50

N - Non-Stop Service
D - Direct Service
T - Transfer Involved

*Includes Springfield, Mass.

TABLE III.1
1968 TRANSPORTATION SERVICE CHARACTERISTICS
PROVIDENCE - WASHINGTON

Service Characteristic	Auto	Air			Bus			Rail		
		N	D	T	N	D	T	N	D	T
Distance	404	357					404		413	
Daily Frequency of Service.....		7	13				19		8	
Travel Times-Minutes Scheduled Terminal- Terminal.....	490	70					510		475	
Estimated Center City to Center City.....	500	137	137				547		519	
Travel Costs										
Operating Cost.....	12.12									
Coach Fare.....		26.25					16.45		20.94	
First Class Fare...		31.50							32.17	
Tolls.....	6.05									
Annual Person Trips.. (Thousands) <i>168</i> <i>59,976</i>	85	67			5			11		

Common Carrier Access and Terminal Characteristics	Air		Bus		Rail	
	Prov	Wash	Prov	Wash	Prov	Wash
Driving Time to Center City-Minutes	18	20	7	12	7	15
Fares to Center City						
Cab.....	4.00	2.25	.60	.75	.60	.75
Limousine.....	1.50	1.35	-	-	-	-
Transit.....	-	-	.30	.30	.30	.30
Terminal Times-Minutes						
Access.....	20	18	10	10	14	15
Egress.....	10	10	7	7	7	8
Terminal Parking Cost (Daily).....	1.50	2.50	-	-	1.50	-

N - Non-Stop Service
D - Direct Service
T - Transfer Involved

TABLE III.1
1968 TRANSPORTATION SERVICE CHARACTERISTICS
PROVIDENCE - BALTIMORE

Service Characteristic	Auto	Air			Bus			Rail		
		N	D	T	N	D	T	N	D	T
Distance	365		328				365		373	
Daily Frequency of Service.....			4	12			18		8	
Travel Times-Minutes Scheduled Terminal-Terminal.....	445		105				470		427	
Estimated Center City to Center City.....	455		172				502		466	
Travel Costs										
Operating Cost.....	10.95									
Coach Fare.....			24.15				15.70		19.04	
First Class Fare...			28.35						28.82	
Tolls.....	5.95									
Annual Person Trips.. (Thousands) <i>64</i> <i>20992</i>	46	14			1			3		

Common Carrier Access and Terminal Characteristics	Air		Bus		Rail	
	Prov	Balt	Prov	Balt	Prov	Balt
Driving Time to Center City-Minutes	18	20	7	7	7	10
Fares to Center City						
Cab.....	4.00	4.00	.60	1.00	.60	1.00
Limousine.....	1.50	1.60	-	-	-	-
Transit.....	-	-	.30	.30	.30	.30
Terminal Times-Minutes						
Access.....	20	20	10	10	14	14
Egress.....	10	10	7	7	7	8
Terminal Parking Cost (Daily).....	1.50	2.25	-	-	1.50	1.50

N - Non-Stop Service
D - Direct Service
T - Transfer Involved

TABLE III.1
1968 TRANSPORTATION SERVICE CHARACTERISTICS
PHILADELPHIA - PROVIDENCE

Service Characteristic	Auto	Air			Bus			Rail		
		N	D	T	N	D	T	N	D	T
Distance	268		237				268		279	
Daily Frequency of Service.....		2	10			-	20		8	
Travel Times-Minutes Scheduled Terminal- Terminal.....	340		83				375		330	
Estimated Center City to Center City.....	350		146				413		371	
Travel Costs										
Operating Cost.....	8.04									
Coach Fare.....			22.05				10.80		14.59	
First Class Fare...			22.05			-				
Tolls.....	4.25									
Annual Person Trips.. (Thousands) <i>206</i> <i>48,822</i>	150	39			9			8		

Common Carrier Access and Terminal Characteristics	Air		Bus		Rail	
	Phil	Prov	Phil	Prov	Phil	Prov
Driving Time to Center City-Minutes	26	17	12	7	13	7
Fares to Center City						
Cab.....	4.00	4.00	.70	.60	1.00	.60
Limousine.....	1.75	1.50	-	-	-	-
Transit.....	-	-	.25	.30	.25	.30
Terminal Times-Minutes						
Access.....	20	20	12	10	14	14
Egress.....	10	10	7	7	8	7
Terminal Parking Cost (Daily).....	2.00	1.50	-	1.50	1.50	1.50

N - Non-Stop Service
D - Direct Service
T - Transfer Involved

TABLE III.1
1968 TRANSPORTATION SERVICE CHARACTERISTICS
DOVER, DEL. - WASHINGTON

Service Characteristic	Auto	Air			Bus			Rail		
		N	D	T	N	D	T	N	D	T
Distance	98					98				
Daily Frequency of Service.....			N/S		-	2	-		N/S	
Travel Times-Minutes Scheduled Terminal-Terminal.....	120					160				
Estimated Center City to Center City.....	130					194				
Travel Costs										
Operating Cost.....	2.94									
Coach Fare.....						3.80				
First Class Fare...										
Tolls.....	1.00									
Annual Person Trips.. (Thousands)	N/A					N/A				

Common Carrier Access and Terminal Characteristics	Air		Bus		Rail	
			Dover	Wash		
Driving Time to Center City-Minutes			5	12		
Fares to Center City						
- Cab.....			N/A	.75		
Limousine.....			-	-		
Transit.....			N/S	.30		
Terminal Times-Minutes						
Access.....			10	10		
Egress.....			7	7		
Terminal Parking Cost (Daily).....			-	-		

N - Non-Stop Service
D - Direct Service
T - Transfer Involved

TABLE III.1
1968 TRANSPORTATION SERVICE CHARACTERISTICS
DOVER, DEL. - NEW YORK

Service Characteristic	Auto	Air			Bus			Rail		
		N	D	T	N	D	T	N	D	T
Distance	161		130*			161				
Daily Frequency of Service.....			4			20		N/S		
Travel Times-Minutes Scheduled Terminal- Terminal.....	175		85			195				
Estimated Center City to Center City.....	185		159			234				
Travel Costs										
Operating Cost.....	4.83									
Coach Fare.....			26.25			6.50				
First Class Fare...			26.25							
Tolls.....	2.60									
Annual Person Trips.. (Thousands)	N/A	N/A			N/A					

Common Carrier Access and Terminal Characteristics	Air		Bus		Rail	
	Dover	New York	Dover	New York		
Driving Time to Center City-Minutes	12	35	5	12		
Fares to Center City						
Cab.....	N/A	4.25	N/A	1.00		
Limousine.....	-	1.50	-	-		
Transit.....	N/S	-	N/S	.20		
Terminal Times-Minutes						
Access.....	10	17	10	15		
Egress.....	7	10	7	9		
Terminal Parking Cost (Daily).....	N/A	2.00	-	-		

N - Non-Stop Service
D - Direct Service
T - Transfer Involved

*Air Taxi Service was
available in 1968. It
has since been discontinued.

TABLE III.1
1968 TRANSPORTATION SERVICE CHARACTERISTICS
DOVER, DEL. - PHILADELPHIA

Service Characteristic	Auto	Air			Bus			Rail		
		N	D	T	N	D	T	N	D	T
Distance	72					72				
Daily Frequency of Service.....			N/S			12			N/S	
Travel Times-Minutes Scheduled Terminal-Terminal.....	110					130				
Estimated Center City to Center City.....	120					165				
Travel Costs										
Operating Cost.....	2.16									
Coach Fare.....						2.60				
First Class Fare....										
Tolls.....										
Annual Person Trips.. (Thousands)	N/A					N/A				

Common Carrier Access and Terminal Characteristics	Air		Bus		Rail	
			Dover	Phil		
Driving Time to Center City-Minutes			5	12		
Fares to Center City						
Cab.....			N/A	.70		
Limousine.....			-	-		
Transit.....			N/S	.25		
Terminal Times-Minutes						
Access.....			10	12		
Egress.....			7	7		
Terminal Parking Cost (Daily).....			-	-		

N - Non-Stop Service
D - Direct Service
T - Transfer Involved

TABLE III.1
1968 TRANSPORTATION SERVICE CHARACTERISTICS
DOVER, DEL. - BOSTON

Service Characteristic	Auto	Air *			Bus			Rail		
		N	D	T	N	D	T	N	D	T
Distance	375			325			375			
Daily Frequency of Service.....				4			18	N/S		
Travel Times-Minutes Scheduled Terminal-Terminal.....	445			165			460			
Estimated Center City to Center City.....	455			228			494			
Travel Costs										
Operating Cost.....	8.25									
Coach Fare.....				43.05			14.95			
First Class Fare...				46.20						
Tolls.....	5.25									
Annual Person Trips.. (Thousands)	N/A	N/A								

Common Carrier Access and Terminal Characteristics	Air		Bus		Rail	
	Dover	Boston	Dover	Boston		
Driving Time to Center City-Minutes	12	24	5	12		
Fares to Center City						
Cab.....	N/A	2.50	N/A	.75		
Limousine.....	-	1.25	-	-		
Transit.....	N/S	.35	N/S	.25		
Terminal Times-Minutes						
Access.....	10	17	10	10		
Egress	7	10	7	7		
Terminal Parking Cost (Daily).....	-	2.25	-	-		

N - Non-Stop Service
D - Direct Service
T - Transfer Involved

*Air Taxi - Dover to New York Service has now been discontinued.

TABLE III.1
1968 TRANSPORTATION SERVICE CHARACTERISTICS
FITCHBURG, MASS. - NEW YORK

Service Characteristic	Auto	Air*			Bus			Rail		
		N	D	T	N	D	T	N	D	T
Distance	200					200				
Daily Frequency of Service.....			N/S			6	8		N/S	
Travel Times-Minutes Scheduled Terminal- Terminal.....	260					320				
Estimated Center City to Center City.....	270					358				
Travel Costs										
Operating Cost.....	6.00									
Coach Fare.....						8.85				
First Class Fare...										
Tolls.....	1.75									
Annual Person Trips.. (Thousands)	N/A				N/A					

Common Carrier Access and Terminal Characteristics	Air		Bus		Rail	
			Fitch- burg	New York		
Driving Time to Center City-Minutes			5	12		
Fares to Center City						
Cab.....			.75	1.00		
Limousine.....			-	-		
Transit.....			.25	.20		
Terminal Times-Minutes						
Access.....			10	15		
Egress.....			7	9		
Terminal Parking Cost (Daily).....			-	-		

N - Non-Stop Service
D - Direct Service
T - Transfer Involved

*Air taxi service now available
to Boston.

TABLE III.1
1968 TRANSPORTATION SERVICE CHARACTERISTICS
FITCHBURG, MASS. - BOSTON

Service Characteristic	Auto	Air*			Bus			Rail		
		N	D	T	N	D	T	N	D	T
Distance	47					47				
Daily Frequency of Service.....			N/S			20			N/S	
Travel Times-Minutes Scheduled Terminal- Terminal.....	65					78				
Estimated Center City to Center City.....	75					112				
Travel Costs										
Operating Cost.....	1.41									
Coach Fare.....						2.00				
First Class Fare...										
Tolls.....	-									
Annual Person Trips.. (Thousands)	N/A				N/A					

Common Carrier Access and Terminal Characteristics	Air		Bus		Rail	
			Fitch- burg	Boston		
Driving Time to Center City-Minutes			5	12		
Fares to Center City						
Cab.....			.75	.75		
Limousine.....			-	-		
Transit.....			.25	.25		
Terminal Times-Minutes						
Access.....			10	10		
Egress.....			7	7		
Terminal Parking Cost (Daily).....						

N - Non-Stop Service
D - Direct Service
T - Transfer Involved

*Air taxi service now available.

TABLE III.1
1968 TRANSPORTATION SERVICE CHARACTERISTICS
FITCHBURG, MASS. - PROVIDENCE

Service Characteristic	Auto	Air			Bus			Rail		
		N	D	T	N	D	T	N	D	T
Distance	69					69				
Daily Frequency of Service.....			N/S			10			N/S	
Travel Times-Minutes Scheduled Terminal-Terminal.....	100					155				
Estimated Center City to Center City.....	110					184				
Travel Costs										
Operating Cost.....	2.07					3.00				
Coach Fare.....										
First Class Fare...										
Tolls.....										
Annual Person Trips.. (Thousands)	N/A				N/A					

Common Carrier Access and Terminal Characteristics	Air		Bus		Rail	
			Fitchburg	Prov		
Driving Time to Center City-Minutes			5	7		
Fares to Center City						
Cab.....			.75	.60		
Limousine.....			-	-		
Transit.....			.25	.30		
Terminal Times-Minutes						
Access.....			10	10		
Egress.....			7	7		
Terminal Parking Cost (Daily).....			-	-		

N - Non-Stop Service
D - Direct Service
T - Transfer Involved

TABLE III.1
1968 TRANSPORTATION SERVICE CHARACTERISTICS
FITCHBURG, MASS. - HARTFORD

Service Characteristic	Auto	Air			Bus			Rail		
		N	D	T	N	D	T	N	D	T
Distance	90					90				
Daily Frequency of Service.....			N/S			2	2		N/S	
Travel Times-Minutes Scheduled Terminal-Terminal.....	110					185				
Estimated Center City to Center City.....	120					215				
Travel Costs										
Operating Cost.....	2.70					3.70				
Coach Fare.....										
First Class Fare...										
Tolls.....	.25									
Annual Person Trips.. (Thousands)	N/A				N/A					

Common Carrier Access and Terminal Characteristics	Air		Bus		Rail	
			Fitchburg	Hart		
Driving Time to Center City-Minutes			5	7		
Fares to Center City						
Cab.....			.75	1.00		
Limousine.....			-	-		
Transit.....			.25	.25		
Terminal Times-Minutes						
Access.....			10	10		
Egress.....			7	7		
Terminal Parking Cost (Daily).....			-	-		

N - Non-Stop Service
D - Direct Service
T - Transfer Involved

TABLE III.1
1968 TRANSPORTATION SERVICE CHARACTERISTICS
FITCHBURG, MASS. - WASHINGTON

Service Characteristic	Auto	Air *			Bus			Rail		
		N	D	T	N	D	T	N	D	T
Distance	433		446				433			
Daily Frequency of Service.....			2				14	N/S		
Travel Times-Minutes Scheduled Terminal-Terminal.....	515		70				600			
Estimated Center City to Center City.....	525		192				629			
Travel Costs										
Operating Cost.....	12.99									
Coach Fare.....			28.35				18.85			
First Class Fare...			34.65							
Tolls.....	6.30									
Annual Person Trips.. (Thousands)	N/A	N/A			N/A					

Common Carrier Access and Terminal Characteristics	Air via Boston		Bus		Rail	
	Fitch.-Boston	Wash	Fitch-burg	Wash		
Driving Time to Center City-Minutes	75	20	5	12		
Fares to Center City						
Cab.....	25.00	2.25	.75	.75		
Limousine.....		1.35		-		
Transit.....		-	.30	.30		
Terminal Times-Minutes						
Access.....	18	18	10	10		
Egress.....	10	10	7	7		
Terminal Parking Cost (Daily).....	2.00	2.50	-	-		

N - Non-Stop Service
D - Direct Service
T - Transfer Involved

*Air trip via Boston -
Airline distance includes
47 miles by highway. Air
taxi service is now avail-
able to Boston.

TABLE III.1
1968 TRANSPORTATION SERVICE CHARACTERISTICS
DOVER, DEL. - FITCHBURG, MASS.

Service Characteristic	Auto	Air			Bus via NY			Rail		
		N	D	T	N	D	T	N	D	T
Distance	361						361			
Daily Frequency of Service.....			N/S				10		N/S	
Travel Times-Minutes Scheduled Terminal- Terminal.....	435						525			
Estimated Center City to Center City.....	445						552			
Travel Costs										
Operating Cost.....	10.83									
Coach Fare.....										
First Class Fare...							15.35			
Tolls.....	4.35									
Annual Person Trips.. (Thousands)	N/A				N/A					

Common Carrier Access and Terminal Characteristics	Air		Bus		Rail	
			Dover	Fitch- burg		
Driving Time to Center City-Minutes			5	5		
Fares to Center City						
Cab.....			N/A	.75		
Limousine.....			-	-		
Transit.....			N/S	.25		
Terminal Times-Minutes						
Access.....			10	10		
Egress.....			7	7		
Terminal Parking Cost (Daily).....			-	-		

N - Non-Stop Service
D - Direct Service
T - Transfer Involved

Highway Access Times to Major Transportation Terminals

In addition to the tables indicating the level of service between certain communities, a series of graphic presentations are included which show the area within 30 minutes and one hour driving time of terminals which provide a high level of service to other Corridor cities. The data shown represent an average of peak and off-peak driving conditions. (Figures III.1, 2 and 3).

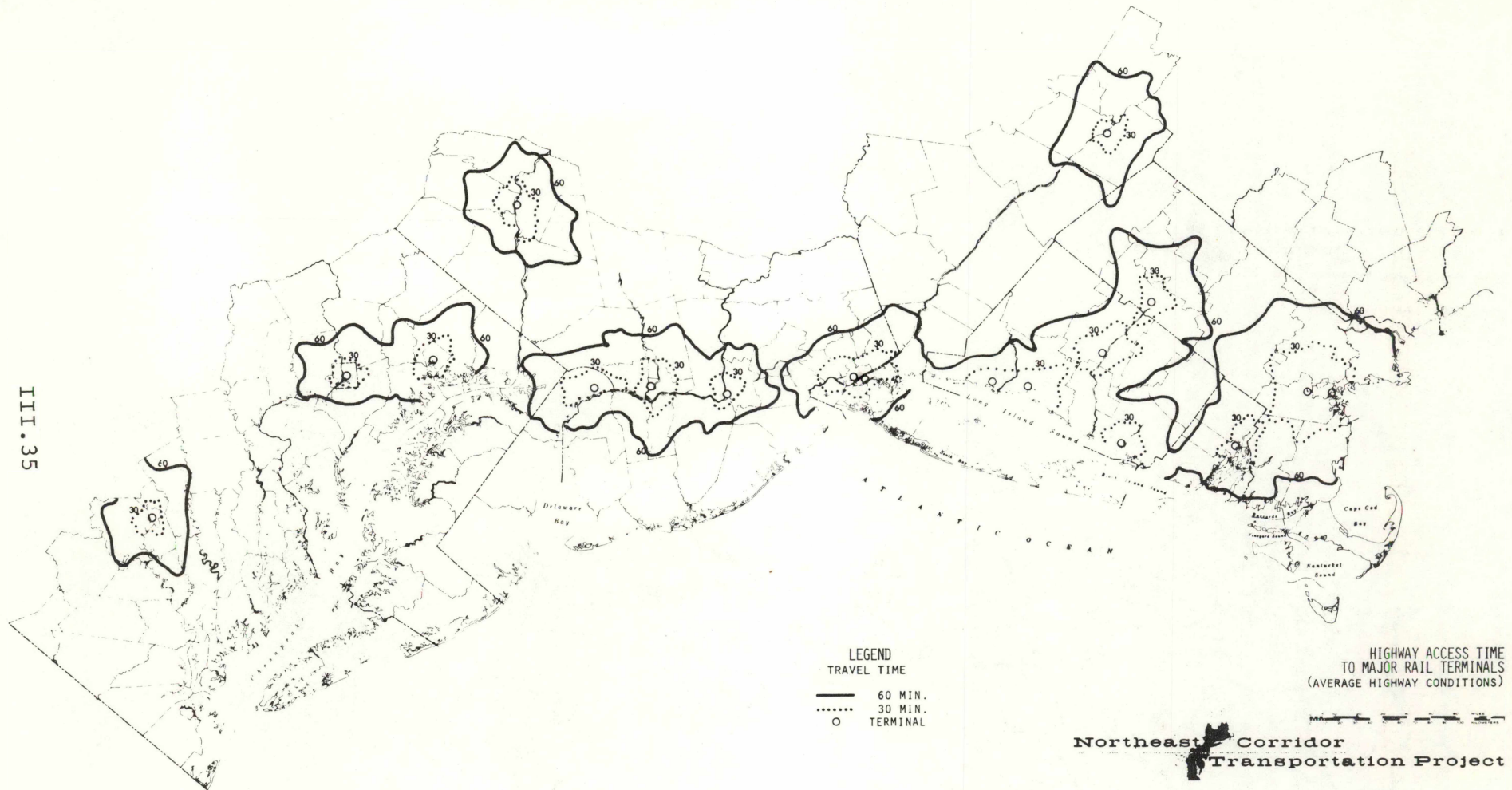


FIGURE III.1

HIGHWAY ACCESS TIME TO MAJOR RAIL TERMINALS

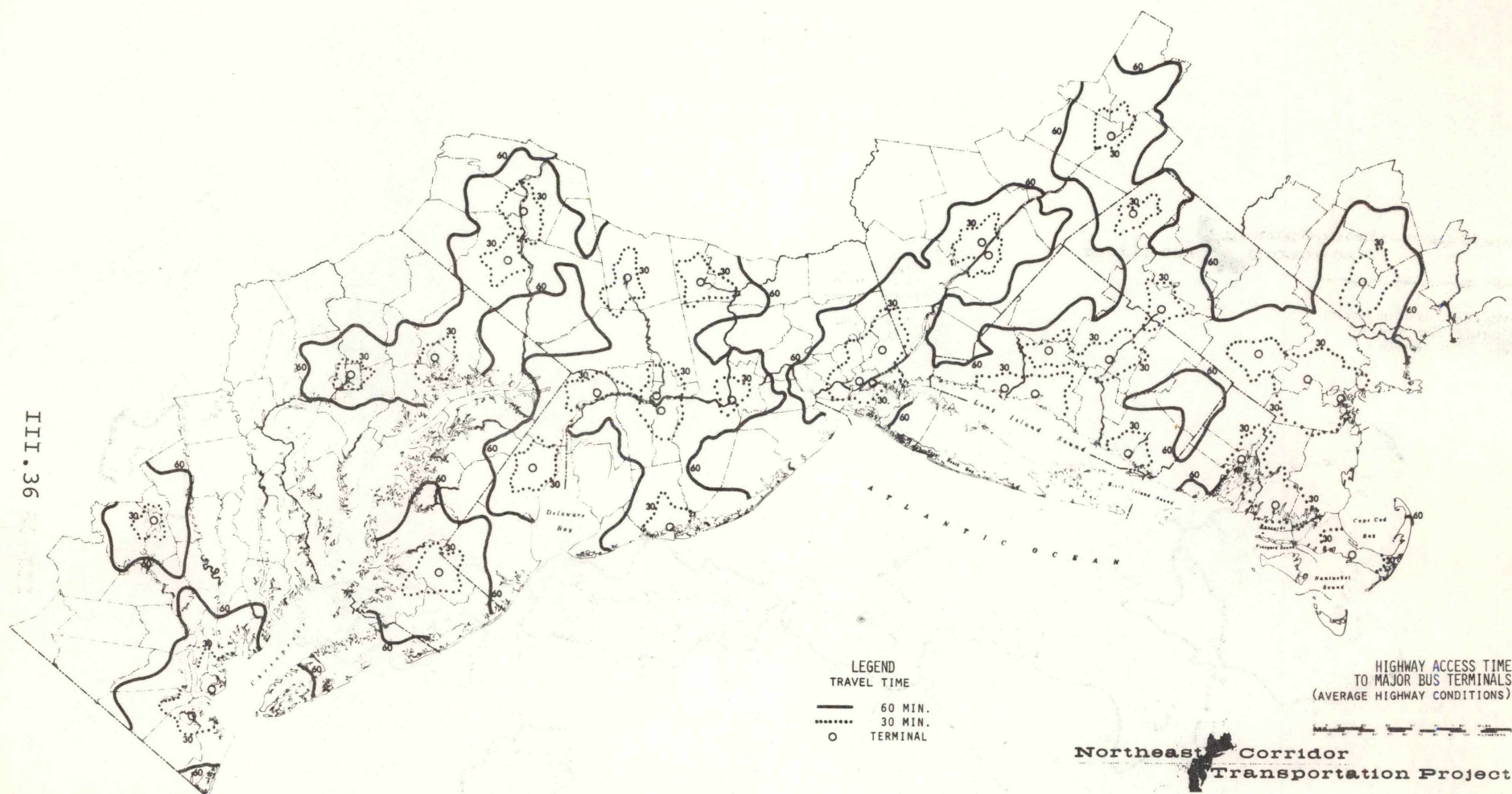


FIGURE III.2

HIGHWAY ACCESS TIME TO MAJOR BUS TERMINALS

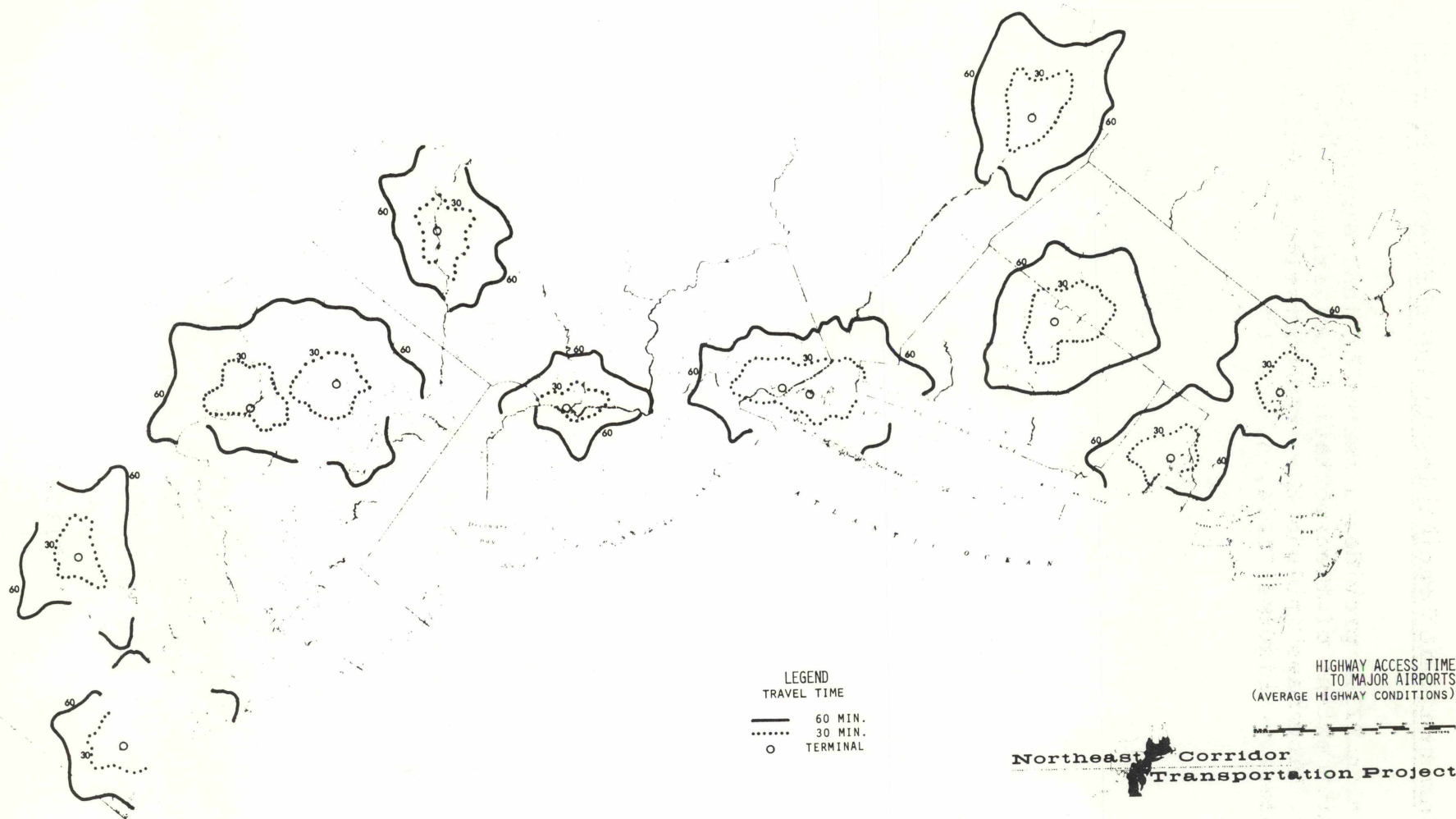


FIGURE III.3

HIGHWAY ACCESS TIME TO MAJOR AIRPORTS

III.2 Transportation Facilities in the Northeast Corridor

Section III.2 provides a series of maps displaying the current extent of transportation facilities in the Corridor. The maps include the transportation facilities of all modes. (Figures III.4, 5, 6 and 7).

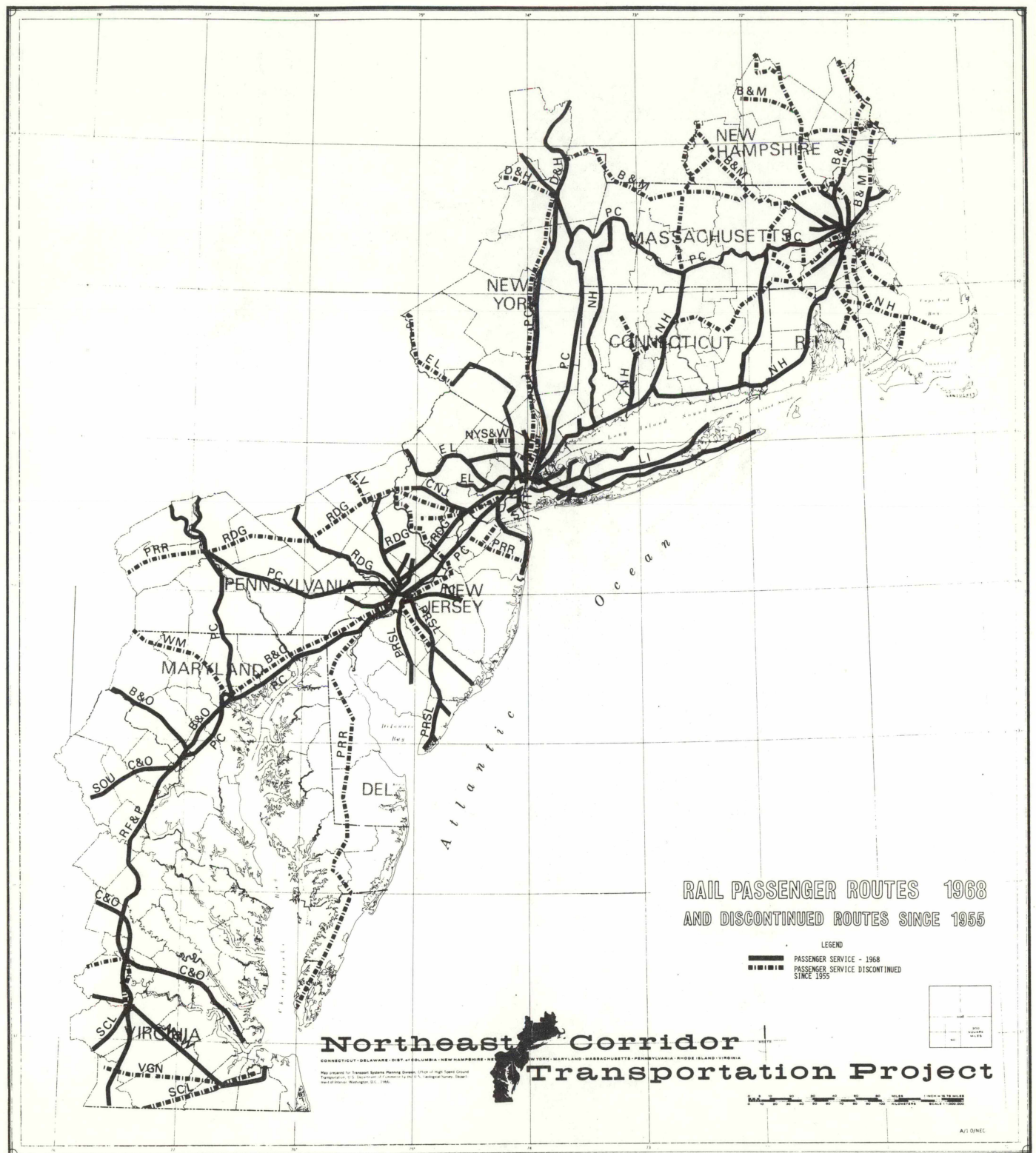


FIGURE III.4
RAIL PASSENGER ROUTES - 1968

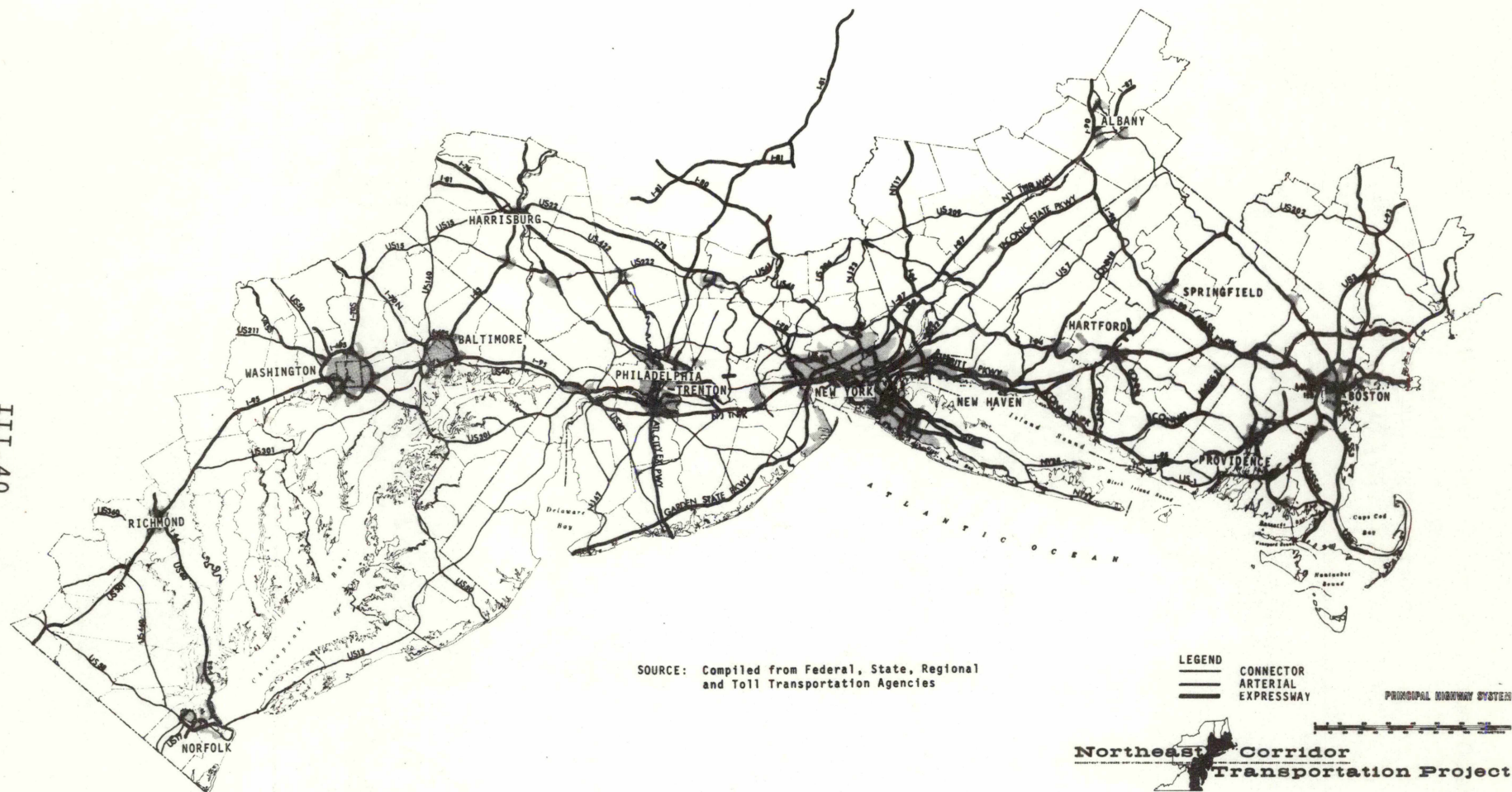


FIGURE III.5
 PRINCIPAL HIGHWAY SYSTEM

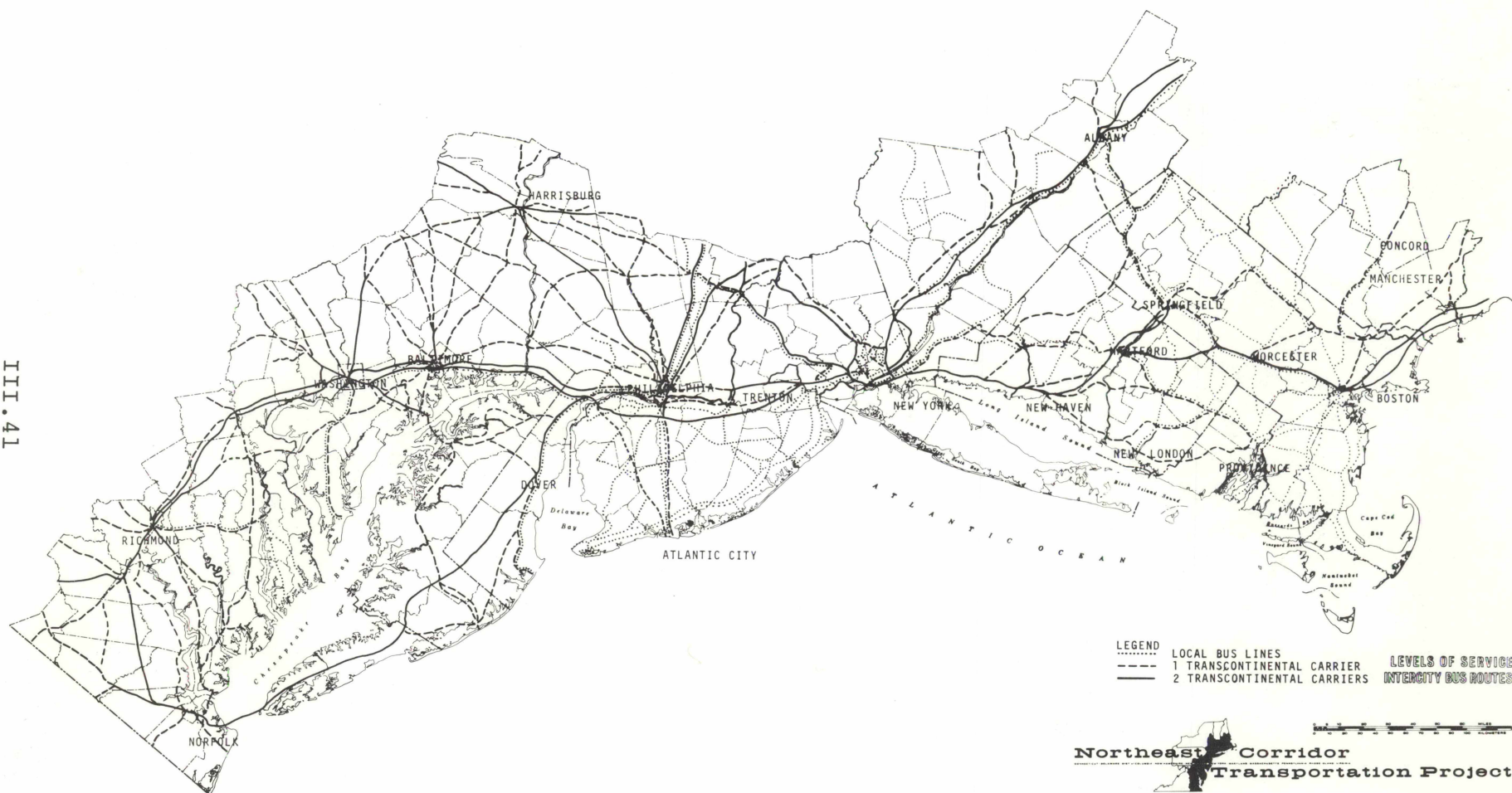
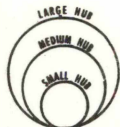


FIGURE III.6
INTERCITY BUS ROUTES



NOTE: See text for definition of hubs. The size of circle is symbolic and does not indicate the area comprising the hub.

III.42

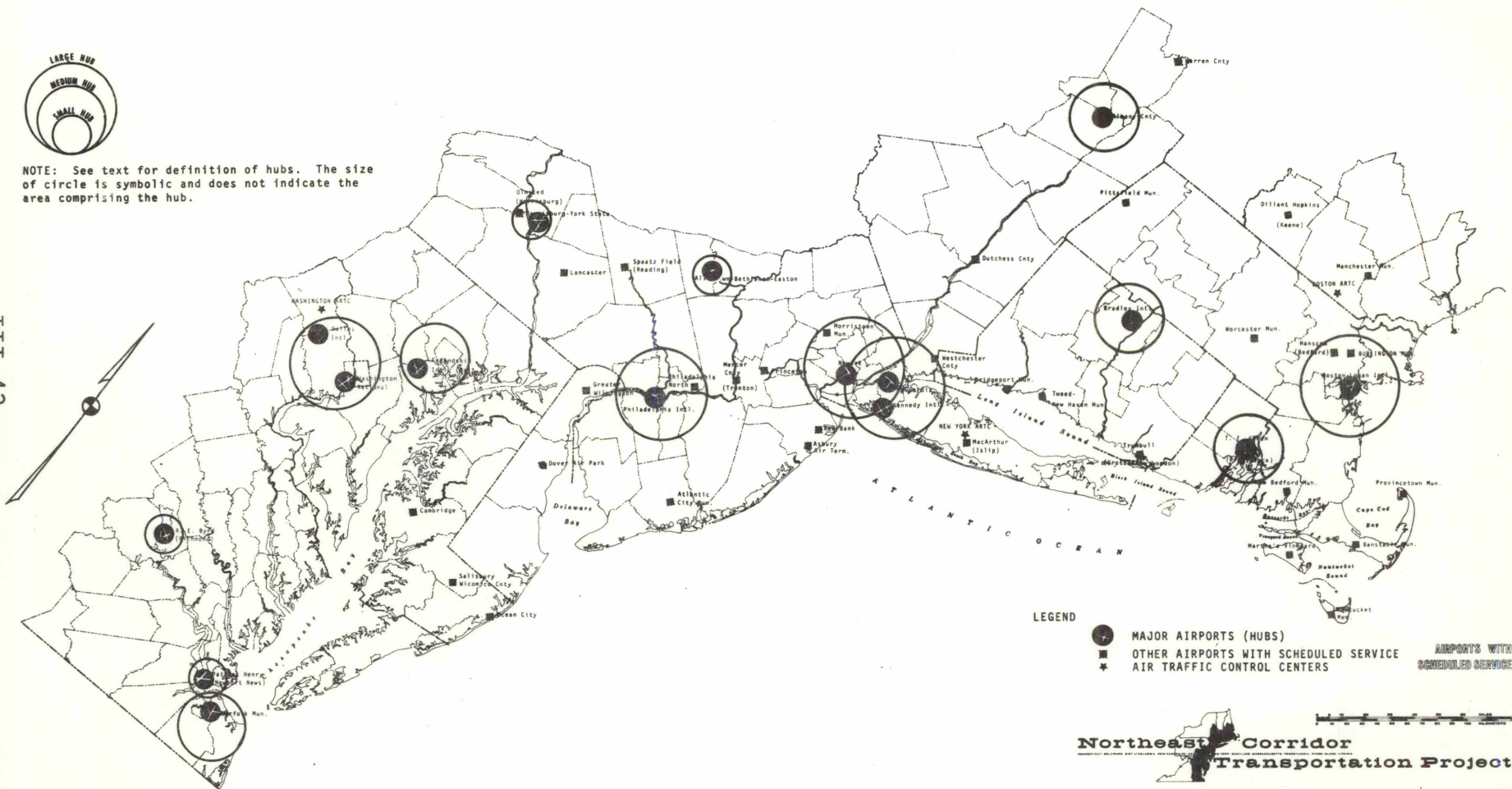


FIGURE III.7
AIRPORTS WITH SCHEDULED SERVICE

HUB Airports

The Federal Aviation Administration classifies communities into four categories of "Hub," based on the percentage of total national enplanements that occur at the airports in each community. The classifications are:

- . Large Hub (L) - Greater than 1.00 percent
- . Medium Hub (M) - 0.25 to 0.99 percent
- . Small Hub (S) - 0.05 to 0.24 percent
- . Non-Hub (N) - less than 0.05 percent

Of the nation's 23 large hub communities (counting New York and Newark independently), five are located within the Northeast Corridor, including: Boston, New York, Newark, Philadelphia, and Washington. Also located in the Corridor are four of the nation's 34 medium hubs (Albany, Hartford/Springfield, Baltimore and Norfolk) and four of the 56 small hubs (Allentown/Bethlehem, Harrisburg, Newport News, and Richmond).

TABLE III.2

NORTHEAST CORRIDOR
AIRPORTS WITH SCHEDULED PASSENGER SERVICE - 1968

NEW HAMPSHIRE

KEENE
MANCHESTER
(OTHER PUBLIC USE AIRPORTS-7)

MASSACHUSETTS

Bedford*
BOSTON
Burlington
HYANNIS
MARTHA'S VINEYARD
NANTUCKET
NEW BEDFORD
Pittsfield
Provincetown
WORCESTER
(OTHER PUBLIC USE AIRPORTS-44)

RHODE ISLAND

PROVIDENCE
(OTHER PUBLIC USE AIRPORTS-8)

CONNECTICUT

BRIDGEPORT
NEW LONDON
NEW HAVEN
HARTFORD/SPRINGFIELD
(OTHER PUBLIC USE AIRPORTS-16)

NEW YORK

ALBANY
ISLIP
NEW YORK
KENNEDY
LAGUARDIA
POUGHKEEPSIE
WHITE PLAINS
GLENS FALLS
(OTHER PUBLIC USE AIRPORTS -51)

NEW JERSEY

ATLANTIC CITY
Asbury Park
Morristown
NEWARK
Princeton
Red Bank
TETERBORO
TRENTON
(OTHER PUBLIC USE AIRPORTS-48)

PENNSYLVANIA

ALLENTOWN, BETHLEHEM, EASTON
HARRISBURG, YORK, OLMSTED
HARRISBURG, York State¹
LANCASTER
PHILADELPHIA INTERNATIONAL
North Philadelphia¹
READING
(OTHER PUBLIC USE AIRPORTS-48)

DELAWARE

Dover
WILMINGTON
(OTHER PUBLIC USE AIRPORTS-11)

MARYLAND

Cambridge
BALTIMORE
Ocean City
SALISBURY
(OTHER PUBLIC USE AIRPORTS-30)

DISTRICT OF COLUMBIA

WASHINGTON NATIONAL
DULLES INTERNATIONAL
(OTHER PUBLIC USE AIRPORTS-0)

VIRGINIA

NEWPORT NEWS
NORFOLK
RICHMOND
(OTHER PUBLIC USE AIRPORTS-34)

*Airports shown in lower case provide scheduled air taxi service only.

III.3 Major Common Carrier Terminals in the Northeast Corridor

Section III.3 presents a series of tables which list the major common carrier terminals serving the Northeast Corridor. The tables provide information on the characteristics of the terminals. (Tables III.3, 4 and 5).

TABLE III.3

SELECTED RAIL TERMINALS IN THE NORTHEAST CORRIDOR

<u>Terminal Name</u>	<u>Location</u>	<u>Year Built</u>	<u>Owned by</u>	<u>Railroads Served</u>
Albany	Rennsalear, N.Y.	1968	PC	PC, D&H
South Station	Boston, Mass.	1898	Boston Red. Authority	PC
Back Bay	Boston, Mass.	--	PC	PC
Route 128	Boston, Mass.	1953	PC	PC
Union Station	Providence, R.I.	1905	PC	PC
Union Station	New London, Conn.	--	PC	PC
Union Station	Worcester, Mass.	--	PC	PC
Union Station	Springfield, Mass.	--	PC	PC *
Union Station	Hartford, Conn.	--		PC *
Union Station	New Haven, Conn.	--	PC	PC
Grand Central	New York, N.Y.	1914	PC	PC
Penn Station	New York, N.Y.	1910	PC	PC, LI
		(1966)**		
Newark	Newark, N.J.	1935	PC	PC, CNJ *
Trenton	Trenton, N.J.	1910	PC	PC
Penn Central (30th Street)	Philadelphia, Pa.	1933	PC	PC
North Philadelphia	Philadelphia, Pa.	1910	PC	PC
Harrisburg	Harrisburg, Pa.	1910	PC	PC *
Wilmington	Wilmington, Del.	1910	PC	PC
Union Station	Baltimore, Md.	1912	PC	PC
Union Terminal	Washington, D.C.	1907	PC, B&O	PC, B&O, C&O Southern, RF&P
Union Station (Broad Street)	Richmond, Va.		RF&P	RF&P, SCL
Metropark	Woodbridge, N.J.	Proposed	NJDOT	PC
Lanham	Lanham, Md.	Under Construction	PC, Prince Georges County	PC

*Also used by Bus line; **Major Reconstruction.

TABLE III.4

SELECTED BUS TERMINALS IN THE NORTHEAST CORRIDOR

City, State	Terminal	Operated By	Other Carriers Served
Albany, N. Y.	Greyhound Trailways	Greyhound Trailways	Arrow, Interstate, Vermont Arrow, Yankee Trails
Allentown, Pa.	Allentown Bus Terminal	Greyhound Trailways	Edwards, Penn Stages, Public Service
Atlantic City, N.J.	Lincoln Bus Terminal Atlantic City Municipal	Lincoln Transit City	Trailways, Public Service
Baltimore, Md.	Greyhound Trailways	Greyhound Trailways	B&ARR, McMahon, Monumental
Boston, Mass.	Greyhound Trailways	Greyhound Trailways	Englander, Hudson, Michaud, P&B, Short Line, Vermont Almeida, B&W, Peter Pan, Rhode Island, Southern Mass.
Bridgeport, Conn.	Bridgeport Bus Terminal	City	Trailways, Greyhound, Intercity Coach
Camden, N.J.	Public Service Terminal Trailways	Public Service Trailways	Greyhound
Fall River, Mass.	Short Line	Short Line	Union Street Railway
Harrisburg, Pa.	Penn Central Station Trailways	Greyhound Trailways	
Hartford, Conn.	Greyhound Trailways	Greyhound Trailways	Arrow, Super Service Arrow, Short Line, Short Line of Connecticut
Jersey City, N.J.	Greyhound Public Service	Greyhound Public Service	Trailways, Edwards, Martz
Newark, N.J.	Penn Central Station Public Service	Greyhound Public Service	Bridgeton Transit Trailways, Boro, Edwards
New Haven, Conn.	Greyhound Trailways	Greyhound Trailways	Arrow, Empire Arrow
New London, Conn.	Greyhound New London Bus	Greyhound Short Line	Thames Valley Blue Line
Newport News, Va.	Greyhound	Greyhound	
New Rochelle, N.Y.	Greyhound	Greyhound	Vermont Transit
New York, N.Y.	Port Authority	Port of N.Y. Authority	Trailways, Greyhound Inter City, Lincoln, Bridgeton, Edwards, Super Service, Public Service, Others
Norfolk, Va.	Trailways Greyhound	Trailways Greyhound	Virginia Dare
Philadelphia, Pa.	Greyhound Trailways	Greyhound Trailways	Edwards, Trenton -Phila., Public Service Penn States, Short Line Pa., Public Service
Providence,	Short Line	Short Line	ABC, Greyhound, Brander Super Service, IBC, Union Street Railway, Shore Line
Reading, Pa.	Trailways	Trailways	
Richmond, Va.	Greyhound Trailways	Greyhound Trailways	James River, Pickett Cavalier, Winn
Springfield, Mass.	Union Station Interstate Bus	Greyhound Interstate Bus	Blue Line, Vermont Blue Line, Peter Pan, Short Line Connecticut, Trailways
Trenton, N.J.	Union Bus Terminal	Capital Transit	Capital Transit, Trailways, Greyhound, Public Service, Trenton-Phila., Suburban Transit
Washington, D.C.	Greyhound Trailways	Greyhound Trailways	Atwood
Waterbury, Conn.	Travel Center	Greyhound	Arrow, Connecticut, Super Service, Trailways, Valley
Wilmington,	Bus Center	Short Line of Pennsylvania	Delaware, Trailways, Greyhound, Public Service
Worcester, Mass.	Trailways Union Bus Terminal	Trailways Greyhound	Peter Pan, Short Line, Thames Valley ABC, Greyhound, Short Line, W. Mass

SOURCE: Russell's Official Bus Guide, Part 2, September 1968.

TABLE III.5

SELECTED AIR TERMINALS IN THE NORTHEAST CORRIDOR

METROPOLITAN AREA	LOCATION	NAME	OPERATOR	RUNWAYS	
				DESIGNATION	LENGTH(FT)
Albany	Albany, N.Y.	Albany County	Albany County	4-22	7,000
				13-31	7,000
				14-32	1,600
Allentown	Allentown, Pa.	Allentown- Bethlehem- Easton	Lehigh- Northampton Airport Authority	6-24	6,160
				13-31	5,000
				14-32	2,415
				9-27	3,782
Atlantic City	Atlantic City, N.J.	Atlantic City Municipal	Southern Airways, Inc.	2-20	2,300
				12-30	3,100
				16-34	2,975
Baltimore	Baltimore, Md.	Friend- ship Inter- national	Department of Aviation City of Baltimore	10-28	9,400
				15-33	8,400
				4-22	6,000
Boston	Boston, Mass.	Logan Inter- national	Massachusetts Port Authority	4R-22L	10,002
				4L-22R	7,850
				15R-33L	7,873
				15L-33R	2,000
				9-27	7,002
Bridgeport	Bridgeport, Conn.	Bridgeport Municipal	City of Bridgeport	6-24	4,685
				11-29	4,757
				16-34	4,683
Hartford Springfield	Windsor Locks, Conn.	Bradley International	Department of Aeronautics State of Connecticut	6-24	9,500
				15-33	6,850
				1-19	
New York	Islip, N.Y.	MacArthur	Town of Islip	6-24	6,000
				14-32	5,030
				10-28	5,000
	New York, N.Y.	J.F. Kennedy International	Port of New York Authority	13R-31L	14,572
				13L-31R	10,000
				4L-22R	11,350
	New York, N.Y.	LaGuardia	Port of New York Authority	4R-22L	8,400
				14-32	3,000
				4-22	7,000
	White Plains, N.Y.	Westchester County	Port of New York Authority	13-31	7,000
				14-32	7,000
				16-34	6,550
	White Plains, N.Y.	Westchester County	Airport Commission Westchester County	12-30	4,450
				5-23	5,000
Newark	Newark, N.J.	Newark	Port of New York Authority	4-22	7,000
				11-29	6,800
Newport News	Newport News, Va.	Patrick Henry	Peninsular Airport Commission	2-20	5,025
				6-24	6,100
Norfolk	Norfolk, Va.	Norfolk Municipal	Norfolk Port Authority	1-19	4,050
				4-22	6,002
				13-31	4,657
Philadelphia	Philadelphia, Pa.	North Philadelphia	Division of Aviation City of Philadelphia	6-24	5,000
				15-33	5,000
	Philadelphia, Pa.	Philadelphia International	Division of Aviation City of Philadelphia	17-35	5,460
				4-22	4,309
				9-27	9,500

TABLE III.5 (CONTINUED)

METROPOLITAN AREA	LOCATION	NAME	OPERATOR	RUNWAYS	
				DESIGNATION	LENGTH (FT)
Providence	Warwick, R.I.	T.F. Greene	Division of	5L-23R	4,975
			Aeronautics	5R-23L	6,466
			State of	10-28	3,901
			Rhode Island	16-34	6,000
Richmond	Richmond, Va.	Richard E. Byrd	City of	2-20	5,000
			Richmond	6-24	5,300
				15-33	9,000
Trenton	Trenton, N.J.	Mercer County	Mercer County	11-29	3,000
				6-24	5,200
				16-34	4,800
Washington	Washington, D.C.	National	Bureau of	18-36	6,870
			National	15-33	5,212
			Capital	3-21	4,724
			Airports		
			Federal Aviation Administration		
	Chantilly, Va.	Dulles International	Bureau of	1R-19L	11,500
			National	1L-19R	11,500
			Capital	12L-30R	10,000
			Airports		
Wilmington	Wilmington, Del.	Greater Wilmington	Board of	1-19	7,000
			Transportation	9-27	7,200
				14-32	5,000
			Newcastle County	5-23	5,000
Worcester	Worcester, Mass.	Worcester Municipal	Worcester	2-20	3,901
			Airport	11-29	7,150
			Commission	15-33	5,500

Source: Aircraft Owners and Pilots Association Directory (1968).

III.4 Selected Operating Characteristics of Common Carriers Serving the Northeast Corridor

Section III.4 presents a series of tables summarizing basic operating characteristics of common carrier modes serving the Northeast Corridor. The tables include data on the number of passengers carried, revenue-miles, and revenue. (Tables III.6, 7 and 8).

TABLE III.6

RAIL PASSENGER AND PASSENGER REVENUE TRENDS FOR SELECTED CORRIDOR RAILROADS

		Pennsylvania Railroad	New York Central	New Haven Railroad	Baltimore and Ohio	Reading* Railroad	Richmond Fredericksburg & Potomac
NON-COMMUTER*	1955	39,856	17,662	16,799	2,960	6,996	2,211
PASSENGERS	1960	26,506	12,009	10,641	1,911	5,087	1,587
(Thousands)	1965	25,044	8,810	11,201	1,285	5,926	1,396
	1968	29,600		10,846	552	7,248	1,075
NON-COMMUTER	1955	3,405,960	2,510,089	1,301,272	632,291	154,544	230,927
PASSENGER	1960	2,107,401	1,419,681	751,596	515,522	92,517	167,747
MILES	1965	1,593,383	871,572	658,443	309,546	86,833	146,489
(Thousands)	1968	1,700,160		593,314	117,055	103,974	111,830
MILES PER	1955	85.5	142.1	77.5	213.6	22.1	104.5
NON-COMMUTER	1960	79.5	118.2	70.6	269.8	18.2	105.7
PASSENGERS	1965	73.6	98.9	58.8	240.9	14.7	105.0
	1968	57.4		54.7	212.2	14.3	104.0
ALL PASSENGER	1955	\$122,997	\$89,367	\$54,216	\$18,838	\$7,197	\$5,972
REVENUE	1960	99,849	67,937	44,441	15,884	6,043	4,860
(Thousands of	1965	82,957	51,538	38,659	10,111	5,719	4,372
Dollars)	1968	\$105,087		36,372	4,409	7,074	3,913
REVENUE PER	1955	\$1.94	\$2.13	\$1.16	\$5.04	\$.53	\$2.68
PASSENGER	1960	2.16	2.23	1.44	6.04	.58	3.05
(ALL PASSENGERS)	1965	1.89	2.08	1.59	5.68	.49	3.13
	1968	\$1.59		1.52	3.72	.54	3.64

*Non-commuter includes local as well as intercity trips

**Reading figures reflect the high use of special SEPTA fares by passengers who might ordinarily buy commuter tickets.

NOTE: Penn Central (former PRR and NYC) and B&O operate a significant portion of their passenger service outside the Corridor.

SOURCE: Annual Reports of the Railroads to the ICC

TABLE III.7
REVENUES, BUS MILES, AND PASSENGERS FOR SELECTED INTERCITY
MOTOR BUS LINES OPERATING IN THE NORTHEAST CORRIDOR - 1968

CARRIER	REVENUE (000's)\$			BUS MILES (000's)MILES			PASSENGERS (000's)			INTERCITY ROUTE MILES
	INTER- CITY	CHAR- TER	TOTAL	INTER- CITY	CHAR- TER	TOTAL	INTER- CITY	CHAR- TER	TOTAL	
Arrow	521	435	963	1,336	555	1,891	320	87	407	721
Balt & Ann. . Railroad	635	1383	2,061	1,023	2107	3,202	1,397	447	1,985	172
Bridgeton Transit	250	151	420	545	224	804	76	40	237	147
Eastern Greyhound	98,381	7400	120,656	132,268	9659	144,463	22,098	847	24,566	22,244
Hudson Transit	5,354	801	6,255	5,140	998	6,138	2,255	526	2,781	540
Interstate Buses	516	48	612	828	71	900	208	9	217	283
Lincoln	3,281	344	3,647	5,277	597	5,874	2,179	124	2,304	180
Mt. View	399	494	1,008	785	865	1,650	351	863	1,213	161
Peter Pan	976	477	1,525	1,634	681	2,316	544	136	680	428
Safeway Trails	15,845	1471	19,359	19,346	1949	21,295	4,049	150	4,199	1,233
Short Line	2,910	680	4,183	4,575	967	6,050	2,350	145	4,232	811
Short Line of Conn.	143	88	235	463	236	699	147	30	177	294
Short Line of Penn.	352	212	621	1,072	312	1,445	998	178	1,306	372
Super Service	564	20	602	961	24	985	298	11	310	315
Trailways of N.E.	5,651	319	6,721	8,240	340	8,581	1,254	38	1,292	1,416
Tren-Phil Coach Co.	71	578	657	374	828	1,233	109	203	340	58

Note: Totals include local and suburban operation figures. Some lines operate extensive portions of their service outside the Corridor, such as Eastern Greyhound.

Source: Individual Carrier Reports to the I.C.C.

TABLE III.8

AIRPORT ACTIVITIES AT SELECTED NORTHEAST CORRIDOR AIRPORTS

AIRPORT	NUMBER OF OPERATIONS - 1968 *				1967**
	AIR CARRIER	GENERAL AVIATION	MILITARY	TOTAL OPERATIONS	PASSENGER ENPLANEMENTS
(ALBANY) ALBANY COUNTY	54,636	82,341	3,955	140,932	393,926
(ALLENTOWN-BETHLEHEM-EASTON)	9,282	98,379	4,205	111,866	73,235
(ATLANTIC CITY) ATLANTIC CITY MUNI.	4,213	80,145	50,593	134,951	17,317
(BALTIMORE) FRIENDSHIP INT.	118,021	101,379	7,176	226,576	1,264,506
(BOSTON) LOGAN INT.	207,758	99,676	4,867	312,301	3,793,294
(BRIDGEPORT) BRIDGEPORT MUNI.	6,816	191,322	3,024	201,162	29,422
(HARTFORD) BRADLEY INT.	62,150	89,300	14,898	166,348	674,482
(ISLIP) MACARTHUR	8,864	266,414	981	276,259	36,213
(NEW YORK) LAGUARDIA	251,026	105,416	940	357,120	4,018,355
(NEW YORK) KENNEDY INT.	398,466	65,452	1,202	465,120	7,749,451
(NEWARK) NEWARK	207,970	72,828	327	281,125	2,999,064
(NEWPORT NEWS) PATRICK HENRY	25,530	106,433	30,544	162,507	171,465
(NORFOLK) MUNICIPAL	44,447	124,960	7,300	176,707	467,682
(PHILADELPHIA) NORTH PHILADELPHIA	-	170,726	2,074	172,800	-
(PHILADELPHIA) PHILADELPHIA INT.	197,345	92,239	3,611	293,195	2,520,303
(PROVIDENCE) T. F. GREEN	37,833	133,813	16,390	188,036	343,244
(RICHMOND) RICHARD E. BYRD	36,545	107,278	51,492	195,315	295,240
(TRENTON) MERCER COUNTY	2,835	162,154	11,231	176,220	6,678
(WASHINGTON) DULLES INT.	58,876	98,128	56,606	213,610	690,307
(WASHINGTON) NATIONAL	235,039	108,124	3,254	346,417	4,563,855
(WHITE PLAINS) WESTCHESTER COUNTY	7,231	251,193	2,852	261,276	28,211
(WILMINGTON) GREATER WILMINGTON	8,171	128,676	16,515	153,362	17,057
(WORCESTER) WORCESTER MUNI.	6,307	77,342	1,192	84,841	30,063

SOURCE: *FAA Air Traffic Activity, Calendar Year 1968, Federal Aviation Administration.

**Airport Activity Statistics of Certificated Route Air Carriers, Calendar Year 1967, Civil Aeronautics Board and Federal Aviation Administration (U.S. Carriers Only).

III.5 Travel Trends and Travel Characteristics in the Northeast Corridor

Section III.5 presents data showing the trends in travel by mode in the total Northeast Corridor and for certain city pairs. Data is also shown on the characteristics of travel including the magnitude of usage, and the temporal patterns by mode. (Figures III.8, 9, 10, 11, 12, 13, 14, 15, and 16; and Table III.9).

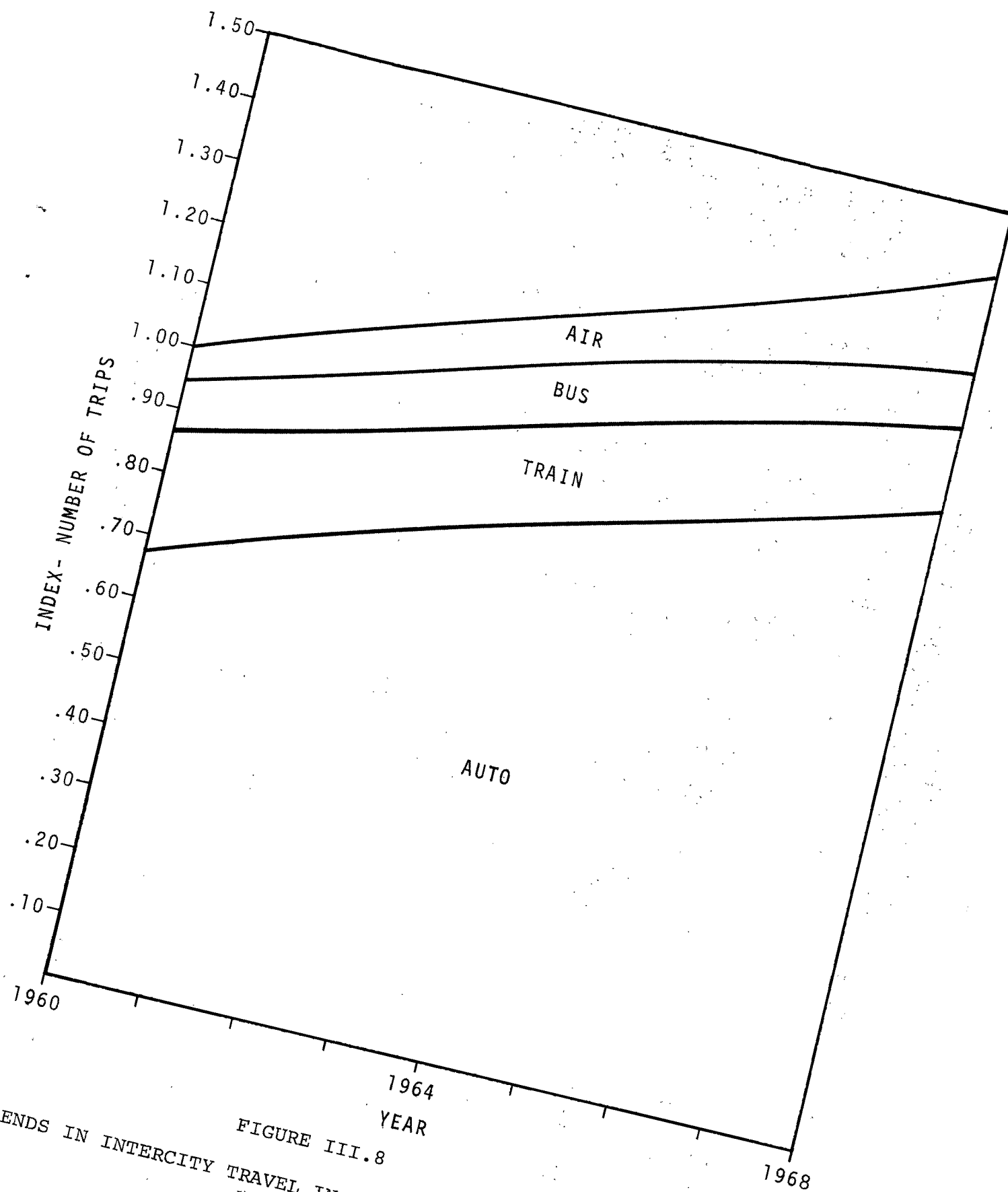


FIGURE III.8
TRENDS IN INTERCITY TRAVEL IN THE NORTHEAST CORRIDOR
1960 - 1968
III.55

Table III.9

TRENDS IN INTERCITY TRAVEL IN THE NORTHEAST CORRIDOR FOR SELECTED CITY PAIRS

City Pair	Annual Number of Trips					
	Year	Auto	Air	Bus	Rail	Total
Boston* - New York**	1960	1,640,000	860,000	275,000	665,000	3,440,000
	1965	1,940,000	1,770,000	310,000	410,000	4,430,000
	1968	2,150,000	2,410,000	345,000	260,000	5,165,000
Boston - Philadelphia	1960	435,000	130,000	28,000	30,000	623,000
	1965	550,000	210,000	29,000	25,000	814,000
	1968	570,000	325,000	30,000	14,000	939,000
Boston - Washington	1960	300,000	165,000	30,000	55,000	550,000
	1965	375,000	360,000	34,000	40,000	809,000
	1968	425,000	520,000	35,000	30,000	1,010,000
New York - Philadelphia	1960	7,750,000	61,000	1,050,000	2,230,000	11,091,000
	1965	9,500,000	113,000	1,150,000	2,210,000	12,973,000
	1968	10,700,000	130,000	1,090,000	2,740,000	14,660,000
New York - Washington	1960	1,810,000	690,000	510,000	830,000	3,840,000
	1965	2,180,000	1,390,000	540,000	650,000	4,760,000
	1968	2,400,000	1,905,000	550,000	460,000	5,315,000
Philadelphia - Washington	1960	1,150,000	75,000	250,000	450,000	1,925,000
	1965	1,440,000	130,000	250,000	440,000	2,260,000
	1968	1,640,000	170,000	250,000	400,000	2,460,000

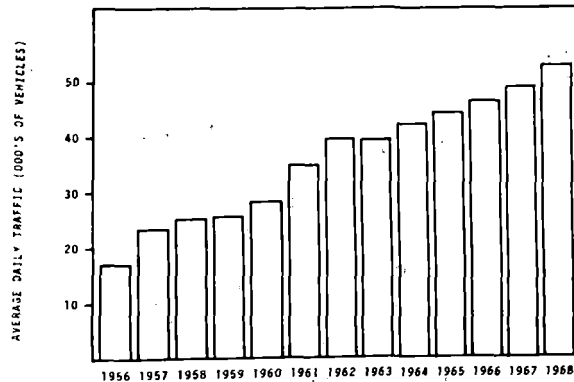
* Includes Boston SMSA only.

** Includes Newark and Northern New Jersey metropolitan area.

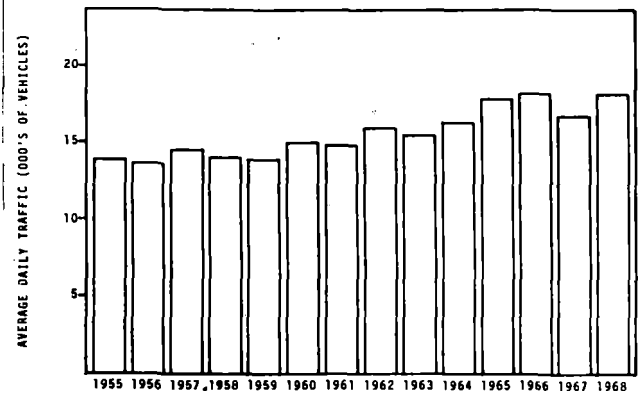
Source: Compiled from travel surveys conducted by Federal, State, Regional and Toll Transportation Authorities and private carriers.

FIGURE III. 9

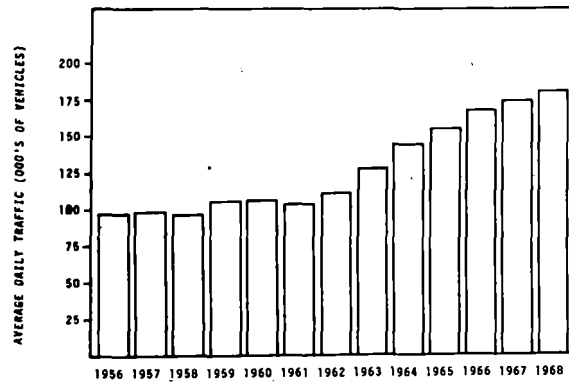
HISTORICAL TRENDS IN AVERAGE DAILY TRAFFIC
AT SELECTED LOCATIONS



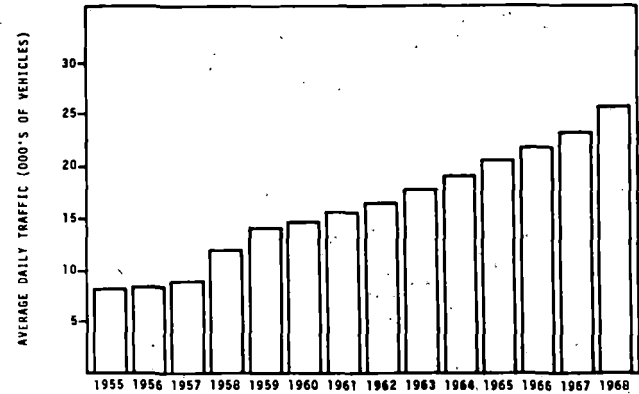
TAPPAN ZEE BRIDGE



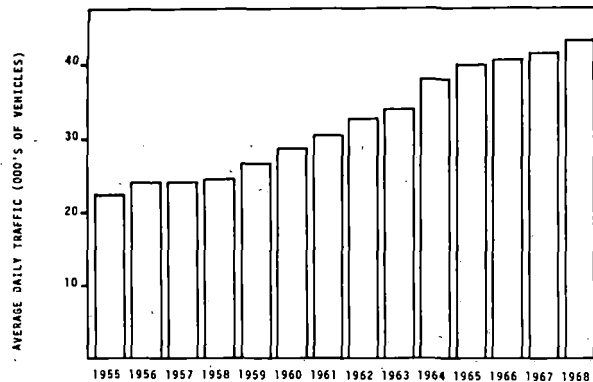
I-84 AT MASSACHUSETTS - CONNECTICUT STATE LINE



GEORGE WASHINGTON BRIDGE

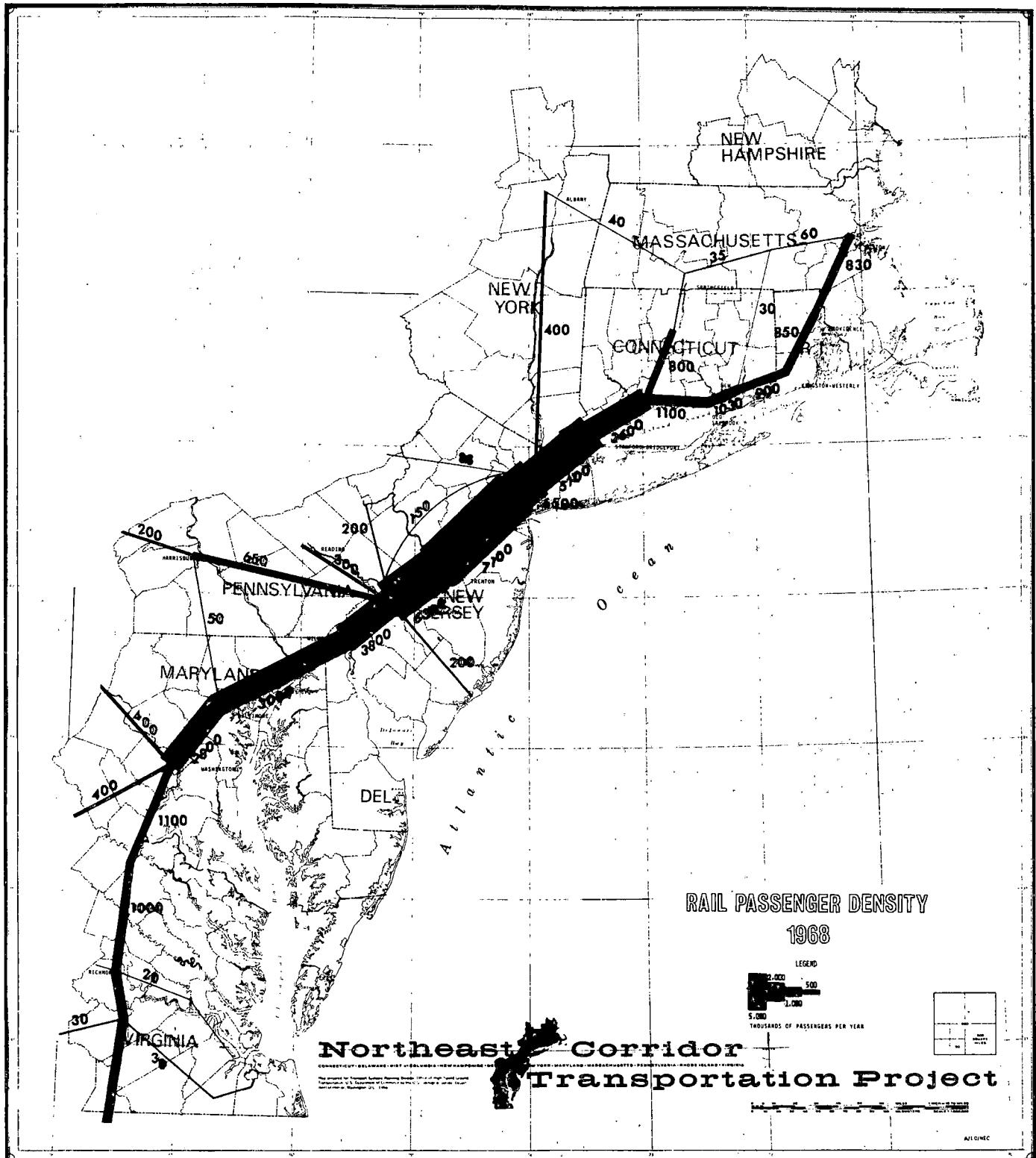


I-95 AT CONNECTICUT RIVER



DELAWARE MEMORIAL BRIDGE

Source: Compiled from various toll Authorities and state highway departments.



SOURCE: Studies conducted by the Office of High Speed Ground Transportation and Railroad origin-destination surveys (Only trips over thirty miles shown)

FIGURE III.10

RAIL PASSENGER DENSITY - 1968

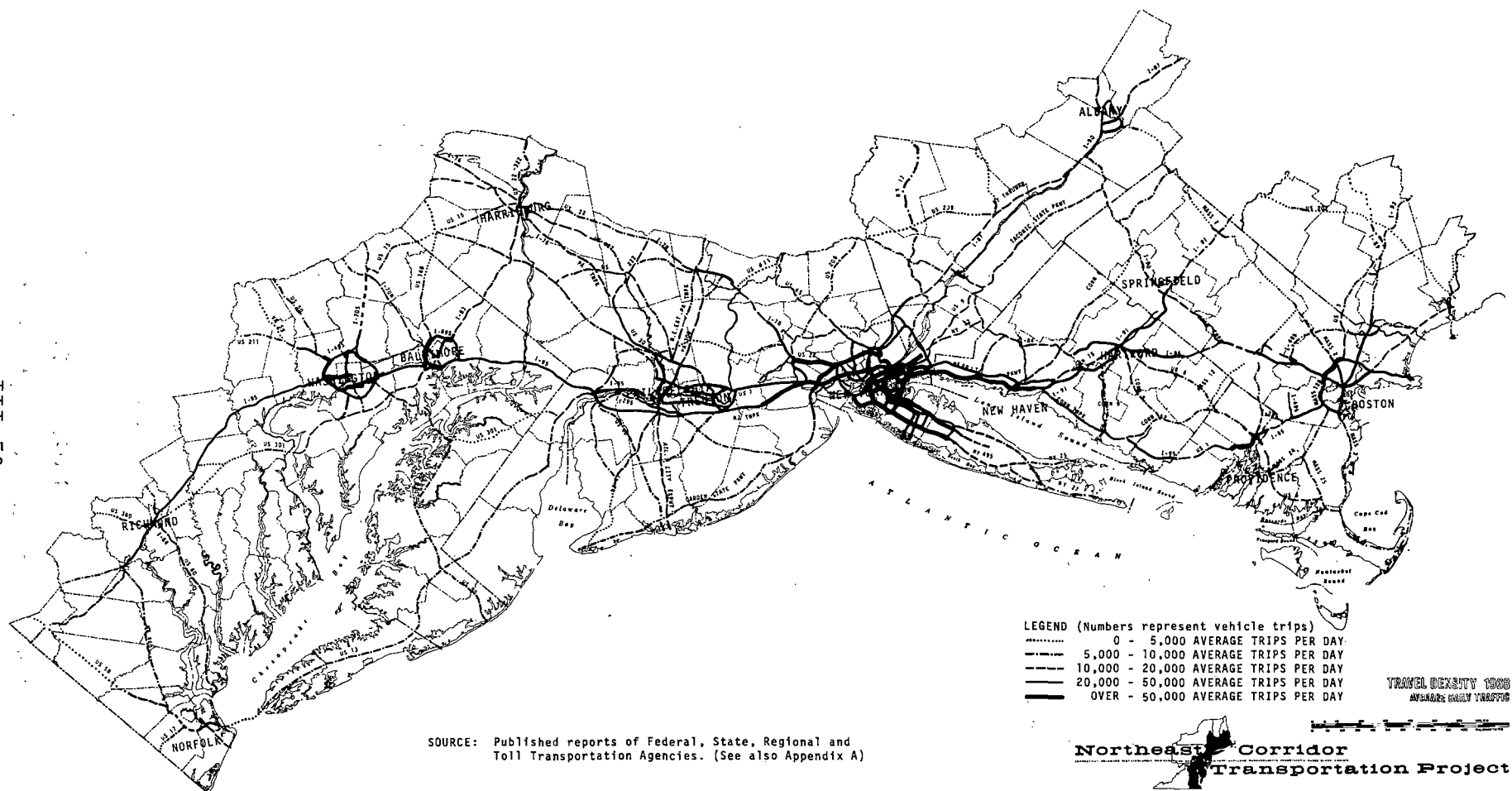


FIGURE III.11
AVERAGE DAILY HIGHWAY TRAVEL - 1968

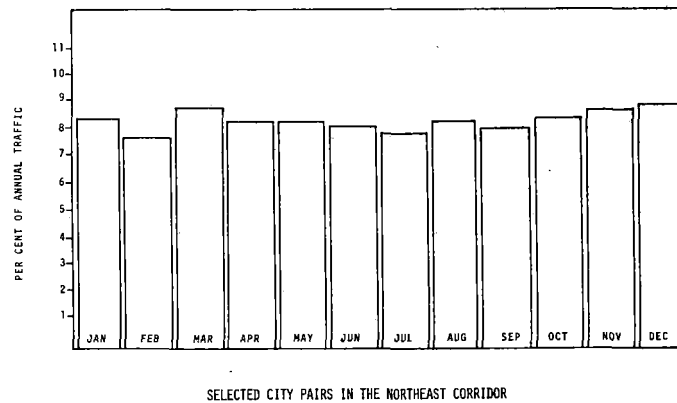
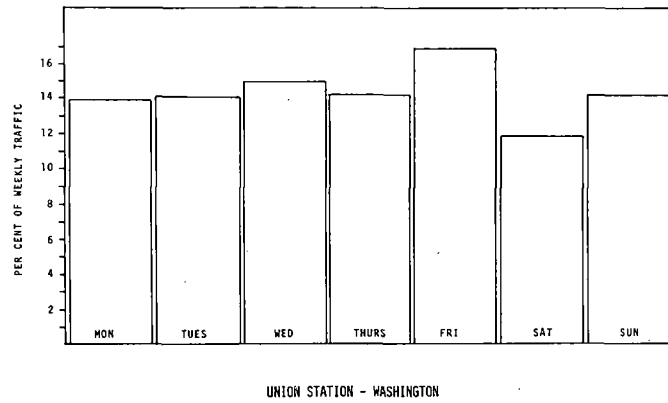
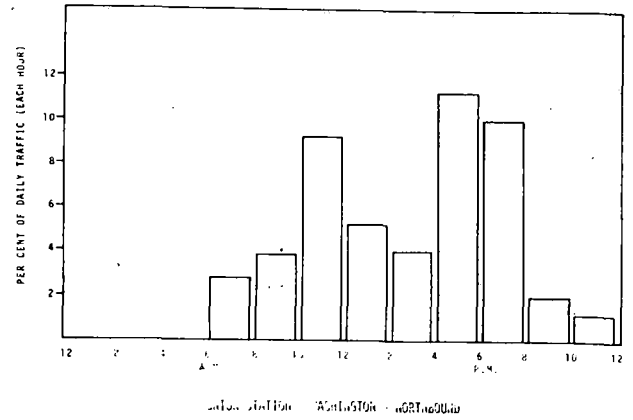
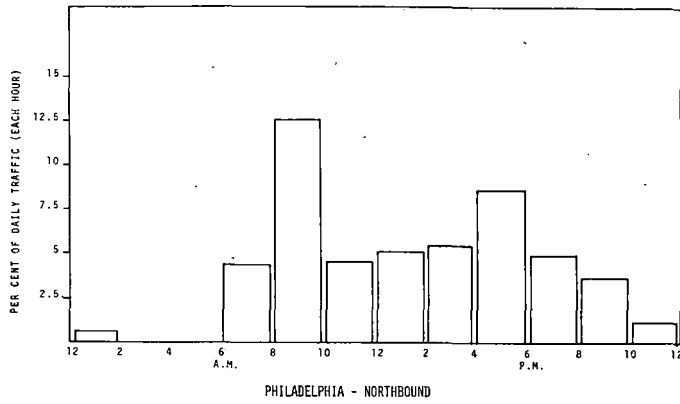
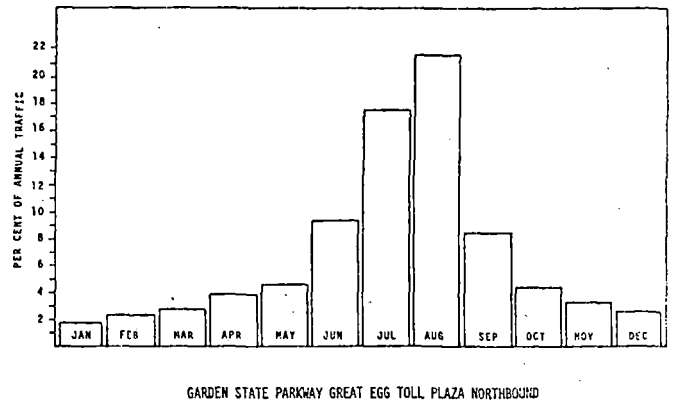
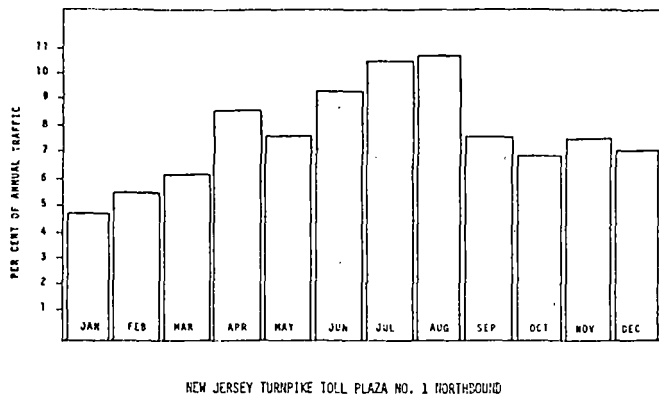
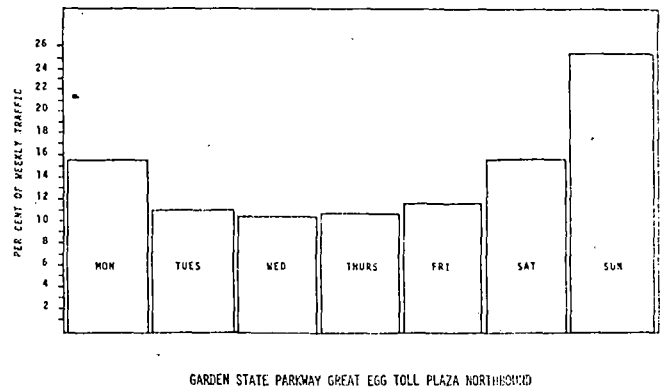
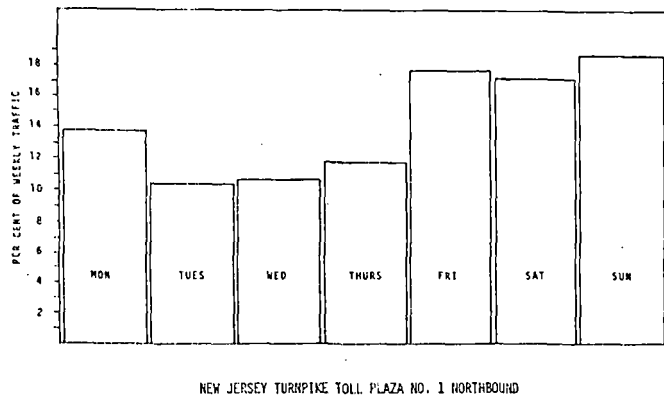
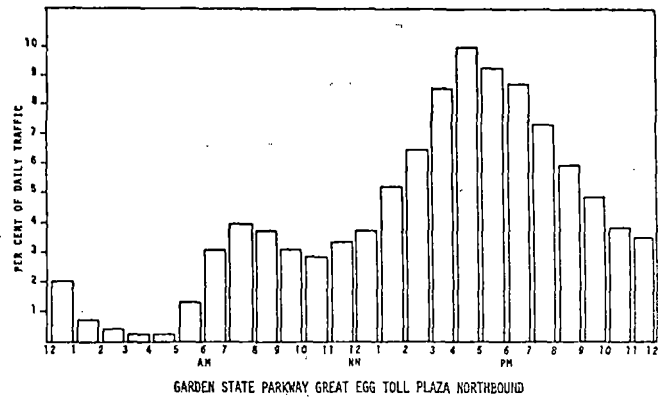
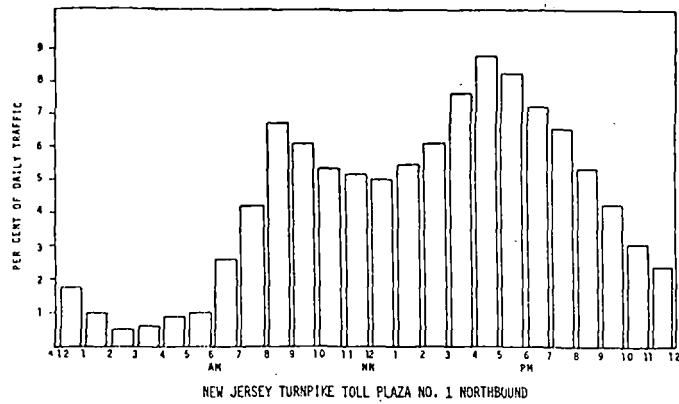


FIGURE III.12
TIME VARIATIONS OF RAIL PASSENGER TRAFFIC

Location 1: Typical Intercity Peaking

Location 2: Summer Peaking



(Near Delaware Memorial Bridge)

(Near Atlantic City, New Jersey)

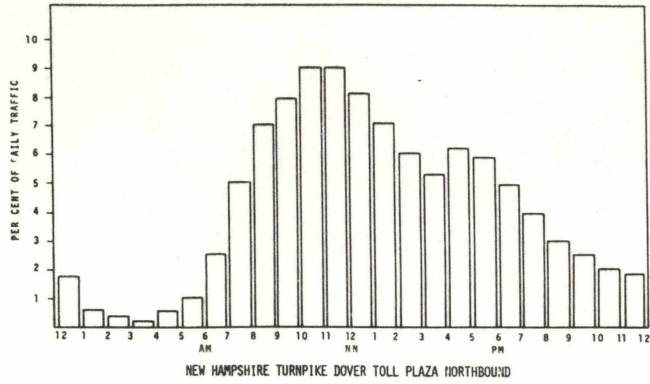
Source: Compiled from selected toll authorities.

FIGURE III.13

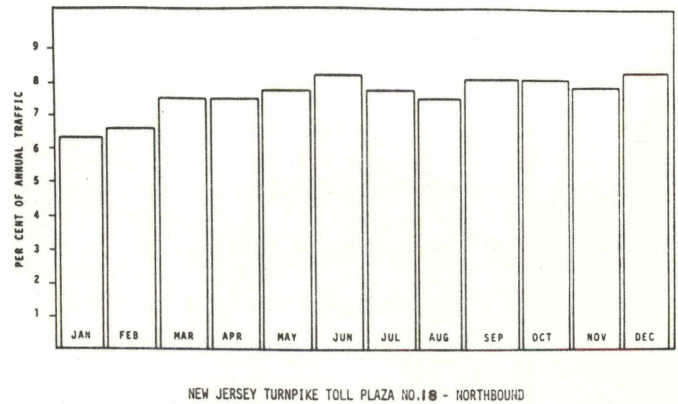
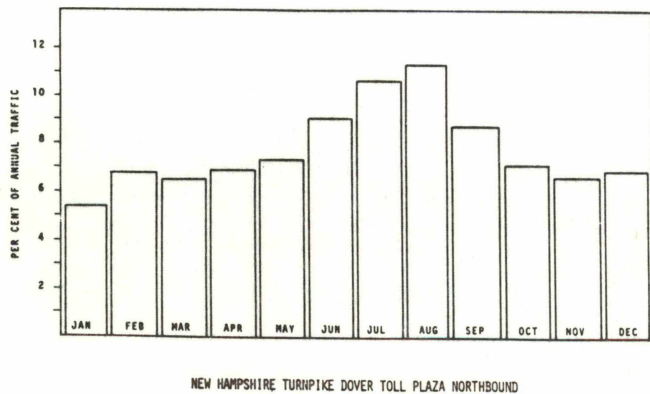
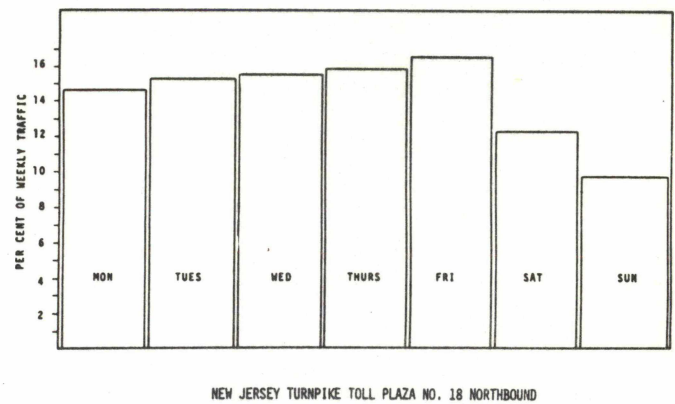
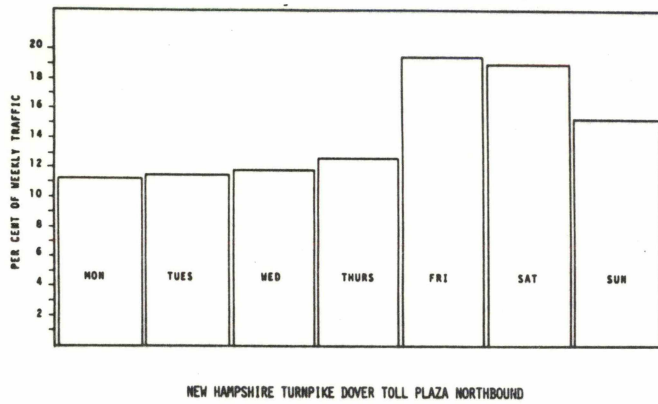
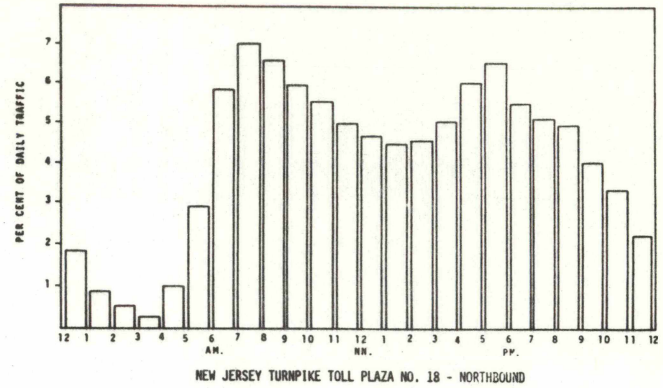
TIME VARIATIONS OF HIGHWAY TRAFFIC AT
SELECTED NORTHEAST CORRIDOR LOCATIONS

FIGURE III.13 (Continued)

Location 3: Weekend Peaking



Location 4: Commuter Peaking



(Near Dover, New Hampshire)

(Near George Washington Bridge)

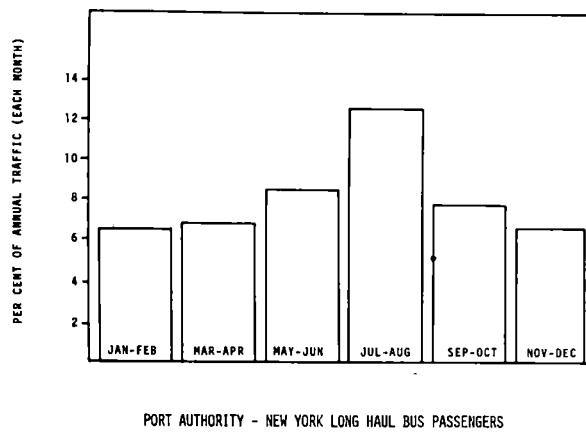
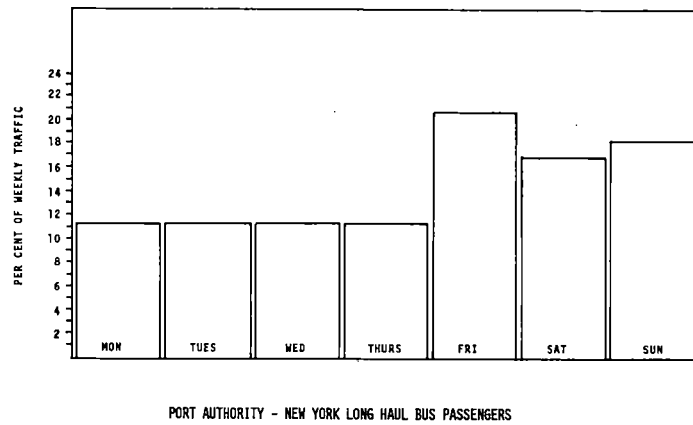
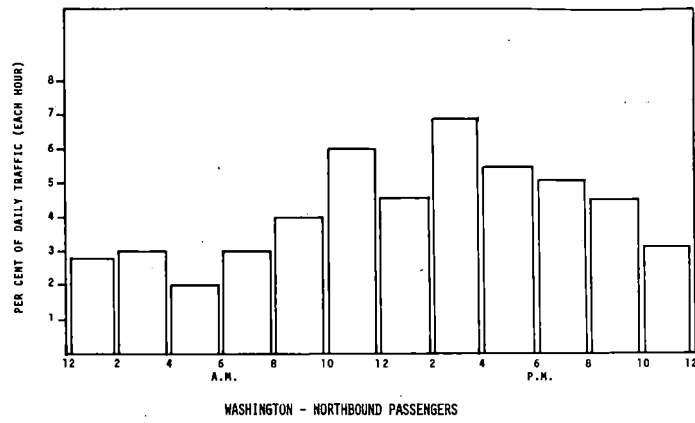
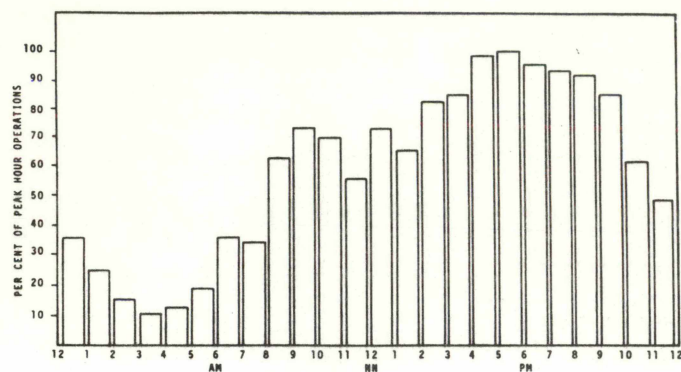
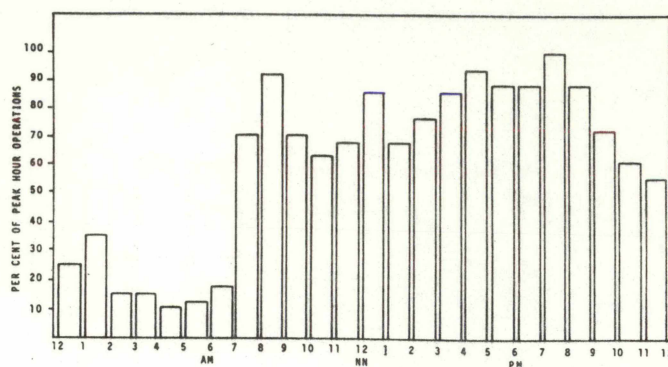


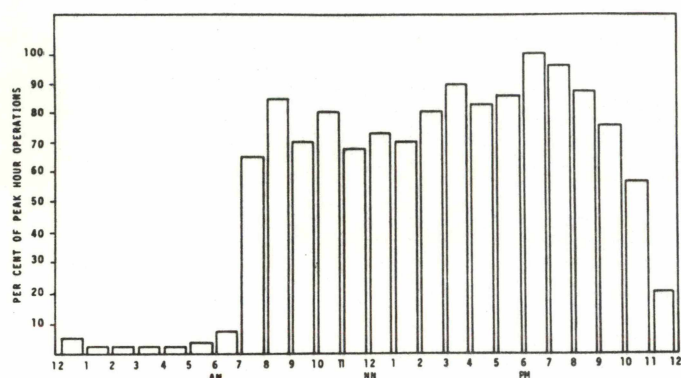
FIGURE III.14
TIME VARIATIONS IN BUS PASSENGER TRAVEL



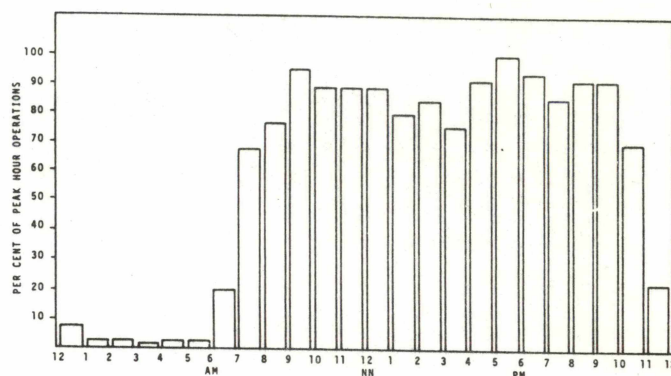
JOHN F. KENNEDY, NEW YORK



NEWARK, NEW JERSEY



LA GUARDIA, NEW YORK

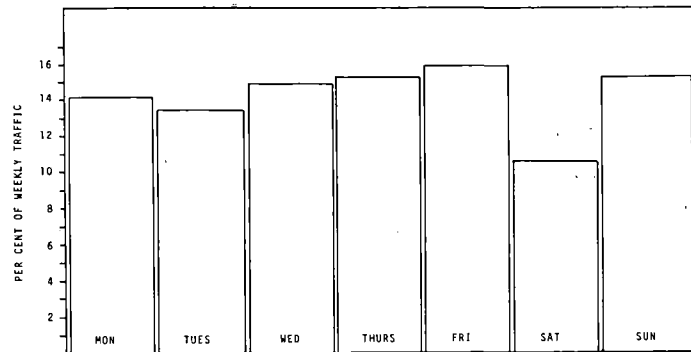


NATIONAL, WASHINGTON, D. C.

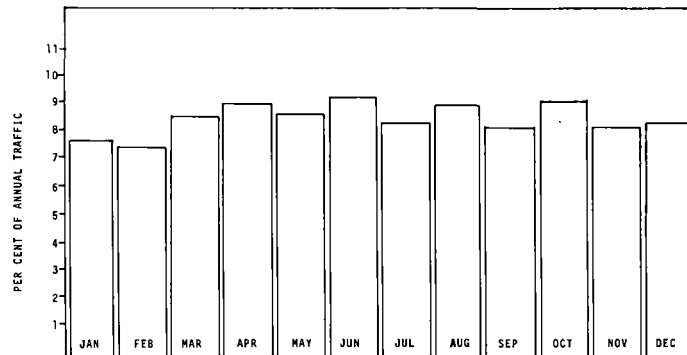
Source: Federal Aviation Administration, Air Traffic Control tower records for February 1968.

Note: Data is for Operations rather than Passengers.

FIGURE III.15
HOURLY DISTRIBUTION OF AIR CARRIER OPERATIONS
AT SELECTED NORTHEAST CORRIDOR AIRPORTS



NATIONAL AIRPORT - WASHINGTON



NATIONAL AIRPORT - WASHINGTON

FIGURE III.16

TIME VARIATIONS IN AIR PASSENGER TRAVEL

III.6 Access Mode Choice at Selected Northeast Corridor Terminals

Section III.6 summarizes data pertaining to the choice of access mode used to get to and from intercity common carrier terminals in the Northeast Corridor. Data is readily available for most air terminals but is quite limited for rail and bus terminals. (Tables III.10, 11 and 12).

TABLE III.10

MODE OF TRANSPORTATION TO UNION STATION

WASHINGTON 1968

<u>ACCESS MODE</u>	<u>PER CENT USING MODE</u>
TAXI	43%
AUTO	21%
BUS	12%
TRAIN	9%
WALK	10%
OTHER	5%
ALL MODES	100%

Source: Survey at Union Station by Barton-Aschman Associates,
April, 1968.

TABLE III.11

MODE OF TRANSPORTATION TO BUS TERMINALS
FOR SELECTED NORTHEAST CORRIDOR CITIES

CITY	YEAR	PER CENT OF PASSENGERS BY ACCESS MODE						
		ALL MODES	SUBWAY	AUTO	TAXI	WALK	BUS	RAIL
NEW YORK*	1964							
WEEKDAY		100%	32	12	25	4	26	1
FRIDAY		100%	36	10	23	5	24	2
SUNDAY		100%	27	23	19	4	25	2
WASHINGTON**	1967							
WEEKDAY		100%	--	13	28	13	46	--

Source:

* Port Authority Bus Terminal Long-Haul Bus Passenger Origin
and Destination Survey, 1964

** Survey at Washington Bus Terminals by Barton-Aschman Associates, May 1967

TABLE III.12

MODE OF TRANSPORTATION TO AIRPORT FOR
SELECTED NORTHEAST CORRIDOR AIRPORTS

(Excludes Transfer Passengers)

AIRPORT	YEAR	Percent of Passengers by Mode of Ground Transportation						
		All Modes	Auto	Taxi	Airport Coach	Public Bus	Heli-copter	Scheduled Suburban Limousine
<u>New York *</u>								
Kennedy	1965	100%	45%	29%	18%	3%	2%	3%
LaGuardia	1965	100%	38%	47%	11%	3%	N/A	1%
Newark	1965	100%	54%	10%	24%	10%	1%	1%
<u>Philadelphia **</u>								
International	1968	100%	67%	18%	--	2%	0	13%
<u>Baltimore ***</u>								
Friendship	1966	100%	73%	9%	18%			
<u>Washington ***</u>								
Dulles	1966	100%	59%	8%	33%			
National	1966	100%	52%	41%	7%			

Source:

* New York's Domestic Air Passenger Market, Port of New York Authority, 1965

** "Ground Transportation to Philadelphia International Airport," Simpson & Curtin, 1968

*** Washington-Baltimore Airport Access Survey, Volume 1, Department of Transportation, May 1968.

IV. JURISDICTIONAL INFORMATION

Material in this section pertains to agencies in the Northeast Corridor that have an involvement in transportation planning and operation.

TABLE IV.1
FIELD REGIONS OF THE FEDERAL HIGHWAY
ADMINISTRATION WITHIN THE NORTHEAST CORRIDOR

F.H.A. Region Number	Address of Regional Planning & Research Engineer	Divisions (States) Comprising Region	Address of Division Planning & Research Engineer	Address of State Planning Official
1	4 Normanskill Boulevard Delmar, New York 12054 518-472-4254	CONNECTICUT	990 Wethersfield Avenue Hartford, Conn. 06114 203-244-2410	Chief of Planning Bureau of Highways Dept. of Transportation 24 Wolcott Hill Road (P.O. Drawer A) Wethersfield, Conn.
		MASSACHUSETTS	J.F. Kennedy Federal Bldg. Government Center Boston, Mass. 02203 617-223-2879	Director, Bureau of Transportation Planning & Development Mass. Dept. of Public Works 100 Nashua Street Boston, Mass. 02114
		NEW HAMPSHIRE	Room 219 Federal Building 55 Pleasant Street Concord, N.H. 03301 603-225-9021	Planning & Economics Engineer Planning & Economics Division N.H. Department of Public Works and Highways State Office Building Concord, N.H. 03301

TABLE IV.1 (Continued)

F.H.A. Region Number	Address of Regional Planning & Research Engineer	States Comprising Region	Address of Division Planning & Research Engineer	Address of State Planning Official
1 (con't)		NEW JERSEY	Suburban Square Building 25 Scotch Road P.O. Box 211 Trenton, N.J. 08628 609-883-2141	Director, of Highway Planning Division of Planning New Jersey Department of Transportation 1035 Parkway Avenue Trenton, N.J. 08628
		NEW YORK	12-14 Russell Road Albany, N.Y. 12206 518-472-3616	Ass't Commissioner for Planning and Development Office of Planning and Development N.Y. State Department of Transportation 1220 Washington Ave. Albany, N.Y. 12226
		RHODE ISLAND	Gardner Building (3rd floor) 40 Fountain Street Providence, R.I. 02903 401-528-4541	Highway Planning Engineer Division of Roads & Bridges R.I. Department of Public Works 312 Roger Williams Building Providence, R.I. 02903

TABLE IV.1 (Continued)

F.H.A. Region Number	Address of Regional Planning & Research Engineer	States Comprising Region	Address of Division Planning & Research Engineer	Address of State Planning Official
2	1633 Federal Building 31 Hopkins Place Baltimore, Md. 21201	DELAWARE	11 North Street (Arden Bldg) P.O.Box 517 Dover, Delaware 19901 302-736-1408	Ass't Chief Engineer- Planning Delaware State Highway Department Administrative Bldg. P.O. Box 151 Dover, Delaware 19901
		DISTRICT OF COLUMBIA	Penn. Building, Room 1248 425 - 13th Street, N.W. Washington, D.C. 20591 202-967-4164	Chief Engineer Office of Planning and Programming Department of Highways and Traffic Presidential Bldg. Washington, D.C. 20004
		MARYLAND	Room 206, Federal Building 31 Hopkins Place Baltimore, Maryland 21201 301-752-8460	Deputy Chief Engineer Planning and Safety Division Maryland State Roads Commission 300 West Preston St. P.O. Box 717 Baltimore, Md. 21201

TABLE IV.1 (Continued)

F.H.A. Region Number	Address of Regional Planning & Research Engineer	States Comprising Region	Address of Division Planning & Research Engineer	Address of State Planning Official
2 (con't)		PENNSYLVANIA	123-127 Walnut Street P.O. Box 1457 Harrisburg, Pa. 17105 717-787-3461	Director Bureau of Highway Planning Statistics Penn. Department of Highways Highways and Safety Building Forster Street Harrisburg, Pa. 17120
		VIRGINIA	Federal Building P.O. Box 10045 Richmond, Virginia 23240 703-649-3611	Traffic and Planning Engineer Division of Traffic and Planning Virginia Department of Highways 1221 East Broad St. Richmond, Va. 23219
Source: "Directory - Urbanized Area Transportation Planning Programs," U. S. Department of Transportation, Federal Highway Administration, Bureau of Public Roads, May 1968				

TABLE IV.2

CURRENT TRANSPORTATION PLANNING PROGRAMS
WITHIN THE NORTHEAST CORRIDOR REGION

<u>Urbanized Area</u>	<u>Name and Address of Program</u>	<u>Title of Key Official Telephone Number</u>
CONNECTICUT		
All Connecticut Standard Metro- politan Statis- tical Areas	(Connecticut Interregional Planning Program)* Office of State Planning Dept. of Finance and Control State Office Bldg. Hartford, Connecticut (and) Bureau of Highways Dept. of Transportation 60 Washington St. Hartford, Conn. 06115	Highway Associate Engineer 203-249-5211 Ext. 349
Bridgeport	Tri-State Transportation Commission 100 Church Street, Room 1806 New York, New York 10007	Executive Director 212-433-4210
Meriden	See Bridgeport	
New Haven	See Bridgeport	
Norwalk	See Bridgeport	
Stamford	See Bridgeport	
Waterbury	See Bridgeport	
DELAWARE		
Wilmington	New Castle County Land Use and Transportation Planning Program 4613 Robert Kirkwood Highway Wilmington, Delaware 19808	Director 302-WY-8-0156

*Now incorporated in the Office of State Planning.

TABLE IV.2 (Continued)

<u>Urbanized Area</u>	<u>Name and Address of Program</u>	<u>Title of Key Official</u> <u>Telephone Number</u>
DISTRICT OF COLUMBIA		
District of Columbia	National Capital Regional Transporta- tion Planning Program Transportation Planning Board Washington Metropolitan Council of Governments 1225 Connecticut Avenue, N.W. Washington, D.C. 20036	Technical Director 202-223-6800
MARYLAND		
Baltimore	Baltimore Metropolitan Area Transportation Study Maryland State Road Commission P. O. Box 717 Baltimore, Maryland 21203	Chief, Urban Transportation Planning 301-828-8900
MASSACHUSETTS		
Boston	Eastern Massachusetts Regional Planning Project Massachusetts Department of Public Works Transportation Center 80 Broad Street Boston, Massachusetts 02108	Project Director 617-482-3410
Brockton	Eastern Massachusetts Regional Planning Project (See BOSTON)	(See BOSTON)
Fall River	Southeastern Massachusetts Area Transportation Study Bureau of Transportation Planning and Development Massachusetts Department of Public Works 100 Nashua Street Boston, Massachusetts 02114	Director, Bureau of Transportation, Planning and Development 617-727-5120
Fitchburg- Leominster	Fitchburg-Leominster Area Trans- portation Study Bureau of Transportation Planning and Development Massachusetts Department of Public Works (See FALL RIVER)	(See FALL RIVER)

TABLE IV.2 (Continued)

<u>Urbanized Area</u>	<u>Name and Address of Program</u>	<u>Title of Key Official Telephone Number</u>
Lawrence- Haverhill	Eastern Massachusetts Regional Planning Project (See BOSTON)	(See BOSTON)
Lowell	Eastern Massachusetts Regional Planning Project (See BOSTON)	(See BOSTON)
New Bedford	Southeastern Massachusetts Area Transportation Study (See FALL RIVER)	(See FALL RIVER)
Pittsfield	Pittsfield Area Transportation Study Bureau of Transportation Planning and Development Massachusetts Department of Public Works 100 Nashua Street Boston, Massachusetts 02114	(See FALL RIVER)
Springfield- Chicopee- Holyoke	Springfield Area Transportation Study Bureau of Transportation Planning and Development Massachusetts Department of Public Works 100 Nashua Street Boston, Massachusetts 02114	(See FALL RIVER)
Worcester	Worcester Area Transportation Study Bureau of Transportation Planning and Development Massachusetts Department of Public Works 100 Nashua Street Boston, Massachusetts 02114	(See FALL RIVER)
NEW JERSEY		
Atlantic City	Atlantic City Urban Area Transporta- tion Study New Jersey Department of Transportation 1035 Parkway Avenue Trenton, New Jersey 08625	Supervising Engineer Bureau of Urban Planning 609-292-3294

TABLE IV.2 (Continued)

<u>Urbanized Area</u>	<u>Name and Address of Program</u>	<u>Title of Key Official Telephone Number</u>
NEW JERSEY (con't)		
Trenton	Delaware Valley Regional Planning Commission 9th Floor, Penn Square Building 1317 Filbert Street Philadelphia, Pennsylvania 19107	Executive Director 215-568-3211
Vineland- Millville- Bridgeton	Division of Planning New Jersey Department of Transportation 1035 Parkway Avenue Trenton, New Jersey 08625	Director, Highway Planning 609-292-3160
NEW YORK		
Albany- Schenectday- Troy	Capital District Transportation Study Subdivision of Transportation Planning and Programming New York Department of Public Works 1220 Washington Avenue Albany, New York 12226	Director 518-457-2320
New York	Tri-State Transportation Commission 100 Church Street, Room 1806 New York, New York 10007	Executive Director 212-433-4210
PENNSYLVANIA		
Allentown- Bethlehem	Lehigh Valley Transportation Study Pennsylvania Department of Highways Highway and Safety Building State Capitol Group Harrisburg, Pennsylvania 17120	Transportation Study Technical Coordinator 717-787-2186
Harrisburg	Harrisburg Area Transportation Study Pennsylvania Department of Highways (See Above)	(See Above)
Lancaster	Lancaster Area Transportation Study Pennsylvania Department of Highways (See Above)	(See Above)

TABLE IV.2 (Continued)

<u>Urbanized Area</u>	<u>Name and Address of Program</u>	<u>Title of Key Official</u> <u>Telephone Number</u>
Philadelphia	Delaware Valley Regional Planning Commission 9th Floor, Penn Square Building 1317 Filbert Street Philadelphia, Pennsylvania 19107	Executive Director 215-568-3211
Reading	Reading Area Transportation Study Pennsylvania Department of Highways Highway and Safety Building State Capitol Group Harrisburg, Pennsylvania 17120	Transportation Study Technical Coordinator 717-787-2186
York	York Area Transportation Study Pennsylvania Department of Highways Highway and Safety Building State Capitol Group Harrisburg, Pennsylvania 17120	(See Above)
RHODE ISLAND		
Providence- Pawtucket	Rhode Island Statewide Planning Program 36 Kennedy Plaza, Suite 300 Providence, Rhode Island 02903	Director 401-521-7100, Ext. 656

Source: Visitations to State and Local transportation agencies,
March - April 1969 by OHS GT and Consultant Staff; and
"Directory - Urbanized Area Transportation Planning
Programs", U.S. Department of Transportation, Federal
Highway Administration, Bureau of Public Roads, May 1968

TABLE IV.3

STATE AVIATION AGENCIESCONNECTICUT

Bureau of Aeronautics
Dept. of Transportation
60 Washington St.
Hartford, Connecticut 06115

DELAWARE

Delaware Aeronautics Commission
Dept. of Transportation
704 Delaware Avenue
Wilmington, Delaware 19809

MARYLAND

State Aviation Commission
of Maryland
State Office Building
301 W. Preston Street
Baltimore, Maryland 21201

MASSACHUSETTS

Massachusetts Aeronautics
Commission
Boston-Logan Airport
Boston, Massachusetts 02128

NEW HAMPSHIRE

New Hampshire Aeronautics
Commission
P. O. Box 237
Concord, New Hampshire 03302

NEW JERSEY

Division of Aeronautics
Dept. of Transportation
1035 Parkway Ave.
Trenton, New Jersey 08625

NEW YORK

Bureau of Aviation
New York State Dept. of
Transportation
1220 Washington Ave.
Albany, New York 12226

PENNSYLVANIA

Pennsylvania Aeronautics
Commission
Harrisburg State Airport
New Cumberland, Pa. 17070

RHODE ISLAND

Division of Aeronautics
T. F. Green State Airport
Warwick, R. I. 03886

VIRGINIA

Division of Aeronautics
Corporation Commission
Room 909, Blanton Building
Richmond, Virginia 23219

DISTRICT OF COLUMBIA

Bureau of National Capital
Airports
900 S. Washington Street
Falls Church, Virginia

APPENDIX TABLE A

NORTHEAST CORRIDOR ANALYSIS DISTRICTS

State	District	County (or City)	Code
MD	011	Calvert, St. Mary's	011
MD	012	Charles	012
MD	013	Montgomery	013
MD	014	Prince Georges	014
DC	015	(Washington)	015
VA	016	Arlington, Fairfax, (Alexandria) Falls	016
VA	017	Cheney	017
VA	018	Fairfax	018
VA	019	Prince William	019
VA	020	Stafford	020
DC	021	Kent	021
MD	022	Lansdowne	022
MD	023	Caroline, Talbot	023
MD	024	Dorchester	024
MD	025	Prince Georges	025
MD	026	Prince Georges	026
MD	027	Prince Georges	027
MD	028	Prince Georges	028
MD	029	Prince Georges	029
MD	030	Prince Georges	030
MD	031	Prince Georges	031
MD	032	Prince Georges	032
MD	033	Prince Georges	033
MD	034	Prince Georges	034
MD	035	Prince Georges	035
MD	036	Prince Georges	036
MD	037	Prince Georges	037
MD	038	Prince Georges	038
MD	039	Prince Georges	039
MD	040	Prince Georges	040
MD	041	Prince Georges	041
MD	042	Prince Georges	042
MD	043	Prince Georges	043
MD	044	Prince Georges	044
MD	045	Prince Georges	045
MD	046	Prince Georges	046
MD	047	Prince Georges	047
MD	048	Prince Georges	048
MD	049	Prince Georges	049
MD	050	Prince Georges	050
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MD	052	Prince Georges	052
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MD	077	Prince Georges	077
MD	078	Prince Georges	078
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MD	081	Prince Georges	081
MD	082	Prince Georges	082
MD	083	Prince Georges	083
MD	084	Prince Georges	084
MD	085	Prince Georges	085
MD	086	Prince Georges	086
MD	087	Prince Georges	087
MD	088	Prince Georges	088
MD	089	Prince Georges	089
MD	090	Prince Georges	090
MD	091	Prince Georges	091
MD	092	Prince Georges	092
MD	093	Prince Georges	093
MD	094	Prince Georges	094
MD	095	Prince Georges	095
MD	096	Prince Georges	096
MD	097	Prince Georges	097
MD	098	Prince Georges	098
MD	099	Prince Georges	099
MD	100	Prince Georges	100

APPENDICES

APPENDIX TABLE A

NORTHEAST CORRIDOR ANALYSIS DISTRICTS

Market Area	Super District Code	District Code	County (or City)	State
Washington	01	011	Calvert, St. Marys	Md.
		012	Charles	Md.
		013	Montgomery	Md.
		014	Prince Georges	Md.
		015	(Washington)	D.C.
		016	Arlington, Fairfax, (Alexandria) (Falls Church)	Va.
		017	Fauquier	Va.
		018	Loudoun	Va.
		019	Prince William, Stafford	Va.
Baltimore	02	021	Kent	Del.
		022	Sussex	Del.
		023	Caroline, Talbot	Md.
		024	Dorchester	Md.
		025	Kent	Md.
		026	Queen Annes	Md.
		027	Somerset	Md.
	03	028	Wicomico	Md.
		029	Worcester	Md.
		031	Anne Arundel	Md.
		032	Baltimore	Md.
		033	(Baltimore)	Md.
		034	Carroll	Md.
		035	Frederick	Md.
Philadelphia	04	036	Harford	Md.
		037	Howard	Md.
		041	New Castle	Del.
	05	042	Cecil	Md.
		043	Salem	N.J.
		051	Atlantic	N.J.
	06	052	Cape May	N.J.
		053	Cumberland	N.J.
		054	Ocean	N.J.
	07	061	Chester	Pa.
		062	Delaware	Pa.
	08	071	Philadelphia	Pa.
		081	Burlington	N.J.
		082	Camden	N.J.
		083	Gloucester	N.J.

APPENDIX TABLE A, CONT.

Market Area	Super District Code	District Code	County (or City)	State
Trenton	{ 09	{ 091	Bucks	Pa.
		{ 092	Montgomery	Pa.
		{ 101	Mercer	N.J.
Newark	{ 11	{ 111	Hunterdon	N.J.
		{ 112	Middlesex	N.J.
		{ 113	Monmouth	N.J.
		{ 114	Somerset	N.J.
	{ 12	{ 121	Essex	N.J.
		{ 122	Morris	N.J.
		{ 123	Sussex	N.J.
		{ 124	Union	N.J.
	{ 16	{ 161	Bergen	N.J.
		{ 162	Hudson	N.J.
		{ 163	Passaic	N.J.
New York	{ 13	{ 131	Richmond	N.Y.
		{ 141	Kings	N.Y.
	{ 14	{ 142	Queens	N.Y.
		{ 151	Nassau	N.Y.
	{ 15	{ 152	Suffolk	N.Y.
		{ 171	Bronx	N.Y.
	{ 17	{ 172	New York	N.Y.
		{ 181	Dutchess	N.Y.
	{ 18	{ 182	Orange	N.Y.
		{ 183	Putnam	N.Y.
		{ 184	Rockland	N.Y.
		{ 185	Westchester	N.Y.
New Haven	{ 19	{ 191	Fairfield	Conn.
		{ 201	New Haven	Conn.
	{ 21	{ 211	Middlesex	Conn.
		{ 212	New London	Conn.
		{ 213	Tolland	Conn.
		{ 214	Windham	Conn.
Hartford/ Springfield	{ 25	{ 251	Litchfield	Conn.
		{ 261	Hartford	Conn.
	{ 27	{ 271	Berkshire	Mass.
		{ 272	Franklin	Mass.
		{ 273	Hampden	Mass.
		{ 274	Hampshire	Mass.

APPENDIX TABLE A, CONT.

Market Area*	Super District Code	District Code	County (or City)	State
Providence	22	221	Bristol	R.I.
		222	Kent	R.I.
		223	Newport	R.I.
		224	Providence	R.I.
		225	Washington	R.I.
	23	231	Bristol	Mass.
		232	Plymouth	Mass.
		241	Barnstable	Mass.
	24	242	Dukes	Mass.
	28	243	Nantucket	Mass.
		281	Worcester	Mass.
Boston	29	291	Essex	Mass.
		292	Middlesex	Mass.
		293	Norfolk	Mass.
		294	Suffolk	Mass.
*No market areas determined for fringe portions of the Corridor.	51	511	Norfolk, Princess Anne, (Norfolk), (Portsmouth), (South Norfolk), (Virginia Beach)	Va.
		512	Nansemond, (Suffolk)	Va.
		513	Isle of Wight, Southampton	Va.
		514	Greensville, Surry, Sussex	Va.
	52	521	James City, York, (Hampton), (Newport News), (Williamsburg)	Va.
		531	Chesterfield, Hanover, Henrico, (Colonial Heights), (Petersburg), (Richmond)	Va.
	53	532	Dinwiddie, Prince George, (Hopewell)	Va.
		533	Charles City, King William, New Kent	Va.
	54	541	Caroline	Va.
		542	Essex, King and Queen	Va.
		543	Gloucester, Mathews, Middlesex	Va.
		544	Spotsylvania, (Fredericksburg)	Va.

APPENDIX TABLE A, CONT.

Market Area*	Super District Code	District Code	County (or City)	State
*No market areas determined for fringe portions of the Corridor.	55	551	Accomack, Northampton	Va.
		561	King George	Va.
	56	562	Lancaster, Northumberland	Va.
		563	Richmond, Westmoreland	Va.
		571	Adams	Pa.
		572	Cumberland	Pa.
		573	Dauphin	Pa.
	57	574	Lancaster	Pa.
		575	Lebanon	Pa.
		576	Perry	Pa.
		577	York	Pa.
		581	Warren	N.J.
	58	582	Berks	Pa.
		583	Lehigh	Pa.
		584	Northampton	Pa.
		591	Columbia	N.Y.
	59	592	Greene	N.Y.
		593	Sullivan	N.Y.
		594	Ulster	N.Y.
		601	Albany	N.Y.
	60	602	Rensselaer	N.Y.
		603	Saratoga	N.Y.
		604	Schenectady	N.Y.
		611	Cheshire	N.H.
		612	Hillsborough	N.H.
	61	613	Merrimack	N.H.
		614	Rockingham	N.H.
		615	Strafford	N.H.

APPENDIX B

TRANSPORTATION MILESTONES IN THE NORTHEAST CORRIDOR

<u>DATE</u>		<u>HIGHWAY TRANSPORTATION</u>
October	1931	George Washington Bridge opened
	1940	Merritt Parkway completed
December	1950	Port Authority Bus Terminal in New York opened
August	1951	Delaware Memorial Bridge opened
January	1952	New Jersey Turnpike completed
July	1952	Chesapeake Bay Bridge opened
December	1955	Tappan Zee Bridge opened
May	1956	Garden State Parkway completed
January	1957	Route 128 Boston largely completed
May	1957	Mass. Turnpike completed - New York - Weston, Mass.
August	1957	Connection between New York Thruway and Garden State Parkway completed
November	1957	Baltimore Harbor Tunnel opened
January	1958	Connecticut Turnpike completed
October	1958	New England Section of New York State Thruway opened
January	1961	Throgs Neck Bridge opened
January	1962	Woodrow Wilson Bridge (Washington) opened
June	1962	Callahan Tunnel (Boston) opened
July	1962	Baltimore Beltway completed
August	1962	George Washington Bridge double decked

TRANSPORTATION MILESTONES IN THE
NORTHEAST CORRIDOR

(Continued)

<u>DATE</u>	<u>HIGHWAY TRANSPORTATION</u>
January 1963	Cabin John Bridge (Washington) opened
November 1963	Kennedy Memorial Highway (I-95) in Delaware and Maryland opened
April 1964	Chesapeake Bay Bridge-Tunnel opened
November 1964	Verrazano-Narrows Bridge opened
December 1964	Washington Beltway completed
February 1965	Mass. Turnpike Extension - Weston to South Station opened
July 1965	Atlantic City Expressway completed
December 1965	I-95 Boston-Providence opened
June 1969	Lower deck of Verrazano - Narrows Bridge opened providing 14 lanes
June 1969	Newport Bridge across Narragansett Bay opened

AIR TRANSPORTATION

	1926	Teterboro Airport opened
October	1928	Newark Airport opened
June	1936	Douglas DC-3 entered service
December	1939	LaGuardia Airport opened
June	1940	Philadelphia International Airport opened
February	1946	Lockheed Constellation entered service
	1946	Logan Airport created from Boston Airport
July	1948	Kennedy International (Idlewild) Airport opened
July	1950	Friendship Airport opened
April	1951	Douglas DC-6B entered service
July	1953	New York Airways inaugurated helicopter service between New York Airports
November	1953	Douglas DC-7 entered service
February	1956	Convair 440 entered service
October	1958	Turbo jet airplane (Boeing 707) entered service
January	1959	Lockheed Electra entered service
April	1961	Eastern inaugurated shuttle service, New York-Boston, New York-Washington
November	1962	Washington Dulles Airport opened

February	1964	Boeing 727 entered service
April	1965	BAC-111 entered U.S. service
November	1965	Douglas D-C 9 entered service
April	1966	Washington National Airport opened to 2 and 3 engined jet planes
June	1969	Peak hour restrictions on the number of operations imposed at National, LaGuardia, Newark and Kennedy Airports

RAILROAD TRANSPORTATION

January	1899	South Station, Boston opened
November	1907	Union Station, Washington, D.C. opened
	1907	Grand Central Terminal rebuilt from old Grand Central Station
November	1907	Penn Station, New York and Manhattan Tunnels opened
	1914	New Haven electrification completed, New York to New Haven
March	1917	Hell Gate Bridge completed providing rail connection through New York
	1931	First air-conditioned passenger cars on Pennsylvania Railroad
	1933	Pennsylvania Railroad electrification completed, New York to Paoli and Wilmington
March	1933	30th Street Station, Philadelphia opened
	1938	All Pennsylvania Railroad electrification completed (to Harrisburg and Washington)
May	1953	Route 128 Station (Boston) opened
April	1958	Baltimore and Ohio abandoned passenger service north of Baltimore
January	1963	Chesapeake and Ohio took over control of Baltimore and Ohio
February	1968	Pennsylvania Railroad and New York Central merged to form Penn Central

January 1969

New Haven included in Penn
Central merger

January 1969

High speed rail service between
Washington and New York inau-
gurated with one round trip
per day (Metroliner)

April 1969

Turbine powered train service
inaugurated between New York
and Boston with one round trip
per day

APPENDIX C

PASSENGER TRAVEL IN THE UNITED STATES

<u>YEAR</u>	<u>PASSENGER MILES-BILLIONS</u>				<u>NUMBER OF PASSENGERS-MILLIONS</u>		
	<u>AUTO</u>	<u>AIR</u>	<u>BUS</u>	<u>RAIL</u>	<u>AIR</u>	<u>BUS</u>	<u>RAIL</u>
1950	438.3	9.3	22.7	32.5	17.5	338.5	209.1
1951	498.1	12.0	23.6	35.3	22.7	336.1	214.3
1952	539.2	13.3	24.7	34.7	25.2	311.3	209.0
1953	575.8	16.2	24.4	32.3	28.9	292.6	200.9
1954	597.1	18.2	22.0	29.5	32.5	256.6	189.5
1955	637.4	21.7	21.9	28.7	38.2	237.8	183.6
1956	669.7	23.9	21.7	28.6	41.9	224.4	181.5
1957	670.5	26.3	21.5	26.3	45.2	212.4	162.0
1958	684.9	26.4	20.8	23.6	44.7	188.0	139.8
1959	687.4	30.5	20.4	22.4	51.0	191.2	129.8
1960	706.1	31.7	19.9	21.6	52.4	187.7	122.7
1961	713.6	32.3	19.7	20.5	52.7	187.5	118.1
1962	735.9	34.8	21.3	20.2	56.0	186.1	117.2
1963	765.9	39.4	22.5	18.6	63.9	185.1	114.5
1964	801.8	45.5	23.3	18.4	73.0	185.8	114.8
1965	817.7	53.7	23.8	17.6	84.5	193.4	106.3
1966	856.4	63.7	24.6	17.3	97.7	203.2	105.3
1967	889.8	80.2	24.2	15.3	118.7	207.3	98.1
1968 ⁽¹⁾	931.0	93.0	24.5	13.2	134.5	199.0	92.6

(1) Preliminary

Source: Transportation Facts and Trends, Transportation Association of America, April 1969.

APPENDIX D

Appendix D contains miscellaneous graphics and tables which relate to specific characteristics of individual modes.

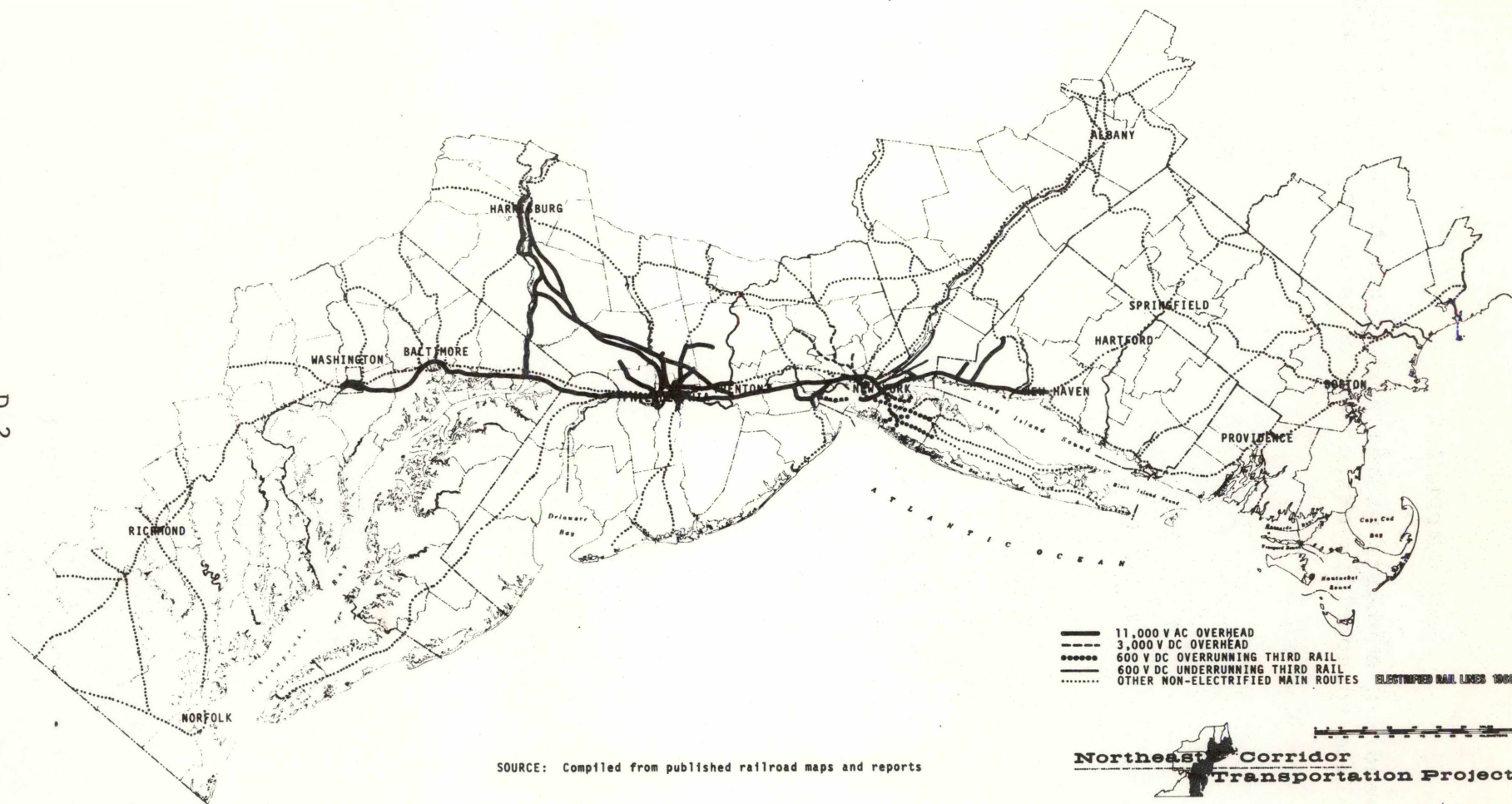
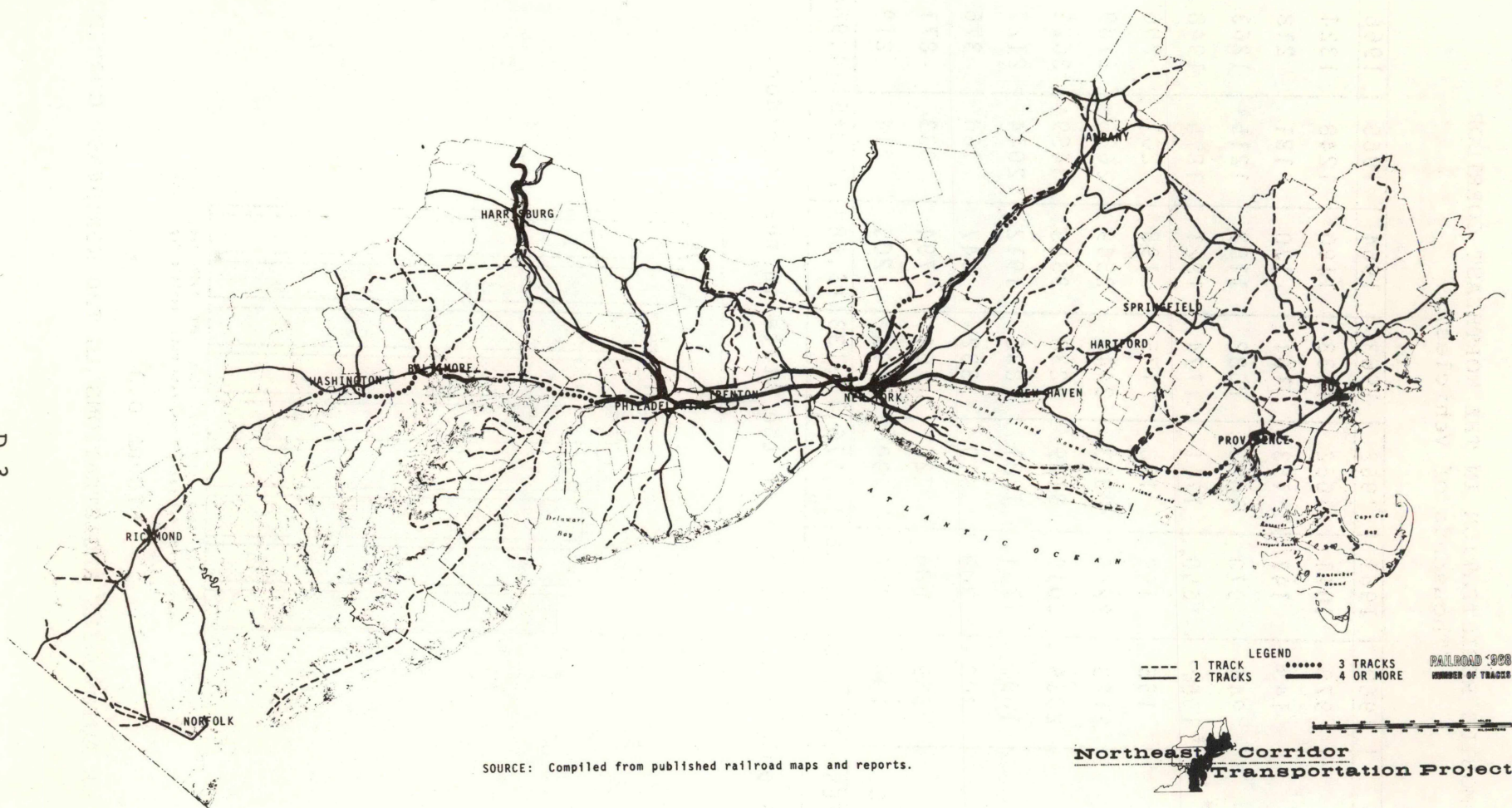


FIGURE D.1
ELECTRIFIED RAIL LINES - 1968

D.3



SOURCE: Compiled from published railroad maps and reports.

FIGURE D.2
NUMBER OF RAILROAD TRACKS - 1968

TABLE D.1

AUTOMOBILE REGISTRATION IN THE NORTHEAST CORRIDOR
(Thousands of Vehicles)

STATE	1960	1961	1962	1963	1964	1965	1966	1967
CONNECTICUT	979	1011	1062	1133	1190	1248	1324	1390
DELAWARE	143	147	153	161	170	181	218	229
MARYLAND*	944	970	1023	1082	1152	1215	1263	1305
MASSACHUSETTS	1567	1660	1711	1774	1821	1875	1948	2000
NEW HAMPSHIRE*	155	169	170	175	195	201	206	207
NEW JERSEY	2123	2248	2313	2440	2549	2686	2789	2842
NEW YORK*	2939	3019	3129	3238	3353	3489	3623	3727
PENNSYLVANIA*	1695	1731	1781	1836	1912	2044	2127	2200
RHODE ISLAND	303	309	319	332	347	360	376	388
VIRGINIA*	659	686	725	764	794	833	871	897
WASHINGTON, D.C.	185	186	190	198	205	214	219	219
TOTAL NEC STATES	11,692	12,136	12,576	13,133	13,688	14,346	14,964	15,404

* Includes only that portion of the state in the Corridor.

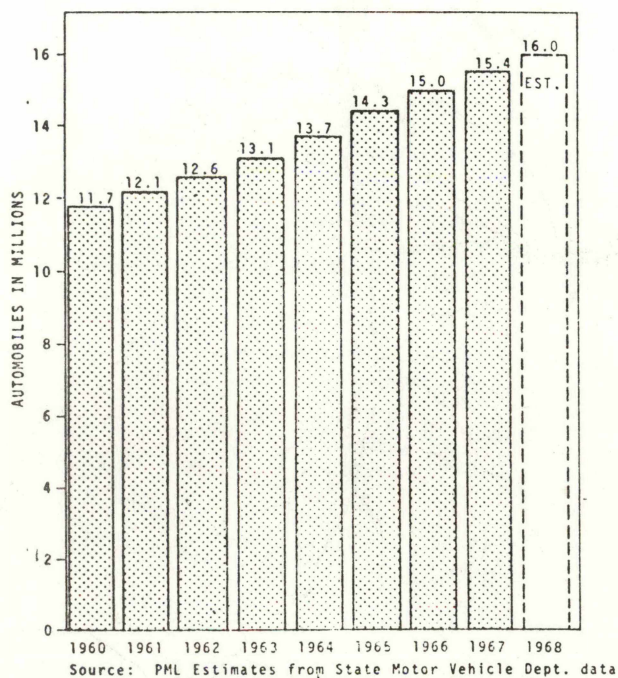


FIGURE D.3

PASSENGER AUTOMOBILE REGISTRATIONS IN THE NORTHEAST CORRIDOR

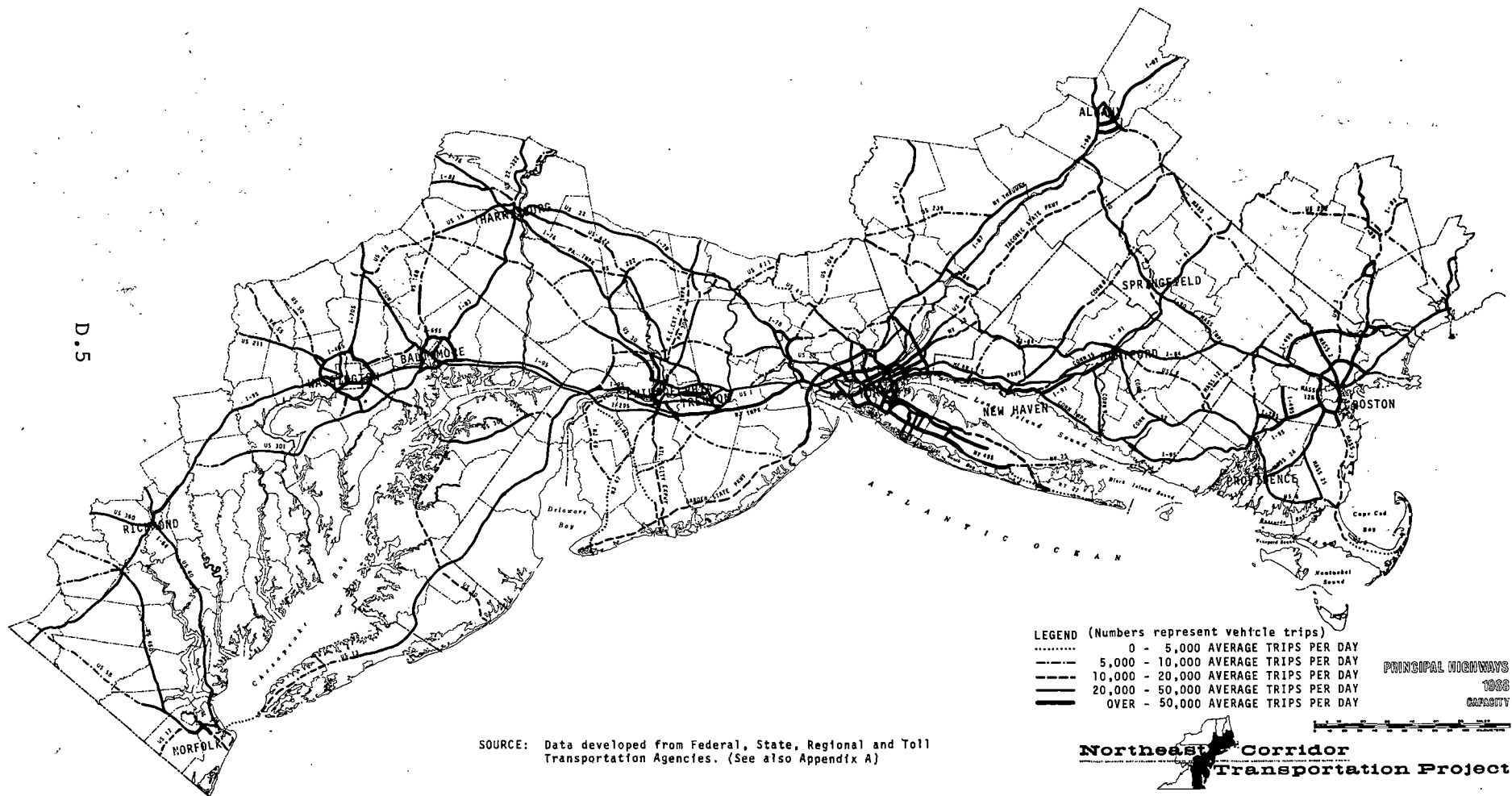


FIGURE D.4
CAPACITY OF PRINCIPAL HIGHWAYS - 1968

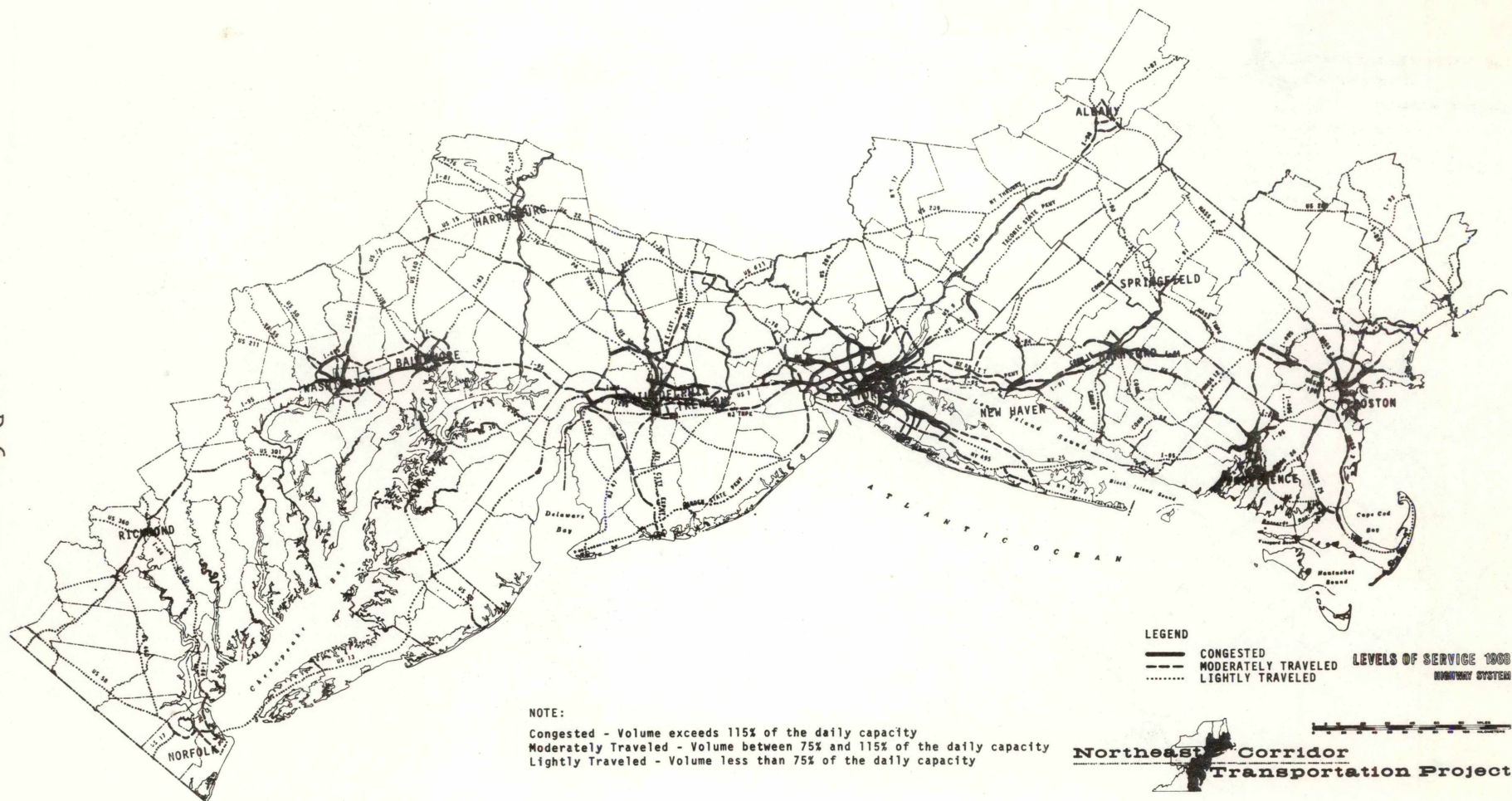


FIGURE D.5
 LEVELS OF HIGHWAY SERVICE - 1968

TABLE D.2

ORIGIN OF PASSENGERS DEPARTING BY AIR FROM N.Y. AIRPORTS
(Excludes Transfer Passengers and Overseas Flights)

Origin County		La Guardia	J. F. Kennedy	Newark
Residents		47%	49%	49%
Non-Residents		53%	51%	51%
Total		100%	100%	100%
Metropolitan Area		97%	94%	89%
Counties East District of Hudson		94%	86%	41%
	No.			
Manhattan	172	60	46	33
Bronx	171	2	3	1
Brooklyn	141	4	7	2
Queens	142	9	9	1
Nassau	151	9	9	1
Suffolk	152	2	2	0
Westchester	185	6	6	2
Fairfield, Conn.	191	2	4	1
Counties West of Hudson		3%	8%	48%
Bergen, N.J.	161	2	2	10
Passaic, N.J.	163	0	1	8
Morris, N.J.	122	0	1	8
Hudson, N.J.	162	0	1	3
Essex, N.J.	121	0	1	3
Union, N.J.	124	0	1	4
Somerset, N.J.	114	0	0	3
Middlesex, N.J.	112	0	0	4
Monmouth, N.J.	113	0	1	2
Orange, N.Y.	182	0	0	1
Rockland, N.Y.	184	0	0	1
Richmond, N.Y.	131	0	0	1
Outside Metro. Area		3%	6%	11%
		100%	100%	100%

Source: "New York's Domestic Air Passenger Market", P.A.N.Y., May 1965. In-flight surveys, on Domestic Flights only, performed April 1963 and March 1964.

TABLE D.3

ORIGIN OR DESTINATION OF DOMESTIC AIRLINE PASSENGERS
DEPARTING FROM AND ARRIVING AT WASHINGTON-BALTIMORE AIRPORTS

Origin County	N.E.C. District No.	Dulles	National	Friendship
Metropolitan Area		98.3	97.8	94.2
<u>Virginia Counties</u>		32.7	26.3	7.6
Prince William	19	1.5	0.7	0.2
Fairfax	16	19.4	14.6	4.2
Loudoun	18	0.7	0.2	0
Arlington	16	11.1	10.8	3.2
<u>District of Columbia</u>		44.2	47.6	10.8
<u>Maryland Counties</u>		21.4	23.9	75.8
Prince Georges	14	4.4	5.6	7.1
Montgomery	13	14.1	12.8	9.2
Frederick	35	0.4	0.3	0.4
Harford	36	0.3	0.3	4.5
Carrol	34	0.1	0	0.6
Howard	37	0.2	0.2	2.0
Anne Arundel	31	0.9	1.4	9.6
Baltimore	32	0.3	1.5	19.0
City of Balt.	33	0.7	1.8	23.4
Outside Study Area		1.7	2.2	5.8
		100.0%	100.0%	100.0%
Passenger Originations and Arrivals per day				
Survey (December 1966)		2,700	17,200	5,400
Average for 1966 (F.A.A.)		3,300	21,000	5,300

Survey taken over 6 days (Monday through Saturday), December 1965.

Source: "Washington-Baltimore Airport Access Survey", Department of Transportation, May 1968

TABLE D.4

ORIGIN OF PASSENGERS DEPARTING BY AIR FROM
PHILADELPHIA INTERNATIONAL AIRPORT
(1967 Average Weekday)

<u>Origin County</u>	<u>District No.</u>	<u>Average Weekday Air Passengers</u>	<u>Percent of Total</u>
Philadelphia County	071	5,096	33.8%
(Philadelphia CBD)*	071	(2,408)	(16.0)
Montgomery County	092	2,100	13.9
Delaware County	062	1,777	11.8
Bucks County	091	438	2.9
Chester County	061	<u>323</u>	<u>2.1</u>
Subtotal		9,734	64.5%
Camden County	082	890	5.9%
Burlington County	081	354	2.4
Gloucester County	083	124	0.8
Mercer County	101	<u>93</u>	<u>0.6</u>
Subtotal		1,461	9.7%
Other Pennsylvania Areas		1,508	10.0%
Other New Jersey Areas		1,100	7.3
Other Delaware Areas		820	5.4
Other Areas		<u>470</u>	<u>3.1</u>
Subtotal		3,898	25.8%
TOTAL		15,093	100.0%

* Included in Philadelphia County total of 5,096.

Samples taken November 1967 by in-flight survey. Place of residence not included.

Source: "Ground Transportation to Philadelphia International Airport - Now to 1992", by Simpson & Curtin, July 1968.

**PUBLISHED REPORTS**

by the

Office of High Speed Ground Transportation

and the

Northeast Corridor Transportation Project

Department of Transportation

October 1969

This bibliography presents and abstracts 174 major research reports published by the Office of High Speed Ground Transportation and the Northeast Corridor Transportation Project in the Department of Transportation. These reports represent results of contracted research and development, systems engineering, transportation surveys, and model development, along with intramural research reports and program summaries.

Technical Categories

The abstracts have been arranged according to the 26 technical categories listed below. Where a report is pertinent to more than one category, secondary entries (without abstracts) are made which refer the reader to the primary field containing the abstract.

<u>Field Number</u>	<u>Technical Category</u>
01	Air Transportation Systems
02	Analytic Methods and Computer Applications
03	AutoTrain Systems
04	Highway Systems
05	Bibliographies
06	Cargo Movement
07	Communication and Control
08	Continuous Capacity Systems
09	Conventional Rail Systems
10	Economics, Finance and Cost
11	Guideways and Structures
12	Human Factors Engineering
13	Legal and Socio-economic Impact Factors
14	Multi-Modal Systems
15	Planning and Management
16	Program Summary Reports
17	Propulsion, Power, and Energy
18	Rolling/Sliding Systems
19	Routes and Routing
20	Scheduling and Travel Demand

- 21 Suspension and Support
- 22 Technology Requirements, Surveys, and Projections
- 23 Terminals, Terminal Selection, and Terminal Access
- 24 Tracked Levitated Systems
- 25 Tube Vehicle Systems
- 26 Tunnels and Tunneling

As of this printing, three technical categories (fields 8, 14, and 18) contain no entries. These categories, however, represent major OHS GT program areas and will be used in future bibliographies.

Personal Author Index

Each OHS GT/NECTP report can be found under the name of the principal scientific investigator(s) on the specific project. Investigators/authors are listed alphabetically. The numbers one through 26 refer to the technical categories as listed above.

Accession/Report Number Index

The accession number (PB prefix) is assigned by the Department of Commerce-Clearinghouse for Federal Scientific and Technical Information which prepared this bibliography for OHS GT. Prefixes other than PB refer to individual contractor reporting systems. Technical category field numbers are listed for reference purposes.

Availability

Any of the listed reports can be ordered by accession number and title directly from: The Department of Commerce, Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151. Unit prices are \$3.00 for paper copy and \$0.65 for microfiche. Prepayment is required by the Clearinghouse.

Office of High Speed Ground Transportation
Federal Railroad Administration
Department of Transportation
October 1969

PUBLISHED REPORTS

01. AIR TRANSPORTATION SYSTEMS

FEASIBILITY AND COST OF EXPANDED INTERCITY AIR SERVICE IN THE WASHINGTON-BOSTON CORRIDOR.

Systems Analysis and Research Corp., Boston, Mass.
1963, 199P

This study has been undertaken in connection with the general program of the Under Secretary of Commerce for Transportation, U. S. Department of Commerce, to evaluate the present and future needs of the Washington-Boston Corridor for intercity passenger services and facilities. The study is concerned specifically with air transport services and facilities and is primarily directed to providing the preliminary foundation for a judgment as to what kinds of additions to and improvements of airports, airway system, and aircraft will best meet the needs of the intercity air passenger market, in 1980, in the Washington-Boston area.
PB-166 883

A SYSTEMS ANALYSIS OF SHORT HAUL AIR TRANSPORTATION.

Massachusetts Inst. of Tech., Cambridge. Flight Transportation Lab.
Aug 65, 499p Technical rept. TR-65-1
Contract C-85-65
Rept. on Proj. Transport, pt-3 Northeast Corridor Transportation.
Identifiers: Northeast Corridor, Short haul air transportation.

The study is concerned with the potentials of air transportation in the 1970-80's as related to the transportation demands in the Northeast Corridor. A complete systems analysis was undertaken, including the determination of optimum vehicle characteristics, estimation of future direct operating costs, management information requirement scheduling and ground facilities, leading to an estimate of the indirect costs of operating a short haul air system, and the possible fares and travel times. The total system capital investment in vehicles, terminals, navigation equipment, maintenance facilities, etc., was estimated. Current values in 1965 dollars were used in this report. Advanced concepts of engines, aircraft and computer technologies anticipated for the 1970-80 period were taken into consideration in the analysis. (Author)
PB-169 521

OPERATING COST ESTIMATES FOR LONG-HAUL SUB-SONIC JET AIRCRAFT.

Planning Research Corp., Los Angeles, Calif.
Ann C. Harvey, and Harold D. Orenstein. 11 Feb 66, 62p PRC-R-804A
Contract SD-274

The study contains a series of estimating equations for determining the operating costs for large four-engine jet aircraft. Designed for jet transport aircraft these equations apply to the present day high speed, sub-sonic variety such as the Douglas DC-8 and the Boeing 707. Because these aircraft were designed for long flight segments, the equations characteristically yield optimal results under these service conditions. The equations are developed for a typical flight distance of 1455 miles domestically and 1980 miles internationally. The equations are generally applicable to other flight distances but in certain instances tend to be less reliable for short segments.
PB-170 691

ANALYSIS OF VSTOL AIRCRAFT CONFIGURATIONS FOR SHORT HAUL AIR TRANSPORTATION SYSTEMS.

Technical rept.,
Massachusetts Inst. of Tech., Cambridge. Flight Transportation Lab.
Robert A. Gallant, M. Scully, and W. Lange. Nov 66, 182p FT-66-1
Contracts C-136-66, C-85-65

The report has investigated the effects of further refinements to the computer programs as used for determining the vehicle characteristics and hence direct operating costs (DOC). Studies of the stowed rotor continue to show this aircraft to be a competitive configuration with DOCs of the same order as those of the helicopter at ranges above 50 miles. Unknown problems associated with stopping, retracting and stowing the rotor continue to make the prediction of the actual DOC of these vehicles difficult. The sensitivity of the results to these assumptions is discussed in the body of the report. An investigation of the effects of multiple hops, typical of a line haul type operation as compared to a shuttle type operation over a given stage length indicated that the average DOC was not appreciably affected by the multiple stop operation when compared with an aircraft operating over the same shorter distance.
PB-174 912

COMPUTERIZED SCHEDULE CONSTRUCTION FOR AN AIRLINE TRANSPORTATION SYSTEM.

Massachusetts Inst. of Tech., Cambridge. Flight Transportation Lab.
For primary bibliographic entry see Field 20.
PB-174 913

MAINTENANCE COST STUDIES OF PRESENT AIRCRAFT SUBSYSTEMS.

Technical rept.,
Massachusetts Inst. of Tech., Cambridge. Flight Transportation Lab.
C. Pearlman, and Robert W. Simpson. Nov 66, 107p FT-66-2
Contracts C-136-66, C-85-65

The report describes two detailed studies of actual maintenance costs for present transport aircraft. The first part describes maintenance costs for jet transport aircraft broken down into subsystem costs according to an ATA classification. From 90 airlines polled, only four were able to supply costs in this breakdown. Despite the lack of data, multiple regression techniques were then used to demonstrate the construction of cost estimating formulae for both subsystems and a total aircraft system. The results indicate the possibility of improving present methods of estimating maintenance costs. The second part of this report discusses actual maintenance costs for the rotor and transmission systems of present commercial helicopters. (Author)
PB-174 914

WEATHER CONDITIONS AFFECTING VTOL AIRBUS OPERATIONS IN THE NORTHEAST CORRIDOR.

Technical rept.,
Massachusetts Inst. of Tech., Cambridge. Flight Transportation Lab.
Robert W. Simpson. Dec 66, 44p FT-66-4
Contracts C-136-66, C-865-65

A detailed study of hourly weather observations in the Northeast Corridor during the periods 0600-2400 for a ten year period 1944-1958 was made to study the implications of weather affecting the operations of a VSTOL Airbus transportation system. As a result, specifications for an automatic approach to a hover ending at 75 feet above ground, and within 350 feet visibility were determined to achieve weather reliable operations of over 99.5 percent throughout the year. Examination of high temperatures indicated that a criterion of operation at 95 F at 1000 feet elevation should be used to ensure 99.5 percent reliability through the summer months over the corridor. The frequency of high winds indicated that a step gust of 30 mph could be used for specifying the aircraft's displacement from a hover position while under an inertially stabilized automatic control system. The study indicates that Category II all weather operations occur about 0.9 percent of the time, and Category III about 1.3 percent of the time in the Northeast Corridor. (Author)
PB-174 915

APPLICATION OF THE CALCULUS OF VARIATIONS IN DETERMINING OPTIMUM FLIGHT PROFILES FOR COMMERCIAL SHORT HAUL AIRCRAFT.

Technical rept.,
Massachusetts Inst. of Tech., Cambridge. Flight Transportation Lab.
Robert A. Gallant. Dec 66, 93p FT-66-5
Contract C-136-66

The method of steepest descent of the calculus of variations is used to determine the optimal flight profile of a hypothetical tilt wing aircraft traveling a distance of 50 miles. Direct operating cost, (as derived from the ATA formulation) is minimized using aircraft lift coefficient and power as control variables each with upper and lower limits. Only the portion of the flight from the end of transition to the beginning of retransition was considered, with both initial and final values of velocity, flight path angle, and altitude specified. The results show that full power is used to accelerate and to climb at a speed about twice the value for maximum rate of climb. At 12,000 feet, power is reduced to flight idle and a high speed, power off glide is made to destination. A rapid deceleration is made at low altitude to achieve the specified conditions for retransition. While the optimal profiles for velocity, altitude, and power are greatly different from the nominal profiles chosen to design the aircraft, the optimal trip cost of \$30.54 is only slightly less than the nominal trip cost of \$31.60. (Author)
PB-174 952

WASHINGTON-BALTIMORE AIRPORT ACCESS SURVEY. VOLUME I.

Abt Associates, Inc., Cambridge, Mass.
For primary bibliographic entry see Field 23.
PB-179 573

WASHINGTON-BALTIMORE AIRPORT ACCESS SURVEY. VOLUME II. BASIC TABULATION.

Abt Associates, Inc., Cambridge, Mass.
For primary bibliographic entry see Field 23.
PB-179 574

WASHINGTON-BALTIMORE AIRPORT ACCESS SURVEY. VOLUME III. A CASE STUDY.

Abt Associates, Inc., Cambridge, Mass.
For primary bibliographic entry see Field 23.
PB-179 575

WASHINGTON-BALTIMORE AIRPORT ACCESS SURVEY. VOLUME IV. DATA PROCESSING USERS MANUAL.

Abt Associates, Inc., Cambridge, Mass.
For primary bibliographic entry see Field 23.
PB-179 576

A MULTI-REGRESSION ANALYSIS OF AIRLINE INDIRECT OPERATING COSTS.

Massachusetts Inst. of Tech., Cambridge. Flight Transportation Lab.
N. K. Taneja, and Robert W. Simpson. Jun 68, 119p FTL-R67-2
Contract C-136-66
Identifiers: Indirect costs, Operating costs.

A multiple regression analysis of domestic and local airline indirect costs was carried out to formulate cost estimating equations for airline indirect costs. The costs were broken down into the classification of the uniform system of accounts Form 41, used by the airlines in reporting to the CAB. Thus regression equations were found for annual system expenses and annual station expenses. A stepwise regression technique is used to select the best combinations of independent variables for the equations. The independent variables were data such as revenue passenger miles, passengers enplaned, revenue aircraft miles, total revenue aircraft departures, etc. (Author)
PB-183 012

Field 01—AIR TRANSPORTATION SYSTEMS

A METHOD FOR DETERMINATION OF OPTIMUM VEHICLE SIZE AND FREQUENCY OF SERVICE FOR A SHORT HAUL V/STOL AIR TRANSPORT SYSTEM,

Massachusetts Inst. of Tech., Cambridge. Flight Transportation Lab.
Robert W. Simpson, and M. J. Neuve Eglise. May 68, 44p FTL-R68-1
Contract C-136-66
Identifiers: Short haul air transport systems.

To compete successfully in short haul markets under 200 miles, an air transport system must offer a high daily frequency of service, N , as well as short air travel times. In a given market, N can be increased by using vehicles of smaller seat capacity, C , which are more expensive per seat to operate. A method of determining optimal values of N and C for assumed market behavior in terms of fare and time elasticities is presented. (Author)
PB-183 013

SOME FLEET ROUTING AND SCHEDULING PROBLEMS FOR AIR TRANSPORTATION SYSTEMS,

Massachusetts Inst. of Tech., Cambridge. Flight Transportation Lab.
Amos Levin. Jan 69, 130p FTL-R68-5
Contract C-136-66

The purpose of the work is to formulate and develop practicable solution methods to some important fleet routing, scheduling and fleet composition problems. These problems arise in the operation of air transportation systems like the operating domestic and international airlines. The minimal single fleet problem is extended to include some extraneous constraints on service frequencies between and at stations. Computational results with examples are provided. The problem of system design with and without a given fleet size is formulated. The problem of decomposition of the system into subsystems, each consisting of a single vehicle type is also formulated in several ways for several considerations. (Author)
PB-183 014

DYNAMIC SCHEDULING IN AIRLINE OPERATIONS,

Massachusetts Inst. of Tech., Cambridge. Flight Transportation Lab.
For primary bibliographic entry see Field 20.
PB-183 474

02. ANALYTIC METHODS AND COMPUTER APPLICATIONS

A SYSTEMS ANALYSIS OF SHORT HAUL AIR TRANSPORTATION,

Massachusetts Inst. of Tech., Cambridge. Flight Transportation Lab.
For primary bibliographic entry see Field 1.
PB-169 521

TRANSIM -- GENERAL PURPOSE TRANSPORTATION SYSTEM SIMULATOR -- USER'S MANUAL,

University of California at Los Angeles, Dept. of Engineering.
May 66, 231p Rept. no. 66-6
Contract Cc-6220
See PB-173 017 for the IBM-1401 and 7090/7094 punched cards.

The TRANSIM transportation simulator was developed at the University of California, Los Angeles, to fill the need for a general-purpose computer simulation method which is simple and economical to use for a wide variety of problems in transportation; these may concern different modes, traffic types, firm sizes, or system situations. The User's Manual describes the simulator and delineates the procedures for its use. The User's Manual also discusses topics of more general interest, such as the concept of the systems approach,

and the difference between mathematical models and computer simulators such as TRANSIM.
PB-173 016

DESIGN FOR IMPACT STUDIES: NORTHEAST CORRIDOR TRANSPORTATION PROJECT,

CONSAD Research Corp., Pittsburgh, Pa.
For primary bibliographic entry see Field 13.
PB-173 484

OPERATIONS ANALYSIS OF SYSTEM SPECIFICATIONS. PART I. PASSENGER SCHEDULING,

Massachusetts Inst. of Tech., Cambridge. Dept. of Civil Engineering.
For primary bibliographic entry see Field 20.
PB-173 635

OPTIMAL DISPATCHING POLICIES BY DYNAMIC PROGRAMMING,

Massachusetts Inst. of Tech., Cambridge. Dept. of Civil Engineering.
For primary bibliographic entry see Field 7.
PB-173 636

ORGANIZATION OF SYSTEM CONTROL,

Massachusetts Inst. of Tech., Cambridge. Electronic Systems Lab.
For primary bibliographic entry see Field 7.
PB-173 641

COMPUTERIZED SCHEDULE CONSTRUCTION FOR AN AIRLINE TRANSPORTATION SYSTEM,

Massachusetts Inst. of Tech., Cambridge. Flight Transportation Lab.
For primary bibliographic entry see Field 20.
PB-174 913

IMPACT STUDIES: NORTHEAST CORRIDOR TRANSPORTATION PROJECT. VOLUME I. BACKGROUND, OVERVIEW, AND SUMMARY,

CONSAD Research Corp., Pittsburgh, Pa.
For primary bibliographic entry see Field 13.
PB-176 478

TRANSPORTATION SYSTEM OPTIMIZATION PROGRAM DEMONSTRATION PROBLEM,

TRW Systems Group, Washington, DC. Washington Operations.
1 Jun 68, 98p* 06818-W917-R000
Contract C-353-66
Report on High Speed Ground Transportation System Engineering Studies Program.

The report describes the application of a computerized methodology to the analysis of a representative ground transportation system. The preferred design and performance characteristics of a tracked air cushioned vehicle system were determined in order to minimize the cost per passenger mile. The vehicle-guideway system was mathematically represented by a set of simultaneous, nonlinear, algebraic equations. This description was combined with a cost accounting model and structured for solution on a digital computer. Results were obtained for parametrically varied system performance levels. (Author)
PB-178 797

SYSTEM FOR SURVEYING REGIONAL TRAVEL. VOLUME I: PROPOSED METHOD FOR SELECTION OF SURVEY SITES FOR A COORDINATED AIR, AUTO, BUS AND RAIL TRAVELER SURVEY IN THE NORTHEAST CORRIDOR,

Peat, Marwick, Livingston and Co., Washington, D.C.
For primary bibliographic entry see Field 20.
PB-182 217

SYSTEM FOR SURVEYING REGIONAL TRAVEL. VOLUME II: PROPOSED SAMPLE DESIGN AND SURVEY PROCEDURES FOR A COORDINATED AIR, AUTO, BUS AND RAIL TRAVELER SURVEY IN THE NORTHEAST CORRIDOR,

Abt Associates, Inc., Cambridge, Mass.
For primary bibliographic entry see Field 20.
PB-182 218

IMPACT STUDIES: NORTHEAST CORRIDOR TRANSPORTATION PROJECT. VOLUME III: PHASE II. MODELLING EFFORTS,

CONSAD Research Corp., Pittsburgh, Pa.
For primary bibliographic entry see Field 13.
PB-182 722

SIMULATION ANALYSIS OF A HIGH SPEED GROUND TRANSPORTATION SYSTEM,

Thesis,
Massachusetts Inst. of Tech., Cambridge. Dept. of Naval Architecture and Marine Engineering.
Michael Allen Crane. Sep 68, 231p 68-20
Contract C-136-66
Sponsored in part by the National Science Foundation, Washington, D.C.
Identifiers: Area planning and development, Rapid transit systems.

A ground transportation system is considered which includes as its proposed operating characteristics: real-time dispatching of trips according to passenger demand; travel from origin to destination without intermediate stops for the purpose of passenger exchange; travel through a network of links and nodes, with constant-speed travel on each link; minimum headway constraints for each link resulting in capacity limits and possible interference between trips; and the possible coupling of vehicles, for more efficient use of channel capacity and reduced propulsion costs. Quantitative measures of cost and utility are developed as criteria for a comparative analysis of operating policies and design parameters. Overall system utility is postulated as an approximate function of a worst-case level of passenger service and a partition-weighted mean measure of service level. Cost impacts are characterized in terms of vehicle size and a measure reflecting fleet size and vehicle-hours of operation. An event-ordered simulation model representing the transportation system is described in some detail. It is used together with the cost-utility relationships in determining policies and parameters such as vehicle size, fleet size, dispatching policy and vehicle coupling policy. Some consideration is given also to the design of train formation policies and vehicle inventory control policies. (Author)
PB-183 156

ENGINEERING DESIGN STUDY OF ACTIVE RIDE STABILIZER FOR THE DEPARTMENT OF TRANSPORTATION'S HIGH-SPEED TEST CARS,

Westinghouse Research Labs., Pittsburgh, Pa.
For primary bibliographic entry see Field 21.
PB-185 008

03. AUTO TRAIN SYSTEMS

TRAIN AUTO FERRY OPERATIONS,

Final rept.,
Whitten (Herbert O.) and Associates, Washington, DC.
Herbert O. Whitten. Apr 66, 158p
Availability: Original document in color until exhausted. A summary of present and proposed concepts and recommendations for a demonstration project.

The idea of moving passengers and their automobiles by train from a point of origin to a common destination is examined. This report discusses past and present attempts to put this idea into practice; analyzes potential costs and prices for such service if operated in this country; and makes recommen-

datations for a proposed demonstration project of such service.
PB-170 798

INVESTIGATION OF CAR FERRY SERVICE FOR HIGH SPEED GROUND TRANSPORTATION.

Association of American Railroads, Chicago, Ill.
Jul 66, 72p
Contract C-240-66- (N)

The report presents the results of an over-the-road investigation for determining the ride characteristics of automobiles and passengers on railroad cars incorporating three different truck suspension systems. The three rail cars used for this investigation are as follows: a tri-level auto rack car loaded with four automobiles on a freight type suspension, an end-door baggage car loaded with two automobiles on a six-wheel semi-soft suspension and a passenger coach on a four-wheel soft suspension system. One test auto on each car was instrumented and carried an instrumented simulated passenger in the drivers seat, also, a simulated passenger was placed in the coach. Test results show the tri-level rack car experienced the highest loadings and that the acceleration frequency range (0.85 to 5.00 cps) falls in the same bandwidth of 0.55 to 5.00 cps in all measured planes for the other two cars. In general, acceleration frequency appears to increase slightly with train speed, but did not exceed 5.00 cps. To design a car for its intended purpose, the truck suspension system, car body structural characteristics, and height of center of gravity of the loaded car, appear to be the areas for main consideration.
PB-173 513

UNITED STATES DEPARTMENT OF COMMERCE AUTO-ON-TRAIN PROJECT EQUIPMENT PREVIEW.

Klauder (Louis T.) and Associates, Philadelphia, Pa.
2 Aug 66, 33p

The train will be designed to offer passenger train comfort, conveniences, and speed to the occupants of any of the common types of automobiles, including sedans, the various coupe models, and station wagons (except Volkswagen's 'Microbus'). Van and camper models in general cannot be accommodated on account of their height. In effect, the passenger brings his own seat aboard when he drives on and no other general seating is proposed. The situation is analogous to a drive-in theater.
PB-174 307

AN INVESTIGATION OF THE RIDE QUALITY OF AUTO-TRAIN SERVICE,

Office of High-Speed Ground Transportation, Washington, DC.
Kenneth B. Ullman. Nov 67, 51p

The ride quality in automobiles carried aboard enclosed, airsprung railcars traveling over conventional rail roadbeds was determined. Evaluation of the data indicates that railcars transporting automobiles with their passengers could be built with minimal securement systems and could provide a ride of good quality. Two test automobiles were inserted inside an air-sprung railcar, equipped with instrumented dummies, and transported a total of 2200 rail miles during which ride vibrations and passenger reactions were recorded. The testing included alterations to the automobiles' suspension systems and different types of trackwork. Ride quality was also determined on highways using the same instrumentation. The data was analyzed by a combination of manual and automated methods. Acceleration distribution functions and frequency spectra were generated with a digital computer. (Author)
PB-176 044

DYNAMIC SIMULATION OF AUTO AND PASSENGER RAIL TRANSPORTS.

Final rept. 8 Sep 66-22 Mar 67,
IIT Research Inst., Chicago, Ill.
R. R. Robinson. Jan 68, 179p*
Contract DT-7-35086
Identifiers: FORTRAN, Auto ferrying, Degrees of freedom.

A method of analysis and computer program was developed to generate dynamic response solutions for a bilevel auto ferry rail transport car. The analysis views the auto ferry as a system of rigid bodies interconnected by suspension system components, which include linear and nonlinear springs and rubber bumpers, bilinear rotary shock absorbers, etc. The rigid bodies consist of the rail car structure, front and rear trucks, each automobile carried (from 0 to 8) and a front and rear seat passenger in each auto. The rail suspension system is based on an air sprung truck system. The auto suspension system is based on a representative late model automobile. Five degrees of freedom are considered for the majority of the rigid bodies. The sixth degree of freedom is a prescribed function of time, equal to the current train velocity. Initially, the rail car and its contents are assumed to be traveling at constant longitudinal velocity in the equilibrium configuration. A Runge-Kutta numerical integration technique has been employed for the solution of this initial value rigid body system. (Author)
PB-180 132

A FEASIBILITY ANALYSIS FOR AUTO-ON-TRAIN SERVICE BETWEEN WASHINGTON, D.C. AND JACKSONVILLE, FLORIDA.

Center for Advanced Administrative Research, Inc., Boca Raton, Fla.
George Horton. 1967, 96p
Identifiers: Auto on train service, Interviews, Tourism, Jacksonville (Florida).

The study examines the potential market for automobile-on-train passenger service between Washington, D. C. and Jacksonville, Florida. The methodology employed in gaining information is discussed in detail. Indications are that the number of those willing to pay \$100 or more per one-way trip between Washington, D. C. and Jacksonville, Florida, is about 14 times the capacity of a 10-car (78 autos) train making 2 round trips each 3 days.
PB-182 122

04. HIGHWAY SYSTEMS

A PROJECTION OF TECHNOLOGY APPLICABLE TO THE FUTURE HIGHWAY SYSTEM OF THE BOSTON-WASHINGTON CORRIDOR.

Cornell Aeronautical Lab., Inc., Buffalo, NY.
For primary bibliographic entry see Field 22.
PB-166 878

HIGHWAY TRAVEL IN WASHINGTON, NEW YORK, BOSTON MEGALOPOLIS,

Smith (Wilbur) and Associates, New Haven, Conn.
Wilbur S. Smith. 15 Nov 63, 176p
See also PB-166 878.

A mathematical model was developed and tested for synthesizing current highway travel patterns in the corridor on an intercity basis. Such factors as population, vehicle registration, conventional land use, economic levels, employment, and specific major generators of intercity travel were included.
PB-166 881

05. BIBLIOGRAPHIES

LITERATURE SURVEY OF PASSENGER COMFORT LIMITATIONS OF HIGH-SPEED GROUND TRANSPORTS,

United Aircraft Corp., East Hartford, Conn.
Research Labs.

For primary bibliographic entry see Field 12.
PB-168 171

LITERATURE SURVEY ON THE COMMAND AND CONTROL OF HIGH-SPEED GROUND ORIENTED TRANSPORTATION SYSTEMS.

Hughes Aircraft Co., Fullerton, Calif. Transportation Research Project Office.
For primary bibliographic entry see Field 7.
PB-170 561

BIBLIOGRAPHY OF HIGH SPEED GROUND TRANSPORT. PART IA.

Massachusetts Inst. of Tech., Cambridge.
15 Oct 65, 86p
Contract C-85-65
See also PB-168 648, -169 121.
PB-170 581

PARTIAL BIBLIOGRAPHY ON SUBJECTS RELATED TO ACTIVE VIBRATION ISOLATION AND ACTIVE VEHICLE SUSPENSIONS,

Massachusetts Inst. of Tech., Cambridge. Engineering Projects Lab.
For primary bibliographic entry see Field 21.
PB-173 649

SUPPLEMENT TO SURVEY OF TECHNOLOGY IN FLUID SUSPENSIONS: PATENT SEARCH AND EFFECTS OF FORWARD SPEED,

Massachusetts Inst. of Tech., Cambridge. Engineering Projects Lab.
For primary bibliographic entry see Field 21.
PB-173 653

06. CARGO MOVEMENT

INTERCITY FREIGHT TRANSPORTATION REQUIREMENTS OF THE WASHINGTON-BOSTON CORRIDOR IN 1980.

Final rept.
United Research, Inc., Cambridge, Mass.
Nov 63, 243p
Contract Cc6224

The purpose of this research is to study the intercity freight transportation requirements of the Washington-Boston Corridor in 1980, and the improvements required in transporting commodities through and within the corridor by land, water and air. The study objectives are (1) to estimate in terms of traffic flows, the current total demand for intercity freight commodity transportation existing in the corridor; (2) to describe in qualitative terms the commodities making up these traffic flows; (3) to show how the current demand for commodity freight transportation is being met today; (4) to identify and establish a relationship between significant economic and sociological factors and levels of transportation demand; (5) to identify significant changes in these relationships which may occur in the future as a result of technological innovation; (6) to project the economic and sociological demand factors in 1980; (7) to forecast for 1980, total intercity freight transportation demand (as expressed in terms of traffic flows); (8) to allocate this total commodity flow to the various modes on the basis of foreseeable intermodal competitive relationships; (9) to identify and describe the economic and technical characteristics of the various ways and vehicles which may be made available to freight carriers by 1980; and (10) to describe the methodology by which the cost and technical characteristics of ways and vehicles could be related to possible future demand characteristics.
PB-166 885

STUDIES ON THE DEMAND FOR FREIGHT TRANSPORTATION, VOL. 1.

Mathematica, Princeton, NJ.
For primary bibliographic entry see Field 20.
PB-176 479

WIND TUNNEL TESTS OF A SCALE MODEL RAILROAD AUTOMOBILE RACK CAR,
Office of High-Speed Ground Transportation,
Washington, D. C.
For primary bibliographic entry see Field 9.
PB-180 198

ECONOMICS OF RAILROAD AUTOMOBILE RACK CAR AERODYNAMIC DRAG,
Office of High-Speed Ground Transportation,
Washington, D. C.
For primary bibliographic entry see Field 9.
PB-183 845

07. COMMUNICATION AND CONTROL

LITERATURE SURVEY ON THE COMMAND AND CONTROL OF HIGH-SPEED GROUND ORIENTED TRANSPORTATION SYSTEMS.
Hughes Aircraft Co., Fullerton, Calif. Transportation Research Project Office.
Mar 66, 56p FR-66-11-65
Revision of FR65-11-281.
PB-170 561

OPTIMAL DISPATCHING POLICIES BY DYNAMIC PROGRAMMING.
Research rept.,
Massachusetts Inst. of Tech., Cambridge. Dept. of Civil Engineering.
Donald Evan Ward. 1 Nov 66, 102p R66-55
Contract C-85-65

The paper describes methods of determining optimal vehicle dispatching schedules by the use of dynamic programming techniques. Using cost criteria based on minimizing a combination of passenger delay and system capacity, these techniques were applied to vehicle scheduling for three variations of linear networks of dispatching stations: point-to-point (one way), line of stations (one way), and two-station line (round trip). FORTRAN programs were written to aid in both the generation and analysis of the optimal schedules. Various dispatching policies are examined with respect to system parameters such as vehicle capacity, load factor, and fleet size. An analysis and comparison of the optimal schedules in terms of passenger delay and vehicle fleet size are made with some non-optimal schedules similar to those used in many present-day operations. Optimal schedules yielding minimum passenger delay are shown to be superior with respect to most other system variables. The value of dynamic programming in these and future scheduling studies is discussed. (Author)
PB-173 636

ON THE OPTIMAL AND SUBOPTIMAL POSITION AND VELOCITY CONTROL OF A STRING OF HIGH-SPEED MOVING TRAINS,
Massachusetts Inst. of Tech., Cambridge. Electronic System Lab.
Michael Athans, William S. Levine, and Alexander H. Levis. Nov 66, 73p
Contract C-85-65
Rept. on Project Transport.

The study was motivated by the interest in developing a high-speed ground-transport (HSGT) system for the Northeast Corridor. The report contains general methods for controlling the spacing, velocity, and acceleration of individual vehicles in a tightly-packed string of high-speed trains. The control of vehicles moving in a string can be divided into four functions: The control of the starting and stopping operations; The injection and ejection of vehicles from the main guideway; The normal operation of a string of vehicles (far from stations) at essentially constant velocity and separation; and the control in emergency situations. (Author)
PB-173 640

ORGANIZATION OF SYSTEM CONTROL,
Massachusetts Inst. of Tech., Cambridge. Electronic Systems Lab.
R. W. Brockett, and R. J. Canales. Nov 66, 25p
Contract C-85-65

In the report a general method of designing control laws for very complex systems is described. A particular multipoint scheduling problem which has potential application in the operation of a high-speed ground transportation system is given to illustrate the approach. The basic assumption made is that the system to be controlled is so complex that mathematical optimization, even with the aid of a high-speed computer, is either impossible or too expensive—an assumption that holds even for relatively simple scheduling problems. Of course this assumption implies that the optimization problem must be divided into smaller parts and a sub-optimal solution sought. By the development of precise lower bounds on the performance of the system it is possible, however, to obtain an estimate of how close to optimal the system is. This leads to the definition of a performance ratio which characterizes the efficiency of the control system and provides what should be a very useful design parameter. (Author)
PB-173 641

HEADWAY AND SWITCHING STRATEGIES FOR AUTOMATED VEHICULAR GROUND TRANSPORTATION SYSTEMS.
Massachusetts Inst. of Tech., Cambridge. Engineering Projects Lab.
Michael Bick Godfrey. 1 Nov 66, 170p
Contract C-85-65

The report considers the distribution of headways throughout the vehicle flow on a one-lane guideway, the splitting of such a flow at a diverging switch, and the merging of two such flows at a converging switch. The focus of the investigation was on several vehicles near a single switch, rather than on the entire system as an integrated entity. The minimum headway separating two isolated vehicles or trains is shown to be a function of time delays in information transmission and processing, uncertainties in the measurement of, and errors in, kinematic variables, emergency stopping distance, and a cost criterion pertaining to reliability and expected damage. Several alternative headway distributions among vehicles in single-lane flow are presented, and maximum flow rates are computed as functions of these strategies and system performance parameters. The propagation of velocity transients is discussed in terms of responses to the probable inputs to a single-line of traffic. It is shown that controlling headways to a single-valued function of velocity leads to undesirable responses, and that headways must include some space in excess of the minimum safe headway. In addition to the minimum headway strategies, there is a presentation of several possible merging strategies for a converging switch and of queue disciplines to yield either maximum or minimum queue lengths. (Author)
PB-173 644

ANALYSIS OF OPTIMUM AND PREVIEW CONTROL OF ACTIVE VEHICLE SUSPENSIONS,
Massachusetts Inst. of Tech., Cambridge. Engineering Projects Lab.
For primary bibliographic entry see Field 21.
PB-176 137

OPTIMAL VEHICLE CONTROL FOR THE MERGING PROBLEM,
Massachusetts Inst. of Tech., Cambridge. Electronic Systems Lab.
Michael Athans, and William S. Levine. Nov 67, 30p ESL-R-327
Contract C-85-65

The report deals with the problem of the control of high-speed vehicles so that safe merging from two guideways into a single one takes place. The theory

of optimal control is used to analyze the problem. Two main results are obtained: first, the optimal control of the vehicles is obtained for any given merging sequence and second, the best possible merging sequence is obtained. (Author)
PB-176 921

SAMPLED-DATA CONTROL OF HIGH-SPEED TRAINS,
Massachusetts Inst. of Tech., Cambridge. Electronic Systems Lab.
Alexander H. Levis, and Michael Athans. Jan 68, 56p* ESL-R-339
Contract C-85-65

The report deals with the control of the positions and velocities of high-speed vehicles in a single guideway. It is assumed that each and every train measures its position and velocity every T seconds. The appropriate accelerations or decelerations to be applied to each vehicle are constrained to be constant during the sampling interval. Through the use of a control costs functional, which penalizes the system for any deviations from the desired headway and velocity, the required control accelerations and decelerations are obtained by deriving the system equations in discrete-time and, through the use of available results in the theory of discrete optimal control, the optimal linear time-invariant sampled-data feedback control system is determined. The general results, as well as the general purpose digital computer programs, are presented and are used to study the effect of changing the sampling time T upon the control-system performance. Since, in general, the cost of the communication system (in terms of required channel capacity, bandwidth, etc.) decreases with increasing values of the sampling time, the system designer has the capability of conducting trade-off studies involving the deterioration of the control system performance vs. the decrease in the cost of communication as the sampling time is increased. (Author)
PB-177 669

USE OF SURFACE WAVES IN COMMUNICATION WITH HIGH SPEED VEHICLES.
Technical rept.,
Institute for Telecommunication Sciences, Boulder, Colo.
R. L. Gallawa, W. M. Beery, T. M. Chu, K. R. Cook, and R. G. FitzGerrell. 15 Jun 68, 155p*
Prepared in cooperation with Department of Transportation, Washington, DC. Office of High Speed Ground Transportation.

The potential use of surface waves in communicating with and controlling high speed ground vehicles has been under study. Consideration was given to the Goubau line or G-line in particular, and it was found that it has many attractive features. The various facets considered include launching, line characteristics, coupling to the moving vehicle, and communication capacity. It appears that the use of surface waves shows great promise in providing the bandwidth and economy required to meet the communication demands of the high speed ground transportation problem. (Author)
PB-178 794

FEASIBILITY STUDY OF COUPLED LEAKY WAVEGUIDE SYSTEM FOR COMMUNICATION IN HIGH SPEED GROUND TRANSPORTATION.
Technical rept.,
Sumitomo Electric Industries, Ltd., Osaka (Japan). Tsuneo Nakahara, Taichiro Nagao, Noritaka Kurauchi, Ken-ichi Yoshida, and Hiroshi Kitani. 31 Oct 68, 77p
Contract DT-3-0212
Identifiers: Leaky waveguides, Leaky wave antennas, High speed ground transportation, Rapid transit systems.

The use of a coupled leaky waveguide system for high speed ground transportation communication

was studied and found to be feasible. The coupled leaky waveguide system has leaky circular waveguides along the track and a coupling antenna on the trains. Basic properties of the leaky circular waveguides were determined theoretically. The coupling was estimated based on earlier experiments. The FDM-FM system was shown to be applicable to the modulation and multiplex requirement of the system. Basic structure and signal level diagrams were presented for the proposed coupled leaky waveguide system. The unwanted radiation levels were estimated in comparison with the FCC restrictions. The interference on this system was also estimated. (Author)
PB-180 750

09. CONVENTIONAL RAIL SYSTEMS

POSSIBLE IMPROVEMENTS TO RAILROAD PASSENGER SERVICE BETWEEN NEW YORK AND WASHINGTON.
Preliminary engineering rept., Klauder (Louis T.) and Associates, Philadelphia, Pa.
Louis T. Klauder. 1 Jun 64, 135p
Contract Cc6238
Rept. on Washington-Boston Corridor Research Proj.

Studies are made of the possible service improvements on the Pennsylvania Railroad between Washington, D. C. and New York, N. Y. to provide in greater depth an analysis of the operational aspects of such service, the required alterations to existing facilities, and the equipment design features, as well as calculations of the cost of improvements and improved operations between these two cities.
PB-166 879

POSSIBLE IMPROVEMENTS TO RAILROAD PASSENGER SERVICE BETWEEN NEW YORK AND WASHINGTON.
Supplemental engineering rept. Klauder (Louis T.) and Associates, Philadelphia, Pa.
12 Jun 64, 123p
Contract Cc6238
Rept. on Washington-Boston Corridor Research Proj. Supplemental rept. to preliminary rept. dated 1 Jan 64.

The possibility and the cost of establishing two and one-half hour passenger service between New York and Washington was studied, using the tracks of the Pennsylvania Railroad. The results of that study were presented in a 'Preliminary Engineering Report on Possible Improvements to Railroad Passenger Service Between New York and Washington,' dated June 1, 1964 (PB-166 879). In this report the possibility and cost of establishing two and one-quarter and two-hour service between these same two cities are studied.
PB-166 880

WASHINGTON-BOSTON TRANSPORTATION STUDY. PART B. FEASIBILITY AND COST OF IMPROVED RAILROAD SERVICE.
Final rept., MRD Div., General American Transportation Corp., Niles, Ill.
Andrew A. Arentz, Jr., Fred W. Sander, and Richard E. Pages. Nov 63, 228p
Contract Cc6207

Conclusions: A large portion of the total intercity passenger market in 1980 in the Washington-Boston corridor can be effectively and economically served by improved railroad service. To serve the 1980 market, major improvement of existing rail systems does not appear to be economically feasible. The most promising long-range solution to the 1980 corridor problem is a new high-speed high-frequency railriding auto ferry. An immediate

improvement of the present rail systems in the corridor should be made with the object of achieving efficient, dependable, and economical operations. This improvement should be in the lower improved-speed ranges contemplated in the study and should be compatible with the structures of the railroads as they already exist. It should also be predicted on new comfortable equipment that will be consonant with future local and commuter requirements.
PB-166 886

HIGH-SPEED RAILROAD OPERATIONS WITHIN THE NEW YORK METROPOLITAN AREA IN CONNECTION WITH HIGH-SPEED SERVICE BETWEEN WASHINGTON, DC AND BOSTON, MASSACHUSETTS,
Bingham (S. H.), New York.
S. H. Bingham. 15 Nov 63, 156p
Rept. on Research Project.

One of the main objectives was the determination of the limits to high-speed operation imposed by existing rail route alignments and profiles, based upon studies of existing railroad valuation track maps. These studies were translated into the charted changes, presented herein, which would permit minimum train speeds of 100 miles per hour. In addition to this, four alternate routes were studied to develop alignments which give promise of greater speed capabilities within the area. All the routes studied, including two which are not compatible with conventional rail operations, are shown in a Map.
PB-166 887

BUFFETING TESTS ON THE HUDSON TUBE.
Stanford Research Inst., Menlo Park, Calif.
For primary bibliographic entry see Field 10.
PB-168 647

HIGH-SPEED GROUND TRANSPORTATION RESEARCH AND DEVELOPMENT: A PRELIMINARY APPRAISAL.
Office of the Under Secretary for Transportation (Commerce), Washington, DC. Transportation Research Staff.
1965, 69p

The study is concerned primarily with the technological progress of the railroad industry.
PB-168 782

THE NORTHEAST CORRIDOR REGION: MAIN LINE RAIL PASSENGER SERVICE IN THE SOUTHERN SECTION, 1947-1963,
Maryland Univ., College Park.
George M. Smerk. 1963, 125p
Research performed for Office of the Under Secretary of Commerce for Transportation, Washington, DC.

The Northeast Corridor region of the United States, often referred to in recent times as Megalopolis, is that portion of the country lying along the eastern seaboard which stretches in a northeasterly direction from the northern counties of Virginia in the Washington, DC, Metropolitan Area, to several counties in the southeastern portion of the state of New Hampshire. The focus of this study is confined to main-line rail passenger service in the southern section of the Northeast Corridor. That is, to be more precise, the area south from New York City to Washington, DC, and west to Harrisburg, Pennsylvania.
PB-169 214

PRELIMINARY ENGINEERING REPORT ON POSSIBLE IMPROVEMENTS TO RAILROAD PASSENGER SERVICE BETWEEN NEW YORK AND BOSTON.
Klauder (Louis T.) and Associates, Philadelphia, Pa.
15 Nov 65, 191p

Rept. on US Dept. of Commerce Northeast Corridor Transportation Proj.

The purpose of this report is to set forth the changes and additions which might be made in order to reduce the travel time between New York and Boston to 2-1/2 hours, 2-3/4 hours, or 3 hours. In the study of 3-hour travel time top speeds of both 125 mph and 150 mph are considered. In studies of 2-3/4 hour travel time two possibilities are considered: first that the improvements to the right-of-way necessary to reduce the travel time to 2-3/4 hours might be made between New Haven and Providence where the costs are relatively modest, and, second, that these improvements might be made between New York and New Haven where the costs are considerably higher.
PB-169 907

A CALCULATION OF THE LATERAL HUNTING MOTION OF A TRACKED VEHICLE,
Massachusetts Inst. of Tech., Cambridge. Engineering Projects Lab.
Masakazu Iguchi. 1 Nov 66, 27p DSR-76109-5
Contract C-85-65

The lateral hunting motion of a vehicle running on tracks is not only prejudicial to riding comfort, but may also cause dangerous derailment. The initial step in the design of a safe high-speed train is a theoretical and experimental investigation of this lateral hunting motion and a practical method of preventing it. The usual railroad train may be idealized as a system consisting of a number of cars connected end to end like links of a chain. The transfer-matrix technique purports to be applicable to such a system, whereby once the transfer matrices of each component (car) are derived, it is only necessary to perform successive matrix multiplications to fit the entire system. It is demonstrated that the transfer matrix method may be applied successfully in a study of lateral hunting motion. The stability problem associated with this motion, and forced vibrations caused by irregularities and lateral distortions in the rails may also be investigated by the use of the transfer-matrix technique. (Author)
PB-173 652

HYDRAULIC ANALOGY STUDY OF WAVES IN TUNNELS.
Massachusetts Inst. of Tech., Cambridge. Engineering Projects Lab.
For primary bibliographic entry see Field 26.
PB-173 657

STUDY BY HYDRAULIC ANALOGY OF THE PASSAGE OF HIGH-SPEED TRAINS THROUGH TUNNELS.
Massachusetts Inst. of Tech., Cambridge. Engineering Projects Lab.
J. M. Mills, and D. G. Wilson. 15 Dec 67, 52p
Contract C-85-65

When a train enters a tunnel, an unsteady flow of air occurs in the tunnel near the front end of the train, and this disturbance is propagated down the tunnel as a pressure wave. Accompanying this is a change of air pressure on the exterior of the train. In view of the proposal for a high-speed ground-transportation system in this country to operate in the speed range of 250 miles per hour, and faster, it is important to know what pressure fluctuations to expect when fast trains enter tunnels. In order to surmount experimental difficulties associated with high-speed models and transient phenomena, a series of experiments using a water table and two-dimensional train and tunnel models were begun. The work has now been extended to several tunnel-entry shapes, and to square and elliptical train section-models. Experiments included trains entering along the tunnel centerline, as well as trains entering near one wall of the tunnel, and traveling along that wall through the tunnel. (Author)
PB-176 922

Field 09—CONVENTIONAL RAIL SYSTEMS

STUDY OF METHODS OF STABILIZING CONVENTIONAL BALLAST USING POLYMERS.

Materials Research and Development, Inc., Oakland, Calif.

For primary bibliographic entry see Field 11.

PB-179 220

STUDY OF NEW TRACK STRUCTURE DESIGNS.

Transportation Research Inst., Carnegie-Mellon Univ., Pittsburgh, Pa.

For primary bibliographic entry see Field 11.

PB-179 401

A NEW THEORY OF ROLLING CONTACT.

Massachusetts Inst. of Tech., Cambridge. Engineering Projects Lab.

For primary bibliographic entry see Field 21.

PB-179 433

STUDY OF METHODS OF STABILIZING CONVENTIONAL BALLAST USING POLYMERS.

Materials Research and Development, Inc., Oakland, Calif.

For primary bibliographic entry see Field 11.

PB-179 466

WIND TUNNEL TESTS OF A SCALE MODEL RAILROAD AUTOMOBILE RACK CAR.

Office of High-Speed Ground Transportation, Washington, D.C.

John T. Matthews, and William F. Barnett. Jun 68, 36p*

Sponsored in part by Naval Ship Research and Development Center, Washington, D.C.

Identifiers: Axial force, Side force, Automobile rack cars, Normal force, Sideslip angle.

The document covers wind tunnel tests of scaled models of a representative automobile rack car. Various car configurations and arrangements were investigated to determine axial, normal, and side force coefficients for a single car with and without the interference effects of a leading, a trailing, and both a leading and a trailing car. Basic configurations were also tested through a range of sideslip angles. The interference effects from the leading and trailing cars caused notable differences between the coefficients for the one, two, and three car combinations of the configurations tested. (Author)

PB-180 198

RAILROAD RESEARCH FIELD TESTING PROGRAM.

Progress rept. no. 1.

Melpar, Inc., Falls Church, Va.

F. J. Hurley, J. N. Goesser, B. R. Koch, and P. J.

McConnell. Dec 68, 215p

Contract C-111-66

Identifiers: High speed ground transportation project, Rapid transit systems.

The primary purpose of this project is to assist in defining the operational characteristics and constraints of conventional rail systems at speeds of the order of 150 miles per hour. Four electric, multiple-unit commuter-type cars, modified to facilitate instrumentation and to achieve full-power balancing speed in excess of 150 miles per hour, were built and heavily instrumented. High-speed tests are being conducted on an improved 21 mile section of the Penn-Central Railroad between Trenton and New Brunswick, New Jersey, and track geometry measurements reflecting track conditions are being made between Washington, D.C., AND Boston. Of particular interest are the evaluation of ride quality, truck and suspension performance and vibration, track geometry measurements, pantograph performance, catenary profile and dynamic response, track-roadbed characteristics, and interaction between trains. An initial part of the original contract was the formulation of a general purpose mathematical model of car motion suitable for evaluating the performance of new or proposed

vehicles or vehicle components in response to rail excitation at high speeds. The parameters and characteristics of the research cars and statistics of track geometry are being used to validate the mathematical model with actual measurements. This dynamic railcar simulation program will be the subject of a separate comprehensive report. The purpose of this report is to present in summary form the progress achieved thus far on this program.

PB-182 470

FEASIBILITY STUDY FOR A WHEEL-RAIL DYNAMICS RESEARCH FACILITY.

General American Transportation Corp., Niles, Ill. General American Research Div.

V. Milenkovic, and J. J. Pocztack. Dec 68, 180p

Contract DT-7-35363

Identifiers: High speed ground transportation, Rapid transit systems.

The principal objective of the program is to determine the most suitable form of laboratory apparatus required to significantly advance the current knowledge of wheel-rail dynamics, and to establish the safe upper-limit speed for those wheel-rail combinations which hold promise of achieving speeds up to 300 mph. What is sought here is a versatile piece of equipment or equipments capable of accommodating as many of the rail vehicles, suspension systems, mating tracks and/or models or components thereof, as might reasonably be of interest, and being able to evaluate their merits of deficiencies either in component fashion, in scale-model fashion, or in full-scale systems fashion. Such equipment must be both technically feasible and practical, and economically justifiable. (Author)

PB-182 472

OBSTRUCTION DETECTION PROGRAM.

Final rept.

R.C.A., Sarnoff Research Center, Princeton, N. J.

15 Mar 69, 162p

Contract DT-7-35509

Identifiers: Barriers.

An obstacle detection system comprised of transmitters and collocated receivers spaced alongside railroad tracks and scanning across the tracks to a continuous retroreflective fence was studied, tested, and demonstrated. The transmitters emit a very narrow beam of collimated coherent light from a gallium arsenide laser. The retroreflector establishes a narrow region with reflectivity substantially higher than the normal surroundings. An object located between the laser transmitter and the retroreflector will prevent the laser beam from impinging upon the retroreflector and will, therefore, cause a variation in the return energy normally observed by the receiver. This variation is then reported to a central control station for further action. An engineering model of a laser scanner was designed and built. In combination with an engineering model of a retroreflective fence, the scanner engineering model was used to successfully demonstrate the feasibility of the system concepts. (Author)

PB-182 996

HIGH-SPEED RAIL: PROBLEMS AND PROSPECTS.

Office of High-Speed Ground Transportation, Washington, D.C.

Kenneth B. Ullman. 1968, 11p

Presented at conference on Transportation Engineering, Washington, D.C., 28-30 Oct 68.

Identifiers: *Rapid transit railways.

A projection of demand for the current 'high-speed' mode - air - illustrates the importance of developing ground transportation systems of high capability. Presented in this context are the attributes both of the present generation of high speed rail (HSR) equipment and of future HSR systems. The potential of HSR embodies four

distinct features: (1) Ability to compete with air transportation on a door-to-door travel time basis; (2) Greater passenger comfort, convenience, and safety; (3) Greater acceptability due to more efficient land use and less noise and air pollution; (4) Allows more rational use to be made of limited airport capacity and possesses very high limiting capacity. (Author)

PB-183 363

RAIL PASSENGER STATISTICS IN THE NORTHEAST CORRIDOR.

Office of High-Speed Ground Transportation, Washington, D.C.

Feb 69, 22p

Identifiers: *Rapid transit railways.

Using the results of surveys taken on Penn Central trains between Washington, New York, and Boston, this report discusses passengers' origins, destinations, socio-economic characteristics, purposes of travel, frequency of travel, and attitudes toward the service.

PB-183 365

ECONOMICS OF RAILROAD AUTOMOBILE RACK CAR AERODYNAMIC DRAG.

Office of High-Speed Ground Transportation, Washington, D.C.

Robert W. Luebke. Mar 69, 25p

Prepared in cooperation with C and O and B and O Railroads.

Identifiers: *Automobile rack cars, Windage coefficient, Train Performance Calculator computer program.

A program was established to evaluate in detail the causes of the excessive aerodynamic drag of automobile rack cars discovered by the New York Central System (now the Penn Central) and the economics of drag-reducing design modifications. The program consisted of a series of wind tunnel investigations conducted by the Naval Ship Research and Development Center, full scale aerodynamic drag tests conducted by the C and O/B and O Railroads, an analysis of the costs associated with excessive aerodynamic resistance, and an analysis of the savings that could be generated by design modifications to existing railroad auto rack cars. The first part of the program is covered in PB 180 198. The remainder is the subject matter of this report. The full-scale tests confirmed the wind tunnel test results. The economic analysis showed savings could be obtained by the addition of side and end curtains and the removal of the bridge plates. However, these savings are rather low and are quite dependent upon the actual train make up and movements involved. Consequently, the decision to modify car design must be based on the particulars of a railroad's operation and their cost of making modifications. (Author)

PB-183 845

SOME PROBLEMS OF WHEEL/RAIL INTERACTION ASSOCIATED WITH HIGH-SPEED TRAINS.

TRW Systems, Washington, D.C.

Mar 69, 57p 06818-W318-R0-00

Contract C-353-66

Identifiers: Wheel rail interactions, High speed railway trains.

The objective of the study is to identify and evaluate potential problems involving wheel-rail interaction which could limit the speed of a high speed rail (HSR) system. The study is based upon a survey of existing knowledge in the areas pertinent to wheel-rail interaction; no extensive analytical work is presented, but several approximate calculations are given. An attempt has been made to investigate possible wheel-rail speed limitations and to set aside some of the 'non-problems' which may at first appear to constitute a serious constraint upon rolling HSR concepts. The results and discussion are concentrated in four main areas; estimation of the dynamic loads; wheel behavior and structural

integrity; rail dynamics and structural integrity; adhesion, hunting, and related problems. (Author)
PB-183 846

FEASIBILITY STUDY OF LINEAR INDUCTION MOTOR THRUST BOOSTERS FOR DIESEL-ELECTRIC LOCOMOTIVES.

Garrett Corp., Los Angeles, Calif. AiResearch Mfg. Div.
For primary bibliographic entry see Field 17.
PB-184 252

ENGINEERING DESIGN STUDY OF ACTIVE RIDE STABILIZER FOR THE DEPARTMENT OF TRANSPORTATION'S HIGH-SPEED TEST CARS,

Westinghouse Research Labs., Pittsburgh, Pa.
For primary bibliographic entry see Field 21.
PB-185 008

10. ECONOMICS, FINANCE, AND COST

FEASIBILITY AND COST OF EXPANDED INTERCITY AIR SERVICE IN THE WASHINGTON-BOSTON CORRIDOR.

Systems Analysis and Research Corp., Boston, Mass.
For primary bibliographic entry see Field 1.
PB-166 883

WASHINGTON-BOSTON TRANSPORTATION STUDY. PART B. FEASIBILITY AND COST OF IMPROVED RAILROAD SERVICE.

MRD Div., General American Transportation Corp., Niles, Ill.
For primary bibliographic entry see Field 9.
PB-166 886

BUFFETING TESTS ON THE HUDSON TUBE.

Final rept.,
Stanford Research Inst., Menlo Park, Calif.
E. G. Chilton. 4 Jun 65, 30p
Contract C-209-65 (neg)

Buffeting tests were made on a two-car train of the Pennsylvania Railroad as it entered the Hudson tube. The pressure outside the train was measured at its head and at two locations along its side. The pressure inside the car was also measured. Tests were made at speeds between 55 and 70 mph. Results of these tests show that the pressure at the head rises abruptly when the nose of the train enters the tunnel, and gradually to a maximum of about 6 inches of water when the tail of the train enters. Beyond that time the pressure decreases. At the sides the initial abrupt rise is apparent only near the front of the first car and even there its severity is much smaller than at the head. Halfway along the first car the abrupt jump could not be detected. The subsequent gradual pressure rise is observed on all gages and is about equally steep everywhere. The pressure inside the car, which is the pressure experienced by a passenger, rises to a maximum of about 2.5 inches of water at a rate of about 1.5 inches of water per second. This pressure rise was noticeable but not painful. Since the maximum pressure increases as velocity squared and the rate of rise increases as velocity cubed, it seems clear that buffeting will be an important problem whenever speeds are significantly increased. (Author)
PB-168 647

OPERATING COST ESTIMATES FOR LONG-HAUL SUB-SONIC JET AIRCRAFT.

Planning Research Corp., Los Angeles, Calif.
For primary bibliographic entry see Field 1.
PB-170 691

TRAIN AUTO FERRY OPERATIONS.

Whitten (Herbert O.) and Associates, Washington, DC.
For primary bibliographic entry see Field 3.
PB-170 798

ANALYSIS OF VSTOL AIRCRAFT CONFIGURATIONS FOR SHORT HAUL AIR TRANSPORTATION SYSTEMS.

Massachusetts Inst. of Tech., Cambridge. Flight Transportation Lab.
For primary bibliographic entry see Field 1.
PB-174 912

MAINTENANCE COST STUDIES OF PRESENT AIRCRAFT SUBSYSTEMS.

Massachusetts Inst. of Tech., Cambridge. Flight Transportation Lab.
For primary bibliographic entry see Field 1.
PB-174 914

APPLICATION OF THE CALCULUS OF VARIATIONS IN DETERMINING OPTIMUM FLIGHT PROFILES FOR COMMERCIAL SHORT HAUL AIRCRAFT.

Massachusetts Inst. of Tech., Cambridge. Flight Transportation Lab.
For primary bibliographic entry see Field 1.
PB-174 952

A MULTI-REGRESSION ANALYSIS OF AIR-LINE INDIRECT OPERATING COSTS.

Massachusetts Inst. of Tech., Cambridge. Flight Transportation Lab.
For primary bibliographic entry see Field 1.
PB-183 012

A METHOD FOR DETERMINATION OF OPTIMUM VEHICLE SIZE AND FREQUENCY OF SERVICE FOR A SHORT HAUL V/STOL AIR TRANSPORT SYSTEM.

Massachusetts Inst. of Tech., Cambridge. Flight Transportation Lab.
For primary bibliographic entry see Field 1.
PB-183 013

SOME FLEET ROUTING AND SCHEDULING PROBLEMS FOR AIR TRANSPORTATION SYSTEMS.

Massachusetts Inst. of Tech., Cambridge. Flight Transportation Lab.
For primary bibliographic entry see Field 1.
PB-183 014

SIMULATION ANALYSIS OF A HIGH SPEED GROUND TRANSPORTATION SYSTEM.

Massachusetts Inst. of Tech., Cambridge. Dept. of Naval Architecture and Marine Engineering.
For primary bibliographic entry see Field 2.
PB-183 156

ECONOMICS OF RAILROAD AUTOMOBILE RACK CAR AERODYNAMIC DRAG.

Office of High-Speed Ground Transportation, Washington, D.C.
For primary bibliographic entry see Field 9.
PB-183 845

11. GUIDEWAYS AND STRUCTURES

ANALYSIS OF STRESS DISTRIBUTION BENEATH EMBANKMENTS.

Final research rept.,
Massachusetts Inst. of Tech., Cambridge. Soil Mechanics Div.
T. W. Lambe, R. C. Hirschfeld, and J. T. Christian.
1 Nov 66, 57p R66-53
Contract C-85-65
Northeast Corridor Transportation Project.

A mathematical analysis adapted to computer calculation is used to calculate stresses and displacements for complicated soil movements and for a large class of boundary conditions. Vertical stresses are found to be insensitive to variation in material properties and some boundary conditions, but marked changes in horizontal stresses suggest that elastic theory may be inaccurate. Additional work is suggested, to include further computer runs on a systematic basis, some improvements in the programs, and an extension of the work to study consolidation (the time-dependent dissipation of pore pressures), which is a major unsolved theoretical problem. (Author)
PB-173 637

DYNAMICS OF FLEXIBLY SUPPORTED TUNNELS AND OTHER ROADBEDS.

Massachusetts Inst. of Tech., Cambridge. Engineering Projects Lab.
For primary bibliographic entry see Field 26.
PB-173 645

STRESS AND STRAIN IN ROLLING BODIES IN CONTACT.

Massachusetts Inst. of Tech., Cambridge. Engineering Projects Lab.
For primary bibliographic entry see Field 21.
PB-173 651

A CALCULATION OF THE LATERAL HUNTING MOTION OF A TRACKED VEHICLE.

Massachusetts Inst. of Tech., Cambridge. Engineering Projects Lab.
For primary bibliographic entry see Field 9.
PB-173 652

DYNAMICS OF SIMPLE AIR-SUPPORTED VEHICLES OPERATING OVER IR-REGULAR GUIDEWAYS.

Massachusetts Inst. of Tech., Cambridge. Engineering Projects Lab.
For primary bibliographic entry see Field 24.
PB-173 655

STUDY OF METHODS OF STABILIZING CONVENTIONAL BALLAST USING POLYMERS.

Final rept.,
Materials Research and Development, Inc., Oakland, Calif.
F. S. Rostler, and J. W. Newton. Jul 68, 47p
Contract C-352-66
Identifiers: Rapid transit systems, High-speed transportation.

The report presents the results of the work performed in continuation of the research study on stabilized railroad ballast. The purpose of the continuation was to test the feasibility of applying the elastomeric cementing composition in the form of an emulsion. The principal advantage of this is that most of the agent is concentrated at the contact points of the rocks. Included are the testing procedures for the large-scale tests at the A. A. R.
PB-179 220

STUDY OF NEW TRACK STRUCTURE DESIGNS.

Transportation Research Inst., Carnegie-Mellon Univ., Pittsburgh, Pa.
Gurbachan S. Bhatia, James P. Romualdi, and Gerald R. Thiers. Mar 68, 103p*
Contract C-222-66

The effect of an abrupt change elastic foundation properties upon the motion of a high speed vehicle is investigated in detail in this study. Limiting allowable accelerations are chosen as the criteria for riding quality. The study indicates that there is a likelihood of encountering a variety of elastic soil combinations which can seriously deteriorate the riding qualities of a rail vehicle on conventional track. As remedial measures, two alternatives are considered to improve the quality of ride; one by

Field 11—GUIDEWAYS AND STRUCTURES

improving the rigidity of the track structure by means of providing a track structure utilizing narrow vertical walls embedded in the subsoil, and the other by carefully compacting the foundation soil to minimize local variations. A study is also made to evaluate the relative economics of the alternatives. (Author)
PB-179 401

STUDY OF METHODS OF STABILIZING CONVENTIONAL BALLAST USING POLYMERS.

Final rept.,
Materials Research and Development, Inc., Oakland, Calif.
F. S. Rostler, R. M. White, K. Nair, R. G. Hicks, and J. W. Newton. 8 Dec 66, 219p*
Contract C-352-66
See also PB-179 220.
Identifiers: High speed trains, Roadbeds, Graphs (Charts).

An elastomer compound based on a thermoplastic polymer has been developed which when applied to ballast rock as constituting conventional ballast, provides a continuous structure of high strength, good load distribution, and effective damping characteristics. Experiments were performed testing the properties of ballast treated with this compound as compared to non-treated ballast. The preparation was applied in form of a solution of the polymer compound in volatile solvents. One rate of application was explored in detail. (Author)
PB-179 466

MODELING A JOINTED ROCK MASS.

Research rept.,
Massachusetts Inst. of Tech., Cambridge. Dept. of Civil Engineering.
R. A. Nelson, and R. C. Hirschfeld. Sep 68, 233p*
R68-70
Contract C-85-65
Identifiers: Graphs (Charts), Stress strain ratio.

The ultimate goal of the study of jointed rock is to provide fundamental understanding of the mechanics of jointed rock, which is a crucial part of hard-rock tunnel design of the type that might be required for underground high-speed transport systems. The jointed-rock modeling material was selected to meet similitude requirements between the model and a typical field prototype rock and to ensure that it would be possible to make homogeneous, reproducible model specimens. A universal mold was designed for manufacturing specimens having different joint spacings and orientations. Strength tests were performed on the models in a triaxial cell. (Author)
PB-180 248

RAILROAD RESEARCH FIELD TESTING PROGRAM.

Melpar, Inc., Falls Church, Va.
For primary bibliographic entry see Field 9.
PB-182 470

FEASIBILITY STUDY FOR A WHEEL-RAIL DYNAMICS RESEARCH FACILITY.

General American Transportation Corp., Niles, Ill.
General American Research Div.
For primary bibliographic entry see Field 9.
PB-182 472

OBSTRUCTION DETECTION PROGRAM.

R.C.A., Sarnoff Research Center, Princeton, N. J.
For primary bibliographic entry see Field 9.
PB-182 996

A PRELIMINARY DESIGN STUDY OF A TRACKED AIR CUSHION RESEARCH VEHICLE. VOLUME II. GUIDEWAY STUDY REPORT.

Aeroglide Systems, Inc., New York.
For primary bibliographic entry see Field 24.
PB-183 320

SOME PROBLEMS OF WHEEL/RAIL INTERACTION ASSOCIATED WITH HIGH-SPEED TRAINS.

TRW Systems, Washington, D.C.
For primary bibliographic entry see Field 9.
PB-183 846

12. HUMAN FACTORS ENGINEERING

LITERATURE SURVEY OF PASSENGER COMFORT LIMITATIONS OF HIGH-SPEED GROUND TRANSPORTS.

United Aircraft Corp., East Hartford, Conn.
Research Labs.
J. P. Carstens, and D. Kresge. 26 Jul 65, 60p Rept.
no. D-910353-1
Research supported by Department of Commerce, Washington, DC.

A literature survey was made of passenger comfort criteria applicable to high-speed ground transports. Factors considered include acceleration vibration, pressure changes, atmospheric contamination, visual disturbances, and noise. Literature examined includes engineering data pertinent to the analysis of riding comfort in trains, automobiles, and airplanes, as well as aerospace medical and other medical sources. The results of the survey are presented in figures and tables. A summary of recommended values of the pertinent variables is also provided. (Author)
PB-168 171

BUFFETING TESTS ON THE HUDSON TUBE.

Stanford Research Inst., Menlo Park, Calif.
For primary bibliographic entry see Field 10.
PB-168 647

ACTIVE VIBRATION ISOLATION AND ACTIVE VEHICLE SUSPENSION.

Massachusetts Inst. of Tech., Cambridge. Engineering Projects Lab.
For primary bibliographic entry see Field 21.
PB-173 648

RAILROAD RESEARCH FIELD TESTING PROGRAM.

Melpar, Inc., Falls Church, Va.
For primary bibliographic entry see Field 9.
PB-182 470

HIGH SPEED GROUND TRANSPORTATION: NOISE SOURCES.

Bolt Beranek and Newman, Inc., Cambridge, Mass.
C. W. Dietrich, Erich K. Bender, R. D. Bruce, H. H. Heller, and P. Ranganath Nayak. 6 Oct 68, 52p
BBN-1741
Identifiers: Mass transportation, High speed passenger transportation.

Analyzing the noise problem in high-speed ground transportation passenger spaces, this report identifies: (a) sources, (b) paths, and (c) receivers. It examines ways of establishing noise-level criteria for HSGT vehicles.
PB-182 752

ENGINEERING DESIGN STUDY OF ACTIVE RIDE STABILIZER FOR THE DEPARTMENT OF TRANSPORTATION'S HIGH-SPEED TEST CARS.

Westinghouse Research Labs., Pittsburgh, Pa.
For primary bibliographic entry see Field 21.
PB-185 008

13. LEGAL AND SOCIOECONOMIC IMPACT FACTORS

DESIGN FOR IMPACT STUDIES: NORTHEAST CORRIDOR TRANSPORTATION PROJECT.

CONSAD Research Corp., Pittsburgh, Pa.
Wilbur A. Steger. Aug 65, 234p
Contract C-291-65
Prepared in cooperation with Pittsburgh Univ., Pa., Center for Regional Economic Studies.

The report discusses the conduct of economic and demographic impact analyses, the development of impact models, and of measures of indirect benefits and costs constituting the impacts of changes in the regional transportation network.
PB-173 484

IMPACT STUDIES: NORTHEAST CORRIDOR TRANSPORTATION PROJECT. VOLUME I. BACKGROUND, OVERVIEW, AND SUMMARY.

Final rept.,
CONSAD Research Corp., Pittsburgh, Pa.
Sep 67, 89p
Contract C-104-66

The report deals with the nature and strategy of the impact modelling and with the problems of developing measures to evaluate the indirect consequences of changes in the transportation network. The objective of the impact studies is to determine, insofar as possible, the interaction between alternative transportation facilities and the economic, demographic, physical, and social environment of the Northeast Corridor and its subareas. (Author)
PB-176 478

IMPACT STUDIES: NORTHEAST CORRIDOR TRANSPORTATION PROJECT. VOLUME II. MODELS, RESULTS, AND TECHNICAL DISCUSSION.

Final rept.,
CONSAD Research Corp., Pittsburgh, Pa.
Jan 68, 377p
Contract C-104-66

(PB-176 478) provides a broad view of the work performed during Phase I of the Impact Studies project. In this Volume II, the design and implementation of the models developed by CONSAD and currently available for use by the Northeast Corridor Transportation Project is discussed. Also included are the results of thinking in several areas to which future research efforts might well be directed.
PB-177 611

IMPACT STUDIES: NORTHEAST CORRIDOR TRANSPORTATION PROJECT. VOLUME III: PHASE II. MODELLING EFFORTS.

Final rept.,
CONSAD Research Corp., Pittsburgh, Pa.
Jan 69, 514p
Contract C-104-66
See also Volume 2, PB-177 611.
Identifiers: Northeast Corridor Transportation project, Regional planning.

Contents: The impact model system; The area potential (AP) variable; IRIO implementation; Phase II work with the intra-I model; Intra-II, the second generation intraregional model.
PB-182 722

15. PLANNING AND MANAGEMENT

HIGH PRIORITY RESEARCH TASKS FOR HIGH SPEED GROUND TRANSPORT.

Part 2.
Massachusetts Inst. of Tech., Cambridge.

15 Jun 65, 73p
Contract C-85-65

This volume represents Part II of a four part report prepared in partial fulfillment of a Contract initiated in September 1964 between the Massachusetts Institute of Technology and the United States Department of Commerce. The following proposals for additional research of high priority are divided into two groups: technological studies and design studies. The technological studies constitute applied research in various technical areas essential to the realization of a HSGT system. Their purpose is to establish the current state of the art, to determine which lines of attack are technically promising, to ascertain the practical and theoretical feasibility of various design alternatives, and to extend the state of present knowledge to the point where the design of an HSGT system will be a practical possibility. The purpose of the design studies is to generate alternative ideas and proposals for network configuration, access methods, guideway structures, vehicle designs, propulsion, suspension, control, communication, and all other components of the system.

PB-169 121

RESEARCH AND DEVELOPMENT FOR HIGH SPEED GROUND TRANSPORTATION.

Department of Commerce, Washington, DC. Panel on High Speed Ground Transportation.
Mar 67, 40p
Rept. of Panel on High Speed Ground Transportation.

Contents: Research recommendations for pre-prototype studies; Roster of Panel and Subpanels; Presentations to the Panel and Subpanels; Report of the Subpanel on Guideways, Suspensions and Aerodynamics; Report of the Subpanel on Propulsion, Energy and Braking; Report of the Subpanel on Communication and Control; Report of the Subpanel on Terminals and Interfaces; Report of the Subpanel on Passenger and Freight Factors; Current HSGT R and D Contract, Office of High Speed Ground Transportation.
PB-173 911

16. PROGRAM SUMMARY REPORTS

SURVEY OF TECHNOLOGY FOR HIGH SPEED GROUND TRANSPORT, PART I.

Massachusetts Inst. of Tech., Cambridge.
15 Jun 65, 484p
Contract C-85-65

This report presents the results of a research planning study initiated at MIT on September 16, 1964 in support of the Northeast Corridor Transportation Project of the United States Department of Commerce. The objective of the Northeast Corridor Transportation Project is to determine the facilities that will be needed to transport passengers and freight in the region extending roughly from Boston, Massachusetts to Washington, DC in the era of 1980 and thereafter. This includes study of both technological and nontechnological aspects of transportation; analysis of transportation needs and related demographic and economic forecasts for the region; and consideration of the interaction between transportation services and their impact on the development of the region as a whole and of its many urban centers. It includes studies of both existing and projected facilities for all modes of intercity transport, prospective technological improvements in each mode and alternative network configurations.
PB-168 648

TECHNOLOGY FOR HIGH-SPEED GROUND TRANSPORT.

Summary on research at MIT for 16 Sep 65-15 Sep 66.
Massachusetts Inst. of Tech., Cambridge.
William W. Seifert, and Robert J. Hansen. 31 Dec 66, 53p

Contract C-85-65

The report summarizes the research accomplished at the Massachusetts Institute of Technology during the period September 16, 1965 through September 15, 1966. The efforts were on networks and terminals, scheduling, vehicle flow control and switching problems, vehicle-suspension problems, propulsion problems, vehicle and tube aerodynamics, and guideway problems.
PB-173 658

SECOND REPORT ON THE HIGH SPEED GROUND TRANSPORTATION ACT OF 1965.

Department of Transportation, Washington, DC.
Sep 67, 55p

The report complies with Section 10 (a) of the High Speed Ground Transportation Act of 1965 as amended by the Department of Transportation Act of October 15, 1966, requiring the Secretary of Transportation to report to the President and the Congress, not less often than annually, with respect to activities carried out under the Act. The first report covered the fiscal year ending June 1966 and was submitted in September 1966. The three basic activities authorized by the Act are: Research and development in high speed ground transportation; Demonstration projects to determine the contributions that high speed ground transportation could make to more efficient and economical intercity transportation systems; A national program to improve the scope and availability of transportation statistics. (Author)
PB-176 115

TECHNOLOGY FOR HIGH SPEED GROUND TRANSPORT.

Summary rept. 16 Sep 66-15 Nov 67,
Massachusetts Inst. of Tech., Cambridge.
Robert J. Hansen. 31 Dec 67, 67p
Contract C-85-65

This report contains highlights of research findings developed during the second year of research at M. I. T. on the technology of high speed ground transport (HSGT). The research topics are diverse but can be grouped roughly into areas relating to system operational performance, vehicles, including suspension, propulsion, and control; and the problems of the infrastructure of an HSGT system. The research is aimed at establishing a basis for design of HSGT and often treats problems not previously studied for conventional transportation systems. (Author)
PB-176 923

SUMMARY OF RESEARCH AT RPI ON TUBEFLIGHT, (SEPTEMBER 1966-9 NOVEMBER 1967.

Rensselaer Polytechnic Inst., Troy, NY.
For primary bibliographic entry see Field 25.
PB-177 518

TRENDS IN SUPERCONDUCTIVITY RELATED TO ELECTROMAGNETIC SUSPENSION OF HSGT VEHICLES.

TRW Systems Group, Washington, DC. Washington Operations.
For primary bibliographic entry see Field 21.
PB-178 795

TRACKED AIR CUSHION VEHICLE DEVELOPMENT.

Mitre Corp., Bedford, Mass.
For primary bibliographic entry see Field 24.
PB-182 290

SUMMARY OF RESEARCH AT RPI ON TUBEFLIGHT, 15 FEBRUARY 1968 - 15 JANUARY 1969.

Rensselaer Polytechnic Inst., Troy, N.Y.
For primary bibliographic entry see Field 25.
PB-184 317

17. PROPULSION, POWER, AND ENERGY

SOME PROBLEMS RELATED TO ELECTRIC PROPULSION.

Massachusetts Inst. of Tech., Cambridge. Dept. of Electrical Engineering.
David C. White, Richard D. Thornton, Charles Kingsley, Jr., David H. Navon, and Sakutaro Nonaka. 1 Nov 66, 133p
Contract C-85-65

Content: Short-stator effects in linear-induction motor; Discussion of the Laithwaite goodness factor; Summary of double-sided linear induction motor design; Summary of the effect on induction motor performance non-sinusoidal excitation; Laithwaite semiconductor-switched motors; A linear induction power-transfer system for vehicles; Design of a double-sided linear induction motor for electric propulsion; Induction motor supplied by simple frequency inverter, producing rectangular voltage waveform.
PB-173 639

ANALYSIS OF A FREE PISTON HYDRAULIC PUMP.

Massachusetts Inst. of Tech., Cambridge. Engineering Projects Lab.
Dwight M. Baumann, Robert E. Oaklund, and Bruce T. Powell. 1 Nov 66, 83p DSR-6106-2
Contract C-85-65
Identifiers: Chemical fuel, Scavenging process, *Piston pumps.

Among the sets of attributes investigated in the Concepts-keeping, Evaluation, and Development report, were propulsion system reliability, compactness, efficiency and controllability for the family of on-board propulsion component concepts. The consideration of efficiency and compactness pointed to use of chemical fuel with as high a compression ratio as possible. The resulting free-piston-hydraulic pump, (FPHP) described here is a uniflow scavenged, supercharged diesel engine with potential compression ranges up to or exceeding 50:1. (Author)
PB-173 643

UNIVERSAL DRAG LAW.

Rept. for Sep 64-Sep 66.
Massachusetts Inst. of Tech., Cambridge. Engineering Projects Lab.
S. William Gouse, Jr., and Michael Swarden. 6 Dec 66, 79p DSR-76108-2
Contract C85-65
Rept. on Proj. Transport. See also PB-173 646.

The purpose of this report is to present the results of a general examination of the propulsion power requirements of a variety of transport system vehicles in an effort to determine patterns of behavior that might be useful in the preliminary design of high-speed ground-transport systems. The propulsion system will be one of the major sub-systems of any high-speed ground-transport system, and there are several ways in which one can begin making estimates on the magnitude of the power requirements. One way is to extrapolate the performance of existing vehicles into higher speed regions. Another might be to make detailed designs of various HSGT systems. Still a third approach to the estimation of potential power requirements is to base it on the best performance attained by all classes of vehicles with existing technology. The last approach was based on the estimation of potential power requirements on the updating of the Gabrielli-von Karman technology limit line which first appeared in 1947. In addition to adding the performance of supersonic aircraft, supertankers, and missiles on a gross weight basis, we have examined the performance of a variety of transport systems on a payload basis and found a payload performance technology limit line similar to the gross weight performance technology limit line established by Gabrielli and von Karman in 1947. (Author)
PB-173 647

PRELIMINARY DESIGN AND TEST OF LINEAR INDUCTION TRACTION MOTORS AND SUSPENSION SYSTEMS.
Massachusetts Inst. of Tech., Cambridge. Engineering Projects Lab.
Dwight M. Baumann, and G. B. Kirby Meacham. 1 Nov 66, 47p* DSR-6106-3
Contract C-85-65
Identifiers: Tradeoffs, Linear motors.

The report presents some very preliminary calculations and experiments investigating linear induction motors for high speed ground transportation. An iron field slotted rotor configuration is proposed for improved performance. The possibility of combined magnetic suspension and propulsion are discussed and found to require pole pieces that are on the order of weight of the vehicle. (Author)
PB-173 686

STUDY OF LINEAR INDUCTION MOTOR AND ITS FEASIBILITY FOR HIGH-SPEED GROUND TRANSPORTATION.
Final rept.
Garrett Corp., Los Angeles, Calif. AIRResearch Mfg. Div.
Jun 67, 322p Rept. no. 67-1948
Contract C-145-66 (Neg)

The report presents the results of a study program performed by AIRResearch for the Office of High Speed Ground Transportation, U. S. Department of Transportation. This program is concerned with determining the feasibility and practicality of utilizing linear induction motors for high-speed ground transportation (HSGT) propulsion at speeds up to 500 mph. Detailed consideration is given to the electrical, thermal, and mechanical aspects of linear induction motor design. The electrical design analysis considers motor end effects, reaction rail design, and other motor design parameters influencing performance. The analytical models derived in the study for electrical design are verified in laboratory tests using small rotary motors designed to provide the desired data. Data on five reaction rail designs are reported. A composite reaction rail design is recommended for optimum motor performance, although other types are considered for special characteristics. The thermal studies indicate that the minimum motor size consistent with appropriate operating temperature levels for long motor life corresponds to specific continuous thrusts on the order of 1.2 to 2.4 lb per sq. in. per side of motor area. The problems of air gap control, speed control, and power supply are analyzed to determine suitable provisions in the design of HSGT propulsion systems incorporating linear induction motors. Recommendations for future work include fabrication and testing of a full-scale (2500 hp) prototype linear induction motor. (Author)
PB-174 866

APPLICATION OF HIGH POWER SOLID-STATE ELECTRONICS TO ELECTRIC PROPULSION.
Massachusetts Inst. of Tech., Cambridge. Dept. of Electrical Engineering.
Richard D. Thornton, David H. Navon, J. Lichtenberger, C. Erdelyi, and E. Miller. 4 Oct 67, 67p
Contract C-85-65

The work reported here is concerned with the application of high power electronics to electric propulsion. During the last year the effort has been in two main areas: (1) development of improved high power semi-conductor switches and (2) the development of lightweight, low inductance machines which are well matched to semi-conductor device capabilities.
PB-176 920

HIGH SPEED GROUND TRANSPORTATION. A PRELIMINARY STUDY OF THE LINEAR IN-

DUCTION MOTOR FOR HIGH SPEED GROUND TRANSPORTATION.
TRW Systems Group, Washington, D. C. Washington Operations.
Jan 68, 120p Rept. no. 06818-W454-R0-12
Contract C-353-66
Identifiers: High-Speed Ground Transportation project, Linear induction motors, Rapid transit systems.

A theoretical study was undertaken to describe the characteristics of a linear induction motor for High Speed Ground Transportation. A quasi-one-dimensional analysis is made of a linear induction motor without recourse to the usual idealization of the polyphase stator windings into current sheets. The analysis assumes that the stator windings and the induced currents inside the reaction rail (rotor) produce a resultant traveling wave magnetic field at the stator surfaces, and under the assumption of negligible end effect, the electromagnetic boundary conditions are applied to determine the attenuation of the magnetic field, both inside the reaction rail and at the air gap between the reaction rail and stator surfaces. Taking into account real machine effects, expressions based on classical AC machine theory are given for the required exciting current, the generated voltage, the net power output, and the electrical efficiency. Results are reduced into equivalent circuit form so comparisons can be made with conventional rotary induction motors. (Author)
PB-178 202

NONFRICTIONAL POWER COLLECTION FOR GUIDED HIGH-SPEED GROUND VEHICLES.
Final rept. (Part 2).
General Electric Co., Schenectady, NY. Research and Development Center.
12 Apr 68, 147p* S-68-1056
Contract C-7-35121

The report is a preliminary evaluation of four basic noncontacting methods of transferring motive electrical power to high-speed trains (up to 300 miles per hour). The four methods considered are: Gaseous Conduction by a Controlled Electric Arc; Magnetic Induction Using Lenz's Law of Flux Linkage; Capacitive Coupling by Displacement Currents Between Parallel Plates; Electromagnetic Directional Wave-guide Coupling. Examination and calculation of several configurations of the four methods considered established data for comparison. The evaluations include the system functions of power conditioning, power transmission, noncontacting coupling, and onboard power conversion; however, emphasis is on the equipment directly associated with the coupling. (Author)
PB-178 228

SCATTERING OF TE (0)SUB01 MODE ENERGY FROM A CENTERED METAL RING (WITH APPLICATION TO ANTENNA ARRAYS).
Rensselaer Polytechnic Inst., Troy, N. Y. Div. of Electrophysics.
John A. Bradshaw. Jan 68, 19p TR-EP-6801
Contract C-117-66
Report on Project Tubeflight. See also PB-179 465 and PB-174 085.
Identifiers: Tubeflight project, Rapid transit systems.

A variational expression for the fields scattered by a metal ring, centered in round waveguide, is obtained for excitation by circularly symmetric TE modes. An example is worked out and the method supported by application to a rectangular iris for which data are available. An antenna array for launching TE01 or TE02 fields in round waveguide is described, based on current rings, and measurements of its performance given. It is capable of launching rather pure fields in highly over-moded guide, but its efficiency is not high. (Author)
PB-179 464

HIGH FREQUENCY SOLID-STATE POWER RECTIFICATION.
Rensselaer Polytechnic Inst., Troy, N. Y. Div. of Electrophysics.
K. E. Mortenson, P. E. Bakeman, Jr., and W. C. Taft. Dec 67, 42p TR-EP-6803
Contract C-117-66
Report on Project Tubeflight. See also PB-179 464.
Identifiers: Tubeflight project, Rapid transit systems.

This report covers the progress made on high frequency power rectification from September 1966 to September 1967. The requirements for a high frequency rectifying diode are reviewed. The germanium-gallium arsenide p-n heterojunction diode is presented and its material requirements, fabrication technology, and packaging are discussed. The circuit requirements for high frequency rectification are considered, and a new lumped circuit test jig was designed and built. The development of a 220 MHz one kilowatt rectification test facility is reported. Finally, a continuous rectified DC output power of 28 watts was obtained from a 220 MHz source using a single germanium-gallium arsenide heterojunction diode. The overall rectification efficiency of a similar heterojunction diode including circuit losses was 72%. (Author)
PB-179 465

A PRELIMINARY STUDY OF THE COANDA NOZZLE PRINCIPLE FOR PROPULSION OF TUBE VEHICLES.
Final rept. 1 Aug 67-18 May 68,
IIT Research Inst., Chicago, Ill.
Imants Reba. Oct 68, 92p*
Contract DT-7-35512
Identifiers: *Rapid transit systems.

The report describes experimental studies to determine the feasibility of a new type of mass transportation, called the IITRI Passive-Vehicle Tube Transport System. This system (1) uses propulsive guideway concepts based on solely fluid dynamical propulsion principles (the Coanda effect). (2) has the utmost mechanical simplicity, with no moving parts other than vehicles. (3) uses small, inexpensive vehicles providing a personalized mode of mass transportation. (4) is suitable for transportation of goods and passengers. The qualitative and quantitative results of the study provide an insight into various problem areas. The following features were demonstrated: (1) High subsonic speed potential (in the experimental mode, speeds up to 320 fps were reached). (2) Capability of high vehicular frequency. (3) High load-to-power ratios at speeds above 120 mph and at high vehicular frequencies. (4) System efficiency increases with increasing tube diameter. (Author)
PB-180 156

A STUDY OF THE RIBLET COUPLER (FOR RECEPTION OF TE (0)01 MODE ENERGY BY A VEHICLE IN A TUBE).
Rensselaer Polytechnic Inst., Troy, N. Y. Div. of Electrophysics.
John A. Bradshaw. Jan 68, 24p* TR-EP-6802
Contract C-117-66
Report on Project Tubeflight.
Identifiers: *Tubeflight project, Rapid transit systems, Riblet couplers.

The operation of the Riblet coupler in multi-mode round waveguide is described analytically, for the case where three TE (0)01 modes propagate in the coupling gap. A model of the coupling structure, for a vehicle flying in a tube, was built and tested, using this Riblet coupling as a basis. The coupler collected 96% of the power incident on the vehicle; however, the gap length and centering of the vehicle were more critical than expected. Details of the model and measurements are given, as well as a method for subdividing the power collected into 'packages' suitable for rectification. (Author)
PB-180 278

THE CALCULATION OF PROPAGATION CONSTANTS OF A PERIODICALLY LOADED MULTIMODE CIRCULAR WAVEGUIDE.
Rensselaer Polytechnic Inst., Troy, N. Y. Div. of Systems Engineering.
Dean Arden, and John Riganati. Jul 68, 93p* TR-DSF-6801
Contract C-117-66
Report on Project Tubeflight.
Identifiers: *Tubeflight project.

Operation of a circular waveguide at frequencies considerably above cutoff in order to obtain a low attenuation for the circularly symmetric transverse electric modes results in a system capable of propagating many modes. The stability of the launched TE sub 01 energy is a function of both the deviations of the guide from a true right circular cylinder and the mode structure. Guide modifications based on the natural dichotomy between the desired and spurious mode forms may be designed to increase this stability by modifying the mode structure. One way to determine the effect of any periodic modifications is to compute the scattering matrix for each junction and to apply Floquet's theorem. For a modification consisting of a narrow circumferential gap, coupled to either free space or an off resonance coaxial cavity, the scattering matrix may be found if the field in the gap is known. A field equivalence theorem is presented and used to formulate equations for the solution of the electromagnetic boundary value problem for this field. (Author)
PB-180 279

SPECIFICATIONS FOR LINEAR INDUCTION MOTOR P/N 546230, TURBOALTERNATOR PACKAGE P/N 546798, AUXILIARY POWER UNIT P/N 928288, MANUAL CONTROL P/N 44290.
Garrett Corp., Los Angeles, Calif. AiResearch Mfg. Div.
G. P. Kalman, and J. Chapa. 24 Mar 69, 44p 68-3400-1
Sponsored by Office of High Speed Ground Transportation, Washington, D.C.
Identifiers: Turbogenerators, Linear induction motors.

The document describes the basic power systems supplied for the linear induction motor test vehicle. The alternator is matched to the turbine, and is capable of providing 3000KVA at 0.6 pf. at 173 Hz, which can be exceeded only by using military overload of the gas turbine. The linear induction motor was designed to be compatible with the turboalternator and produce 3750 lb thrust, 0 to 250 mph, 2500hp. The linear induction motor, however, is also capable of much higher performance if suitable electrical power is supplied. (Author)
PB-183 362

FAR-FIELD AERODYNAMICS OF TUBEFIGHT PROPULSION.
Rensselaer Polytechnic Inst., Troy, N.Y. Project Tubeflight.
For primary bibliographic entry see Field 25.
PB-183 866

FEASIBILITY STUDY OF LINEAR INDUCTION MOTOR THRUST BOOSTERS FOR DIESEL-ELECTRIC LOCOMOTIVES.
Rept. for 1 Nov-31 Dec 68,
Garrett Corp., Los Angeles, Calif. AiResearch Mfg. Div.
G. P. Kalman, and B. W. Hafele. 21 Mar 69, 51p 69-4862
Contract DOT-FR-9-0014
Identifiers: SD-45 locomotives, Linear induction motors, AC generators, Traction, Diesel electric locomotives.

Both the technical and economic feasibility of utilizing surplus power available from the diesel engine, by adhesion-independent thrust boosters were reviewed. First the power available for thrust

boosting was determined. Then several linear motor reaction rail configurations were considered. A preferred thrust booster configuration (Figure 1-1) which utilized the running rails as the secondary number, was described. It was found that 6000-lb force per locomotive, at 12 to 13 mph train speed can be delivered by such a thrust booster. (Author)
PB-184 252

TUBEFIGHT POWER-DEMAND TESTS AND INITIAL VALIDATION OF THEORY: 1. ESTIMATED PERFORMANCE OF WHEEL-SUPPORTED VEHICLES TO BE TESTED IN FACILITY T-2. 2. INTERPRETATION OF INITIAL TUBEFIGHT PROPULSION TEST RESULTS, AND COMPARISON WITH THEORY. 3. TESTS OF WHEEL-SUPPORTED VEHICLES IN THE T-2 FACILITY.
Rensselaer Polytechnic Inst., Troy, N.Y.
For primary bibliographic entry see Field 25.
PB-184 435

19. ROUTES AND ROUTING

HIGH-SPEED RAILROAD OPERATIONS WITHIN THE NEW YORK METROPOLITAN AREA IN CONNECTION WITH HIGH-SPEED SERVICE BETWEEN WASHINGTON, DC AND BOSTON, MASSACHUSETTS.
Bingham (S. H.), New York.
For primary bibliographic entry see Field 9.
PB-166 887

GEOLOGIC SKETCH OF THE PROPOSED NORTHEAST CORRIDOR HIGH-SPEED GROUND TRANSPORT SYSTEM.
Geological Survey, Washington, DC.
C. F. Withington. May 66, 30p

From a geologic viewpoint, it can be concluded that the rocks of the Crystalline terrain are most suited for underground or surface construction, followed by the rocks of the Triassic terrain. Underground and surface construction in the Appalachian terrain can be recommended with limitation; extensive tunneling in sediments of the Coastal Plain terrain is not recommended because of difficulty of tunneling, but can be effected in underlying crystalline rocks. Subsurface and surface geologic mapping utilizing drilling and geophysical methods is strongly urged before a final route selection is made. Highly detailed engineering geologic studies will be required of the actual route selected before design and construction can begin; feasibility studies and preliminary route selection will require extensive compilation of existing geologic data and mapping at adequate scales. (Author)
PB-173 511

SOME FLEET ROUTING AND SCHEDULING PROBLEMS FOR AIR TRANSPORTATION SYSTEMS.
Massachusetts Inst. of Tech., Cambridge. Flight Transportation Lab.
For primary bibliographic entry see Field 1.
PB-183 014

20. SCHEDULING AND TRAVEL DEMAND

DEMAND FOR INTERCITY PASSENGER TRAVEL IN THE WASHINGTON-BOSTON CORRIDOR.
Systems Analysis and Research Corp., Boston, Mass.
1963, 288p

The study has four main objectives: (1) Identification and measurement of the principal factors influencing intercity passenger demand; (2) identification and measurement of the principal factors influencing the division of intercity passenger de-

mand by mode; (3) projection of intercity passenger demand in the corridor through 1980, and (4) delineation of further study requirements.
PB-166 884

INTERCITY FREIGHT TRANSPORTATION REQUIREMENTS OF THE WASHINGTON-BOSTON CORRIDOR IN 1980.
United Research, Inc., Cambridge, Mass.
For primary bibliographic entry see Field 6.
PB-166 885

STUDIES IN TRAVEL DEMAND.
Mathematica, Princeton, NJ.
Sep 65, 188p
Contract C-247-65

Contents: Methodological problems - A survey of demand for travel studies, by Ronald E. Miller; Some problems in forecasting transportation demand, by Henry M. Peskin; Some perspectives of gravity models, by Richard E. Quandt. Modal studies - The demand for air travel, by Roger E. Alcala; The demand for bus travel, by John Kissin; The demand for rail travel, by Solita C. Monsod; The demand for automobile travel, by Frank Vannerson.
PB-173 499

OPERATIONS ANALYSIS OF SYSTEM SPECIFICATIONS. PART I. PASSENGER SCHEDULING.
Research rept.,
Massachusetts Inst. of Tech., Cambridge. Dept. of Civil Engineering.
E. F. Bisbee, J. W. Devanney, III, K. U. Bhatt, S. Kuroda, and Donald Evan, Ward. 1 Nov 66, 62p R-66-54
Contract C-85-65

In this report some service properties of a transport system that result from operating policies are formulated jointly with system costs. By varying major system design parameters such as vehicle size, allowable dispatching frequency, fleet size and so on, rather different operating practices are possible each of which yields a quantity of service at a given level and an associated cost. The model finds optimal operating policies with respect to a weighted function of system cost and traveller utility (service level). The resulting evaluations for each set of parameters can serve as a basis for comparison of competing systems which, though only a crude basis, contains generalizable components representing dominant measures of transport effectiveness, i.e., its cost and its apparent desirability. The fundamental assumption made is that all technological aspects of a possible system remain to be selected. The models developed here have further use after component choices are made. (Author)
PB-173 635

OPTIMAL DISPATCHING POLICIES BY DYNAMIC PROGRAMMING.
Massachusetts Inst. of Tech., Cambridge. Dept. of Civil Engineering.
For primary bibliographic entry see Field 7.
PB-173 636

OPTIMUM ALLOCATION OF TRANSPORTATION TERMINALS IN URBAN AREAS.
Massachusetts Inst. of Tech., Cambridge. Dept. of Civil Engineering.
For primary bibliographic entry see Field 23.
PB-173 684

COMPUTERIZED SCHEDULE CONSTRUCTION FOR AN AIRLINE TRANSPORTATION SYSTEM.
Technical rept.,
Massachusetts Inst. of Tech., Cambridge. Flight Transportation Lab.
Robert W. Simpson. Nov 66, 97p FT-66-3
Contracts C-136-66, C-85-65

Field 20—SCHEDULING AND TRAVEL DEMAND

The report describes the work which has been carried out for a hypothetical Airbus short haul V/STOL system in the Northeast Corridor. It is only a beginning as valuable extensions are yet to come as more applications come into the open literature. The main presentation describes the computerized processes developed to construct a schedule plan assuming certain demand and operating data. An interesting extension showing the application of network flow theory to a more detailed representation of the schedule is also described. A map of the corridor showing the terminals selected for the Airbus system is shown and some typical distances, travel times, and projected fares for the 1980 Airbus.
PB-174 913

STUDIES IN TRAVEL DEMAND. VOLUME II, Mathematica, Princeton, NJ.

Richard E. Quandt, and William J. Baumol. 30 Sep 66, 231p
Contract C-187-66
See also VOLUME I-PB-173 499.

Contents: Estimation and testing in abstract mode models - The abstract mode model; theory and measurement; Tests of the abstract mode model; A non-linear model of passenger demand; A probabilistic abstract mode model; Some considerations on the choice among forecasting formulas; Alternative approaches and special problems - Some problems and prospects in collecting data on travel demand; A cross-sectional model of the demand for rail passenger service in the Northeast Corridor; Time patterns of traffic volume; An optimization model for Corridor transportation planning.
PB-176 114

STUDIES ON THE DEMAND FOR FREIGHT TRANSPORTATION, VOL. 1.

Mathematica, Princeton, NJ.
Aug 67, 263p
Contract DC-7-35120

The volume is devoted to the estimation of freight demand in the Northeast Corridor. It is argued that a mode of freight transportation should be considered in terms of its abstract attributes, and the demand for freight transportation is analyzed in inventory theoretic terms. A macro-economic approach to the matter provides a more complete micro-model designed for descriptive, as well as forecasting, purposes. The grand total demand for freight transportation at the macro-level is estimated at the first stage on the basis of the values of exogenous variables; then at the second stage, the total is sub-divided with the aid of some specifically pertinent variables. In the third stage, the second stage sub-totals are again sub-divided with the aid of still other specific variables, etc. The interdependence of macro-totals on the sub-totals is exploited as a part of the estimation technique. The data requirements provided can be useful in developing data banks or future statistical system for the Department of Transportation. A more current data requirements list is also provided. A novel technique for estimation of origin-destination data on freight movements using incomplete information is presented.
PB-176 479

THE RELATIONSHIP BETWEEN CARRIER CAPACITY AND MEAN PASSENGER WAITING TIME.

Research rept., Massachusetts Inst. of Tech., Cambridge. Dept. of Civil Engineering.
Kent L. Groninger. Sep 67, 53p R67-74
Contract C-85-65

The study is addressed to the problem of determining the relationship between carrier capacity and the expected waiting time of a random passenger at various demand levels. (Passenger arrivals per time.) A passenger is assumed to be in a waiting state during the total time he is in his station of origin from the time he enters until he departs on a

moving carrier. A mathematical model of the stochastic process resulting from a 'go-when-filled' carrier dispatching policy is formulated and analyzed. The model assumes that individual passenger arrivals to the station are Poisson and that a minimum headway must be enforced between successive carriers leaving the station. A carrier queueing situation of the form E sub K (absolute D)1 results which is solved for the mean waiting time in queue. A solution technique and computer program for obtaining the roots of a c (th) order, complex, transcendental equation (necessary for a numerical solution of the mean waiting time in queue) is also included. Numerical values of the mean waiting time for various carrier capacities and arrival rates are included to illustrate the relationships. (Author)
PB-176 919

TRANSPORTATION SCHEDULING UNDER MULTI-DIMENSIONAL DEMANDS.

Research rept., Massachusetts Inst. of Tech., Cambridge. Dept. of Civil Engineering.
J. W. Devanney, III. 16 Dec 67, 73p R67-72
Contract C-85-65

This report describes an algorithm for scheduling passenger transportation systems under the realization that travel demand will both vary with time of day and depend on the schedule. The control variables used are the number of departures per day on each link, the times of these departures, and the number of units dispatched at each departure. The algorithm uses a combination of dynamic programming and heuristic search to generate scheduling policies which attempt to balance the demand attracted and served against the costs of attracting and serving this demand in a manner consistent with the system's objective. The algorithm can accept a wide variety of demand models and objective functions and may be feasibly applied to networks containing several hundred links.
PB-177 527

STUDIES IN TRAVEL DEMAND. VOLUME III.

Mathematica, Princeton, NJ.
Jul 67, 416p
Contract C-187-66
See also Volume 2, PB-176 114.

The document covers a mathematical means of estimating travel demand in New England and the Middle Atlantic states.
PB-177 610

WASHINGTON-BALTIMORE AIRPORT ACCESS SURVEY. VOLUME I.

Abt Associates, Inc., Cambridge, Mass.
For primary bibliographic entry see Field 23.
PB-179 573

WASHINGTON-BALTIMORE AIRPORT ACCESS SURVEY. VOLUME II. BASIC TABULATION.

Abt Associates, Inc., Cambridge, Mass.
For primary bibliographic entry see Field 23.
PB-179 574

WASHINGTON-BALTIMORE AIRPORT ACCESS SURVEY. VOLUME III. A CASE STUDY.

Abt Associates, Inc., Cambridge, Mass.
For primary bibliographic entry see Field 23.
PB-179 575

WASHINGTON-BALTIMORE AIRPORT ACCESS SURVEY. VOLUME IV. DATA PROCESSING USERS MANUAL.

Abt Associates, Inc., Cambridge, Mass.
For primary bibliographic entry see Field 23.
PB-179 576

SYSTEM FOR SURVEYING REGIONAL TRAVEL. VOLUME I: PROPOSED METHOD FOR SELECTION OF SURVEY SITES FOR A COORDINATED AIR, AUTO, BUS AND RAIL TRAVELER SURVEY IN THE NORTHEAST CORRIDOR.

Peat, Marwick, Livingston and Co., Washington, D.C.
Jun 67, 58p
Contract DT-7-35215
See also Volume 2, PB-182 218.
Identifiers: *Northeast Corridor, Regional travel surveys, Buses (Vehicles), Preferences.

The understanding of travel choices, investment opportunities, and community impact continues to be a distinctive challenge to planning research. A system for surveying regional travel could reasonably serve several objectives, some of which are: to provide statistical data; to establish travel preferences; to determine travel motives and patterns; to establish transportation needs or demand; to produce costs and other financial information; and to forecast future travel. (Author)
PB-182 217

SYSTEM FOR SURVEYING REGIONAL TRAVEL. VOLUME II: PROPOSED SAMPLE DESIGN AND SURVEY PROCEDURES FOR A COORDINATED AIR, AUTO, BUS AND RAIL TRAVELER SURVEY IN THE NORTHEAST CORRIDOR.

Abt Associates, Inc., Cambridge, Mass.
Apr 68, 116p
Contract DT-T8-054

See also Volume 1, PB-182 217. Limited number of copies containing color other than black and white are available until stock is exhausted. Reproductions will be made in black and white only.
Identifiers: *Northeast Corridor, Regional travel surveys, Buses (Vehicles), Objectives.

The survey plan covered in the document is complete with respect to presenting the methodology for accomplishing the stated objectives. It covers the mathematical design and definitions of the survey population; the survey procedures and reasons for their selection; the overall plan for implementation; and guidelines for controlling the fieldwork. Costs documentation, and control requirements necessary to implement a survey of this magnitude are also discussed. (Author)
PB-182 218

A METHOD FOR DETERMINATION OF OPTIMUM VEHICLE SIZE AND FREQUENCY OF SERVICE FOR A SHORT HAUL V/STOL AIR TRANSPORT SYSTEM.

Massachusetts Inst. of Tech., Cambridge. Flight Transportation Lab.
For primary bibliographic entry see Field 1.
PB-183 013

SOME FLEET ROUTING AND SCHEDULING PROBLEMS FOR AIR TRANSPORTATION SYSTEMS.

Massachusetts Inst. of Tech., Cambridge. Flight Transportation Lab.
For primary bibliographic entry see Field 1.
PB-183 014

SIMULATION ANALYSIS OF A HIGH SPEED GROUND TRANSPORTATION SYSTEM.

Massachusetts Inst. of Tech., Cambridge. Dept. of Naval Architecture and Marine Engineering.
For primary bibliographic entry see Field 2.
PB-183 156

RAIL PASSENGER STATISTICS IN THE NORTHEAST CORRIDOR.

Office of High-Speed Ground Transportation, Washington, D.C.
For primary bibliographic entry see Field 9.

PB-183 365

DYNAMIC SCHEDULING IN AIRLINE OPERATIONS.

Technical rept., Massachusetts Inst. of Tech., Cambridge. Flight Transportation Lab. O. J. Akel. Dec 67, 136p FTL-R67-1 Contract DOT-C-136-66

The purposes of this study are to construct simulation models to represent several typical airline situations; to formulate various dispatching criteria compatible with the environments modelled; to demonstrate the use of the simulation models in (a) evaluating the formulated decision criteria, (b) isolating critical system variables, and (c) determining capacity and aircraft requirements for a given system; to explore other uses for the models. (Author)

PB-183 474

21. SUSPENSION AND SUPPORT

INVESTIGATION OF CAR FERRY SERVICE FOR HIGH SPEED GROUND TRANSPORTATION.

Association of American Railroads, Chicago, Ill. For primary bibliographic entry see Field 3. PB-173 513

ACTIVE VIBRATION ISOLATION AND ACTIVE VEHICLE SUSPENSION.

Massachusetts Inst. of Tech., Cambridge. Engineering Projects Lab. Igor L. Paul, and Erich K. Bender. 1 Nov 66, 73p DSR-76109-1 Contract C-85-65

The feasibility of using 'active' elements in suspension systems for high speed ground vehicles to improve vibration isolation characteristics is considered. The characteristics of vehicle excitations (to the suspensions and to the vehicle body) are discussed and a mathematical expression for the suspension input is obtained. Based on data of human tolerance to vertical vibrations a comfort criterion (to vibrations) is established. The problem of vibration isolation to best satisfy this criterion is considered in terms of optimizing the parameters of a given suspension configuration and in terms of finding an optimum transfer function for an unspecified suspension configuration. The methodology for obtaining these optimum solutions for a given comfort criterion is developed and solutions are obtained for the case of vertical vibrations of a two-degree-of-freedom system in which the root mean square acceleration of the vehicle is to be minimized for a given permissible suspension excursion. The optimum suspension transfer function for this case indicates that feedback of both vehicle and unsprung mass acceleration is required. PB-173 648

PARTIAL BIBLIOGRAPHY ON SUBJECTS RELATED TO ACTIVE VIBRATION ISOLATION AND ACTIVE VEHICLE SUSPENSIONS.

Massachusetts Inst. of Tech., Cambridge. Engineering Projects Lab. Igor L. Paul, and Erich K. Bender. 1 Nov 66, 35p DSR-76109-2 Contract C-85-65

The report represents a partial compilation of references on subjects related to active vibration isolation and active vehicle suspensions which have been collected during the past year in connection with active vehicle suspension research. The bibliography is categorized into a number of subject headings which reveal the diversity and scope of published work in general area of vibration isolation, ranging from purely mathematical techniques for optimum vibration filter calculations to the most practical aspects of suspension hardware design. No attempt has been made to sort or classify the reference with respect to the quality, scope, or usefulness of their contents. (Author)

PB-173 649

GENERAL VEHICLE DYNAMIC MODEL.

Massachusetts Inst. of Tech., Cambridge. Engineering Projects Lab. Igor L. Paul, Hariharan Sankaran, and James L. Jackson. Nov 66, 189p DSR-76109-3 Contract C-85-65

Two computer programs were developed to calculate the three-dimensional dynamics of a rigid high-speed ground-vehicle supported vertically and laterally by an arbitrary number of suspensions and excited by arbitrary inputs (acting on the suspensions or on the vehicle body). The first program models each suspension by a linear spring and damper in parallel connected to the unsprung mass and another linear spring and damper in parallel joining the unsprung mass and the vehicle. This model is applicable to a limited class of suspensions over their linear operating range. The second, much more comprehensive program permits non-linear and/or 'active' suspension elements. Each suspension can consist of masses connected (in series or parallel) by elements with force characteristics which can be any function of time or of the relative or absolute displacements, velocities or accelerations of any of the masses (including the vehicle mass). Both programs accept sinusoidal, step, ramp or arbitrary function inputs to the suspensions and print out any or all of the following vehicle response parameters as a function of time: vertical and lateral displacement, velocity and acceleration of the vehicle center of mass; vehicle roll, pitch and yaw (and their first and second derivatives); suspension forces on the vehicle and on the guideway. (Author) PB-173 650

STRESS AND STRAIN IN ROLLING BODIES IN CONTACT.

Massachusetts Inst. of Tech., Cambridge. Engineering Projects Lab. Igor L. Paul, and P. Ranganath Nayak. 1 Nov 66, 43p Contract C-85-65

The three-dimensional solution of the stresses and strains in the contact region of a rolling wheel which carries normal, lateral and tangential loads is sought. Because of the complexity of the general problem a preliminary step has been to seek the solution for two spheres of similar material rolling on each other. The approach has been to divide the 'locked' region into a grid of n cells formed by fixed circular grid lines and variable grid lines which have a shape similar to an assumed shape for the boundary between the 'locked' and 'slipped' regions. The equations and boundary conditions were formulated and a computer program solves $2n$ simultaneous equations to find the stress distributions. If all boundary conditions are not satisfied by the solution the computer program shifts the grid points according to an error criterion and reiterates the solution. The results were encouraging although the final solution is not yet available. The results for the two spheres can be extended to the case of a wheel rolling on a surface of dissimilar material. This solution is of considerable importance for high speed rail travel because forward and sidewise creep (which are vital parameters in stability calculations) and rolling stresses (fatigue, etc.) can be calculated from the complete picture of stresses and strains in the region. (Author) PB-173 651

SUPPLEMENT TO SURVEY OF TECHNOLOGY IN FLUID SUSPENSIONS: PATENT SEARCH AND EFFECTS OF FORWARD SPEED.

Massachusetts Inst. of Tech., Cambridge. Engineering Projects Lab. H. H. Richardson, and W. A. Ribich. 1 Nov 66, 68p DSR-76110-1 Contract C-85-65 See also PB-168 648.

Supplementary information to that given in Part I, Survey of Technology for High Speed Ground Transport, Ref. 1, is presented for fluid suspensions and fluid-supported vehicle systems. Representative patent literature is described which shows that the existing basic concepts and configurations for fluid suspensions and associated vehicles are very old; however, many recent patents have been issued covering variations, improvements and applications to transport vehicles. Published information and experimental facilities and techniques relative to the influence of forward speeds on fluid suspension data are reviewed. Available data are limited to forward speeds less than 150 mph, to ambient pressures of one atmosphere and to low cushion-pressure levels. An adequate theoretical approach to forward speed effects is lacking. No experimental facilities entirely satisfactory for the investigation of the behavior of dynamically similar scale models of HSGT vehicles and guideways were found to exist in the world. (Author) PB-173 653

A TWO-DIMENSIONAL FLUID-SUSPENSION TEST APPARATUS FOR INVESTIGATION OF PRESSURE RATIO, MACH NUMBER AND REYNOLDS NUMBER EFFECTS.

Massachusetts Inst. of Tech., Cambridge. Engineering Projects Lab. For primary bibliographic entry see Field 24. PB-173 654

STATIC AND DYNAMIC BEHAVIOR OF A FLEXIBLE BASE FLUID SUSPENSION.

Massachusetts Inst. of Tech., Cambridge. Engineering Projects Lab. For primary bibliographic entry see Field 24. PB-173 656

DYNAMIC ANALYSIS OF HEAVE MOTION FOR A TRANSPORT VEHICLE FLUID SUSPENSION.

Massachusetts Inst. of Tech., Cambridge. Engineering Projects Lab. W. A. Ribich, and H. H. Richardson. 15 Jan 57, 90p DSR-76110-3 Contract C-85-65

A general lumped-parameter technique for the dynamic analysis of vehicle fluid suspensions operating in the heave mode (translational motion along an axis normal to the mean surface of the vehicle guideway) is presented. The analysis includes the effects of sealing region characteristics, of the fluid source, of the internal geometry, and of base flexibility. A linearization of the general system equations is given which is useful in the study of vehicle-suspension stability and dynamic behavior when the variations in support force are small compared with the average force. The analytical technique described is applied to formulate simple dynamic models for plenum, peripheral-jet, and flexible-base fluid suspensions. The parameters appearing in the dynamic equations can all be determined from computations or measurements of only the static characteristics of the suspensions. Analytical and graphical methods of finding these static parameters are discussed. (Author) PB-173 685

PRELIMINARY DESIGN AND TEST OF LINEAR INDUCTION TRACTION MOTORS AND SUSPENSION SYSTEMS.

Massachusetts Inst. of Tech., Cambridge. Engineering Projects Lab. For primary bibliographic entry see Field 17. PB-173 686

AN INVESTIGATION OF THE RIDE QUALITY OF AUTO-TRAIN SERVICE.

Office of High-Speed Ground Transportation, Washington, DC. For primary bibliographic entry see Field 3. PB-176 044

Field 21—SUSPENSION AND SUPPORT

AN ANALYSIS OF THE EFFECTS OF FINITE FLUID-SUSPENSION PAD LENGTH ON THE DYNAMICS OF A VEHICLE ON AN IRREGULAR GUIDEWAY,
Massachusetts Inst. of Tech., Cambridge. Engineering Projects Lab.
W. A. Ribich, K. M. Captain, and H. H. Richardson. Sep 67, 46p
Contract C-85-65

An analysis is presented which describes the heave motion of a fluid-suspended vehicle moving over a guideway in which the irregularity wavelengths may be shorter than the suspension pad length. The analytical model is applied and exact solutions obtained for the cases of plenum and peripheral jet suspensions traversing sinusoidal and pure step irregularities. The technique is shown to be applicable to general irregularity profiles and numerical procedures for the general case are briefly discussed. It is found that compared to predictions based on zero suspension pad length (uniform guideway-suspension clearance) peak acceleration and relative displacements are generally reduced by the effects of finite pad length. Thus a conservative estimate of performance will usually be obtained if pad length effects are ignored. For most vehicle configurations and speeds, however, the attenuation due to finite pad length will be insignificant near the point of maximum vehicle response (near the natural frequency). Vehicle step responses are smoothed and a slight time delay appears compared with behavior predicted from the zero pad length theory. This work suggests that design criteria based on deterministic irregularities and peak dynamic response of the vehicle system can reasonably neglect the effects of finite suspension pad length. Further work is needed to evaluate these effects for statistically described irregularities. (Author)
PB-176 135

PRESSURE-FLOW-DISPLACEMENT CHARACTERISTICS OF A PERIPHERAL JET FLUID SUSPENSION,
Massachusetts Inst. of Tech., Cambridge. Engineering Projects Lab.
For primary bibliographic entry see Field 24.
PB-176 136

ANALYSIS OF OPTIMUM AND PREVIEW CONTROL OF ACTIVE VEHICLE SUSPENSIONS,
Massachusetts Inst. of Tech., Cambridge. Engineering Projects Lab.
Erich K. Bender, and Igor L. Paul. 1 Sep 67, 75p
DSR-76109-6
Contract C-85-65

The analysis leading to the optimum transfer function for an active suspension excited by a random guideway input is briefly reviewed and a design chart is presented. A parameter sensitivity study of the stability is performed and shows excellent system stability. The wheel-guideway contact problem is considered and a design chart is developed to check wheel-guideway relative displacement (wheel hop) for active suspensions. The equations for the rms force required to prevent wheel hop are derived and a design chart showing the minimum rms vehicle acceleration which can be obtained while applying this force is presented. The improved vibration isolation characteristics of active suspensions using preview control are investigated for infinite and finite preview distances. It is found that for a simple model infinite preview can reduce the rms vehicle acceleration by a factor of 16 and that a preview time of .4-.5 seconds is sufficient to provide almost the same improvement as infinite preview. It is concluded that active suspension development for vehicle heave, roll and pitch control, particularly for use with preview control is warranted. (Author)
PB-176 137

STUDY OF THE POTENTIAL OF HOVAIR FOR HIGH-SPEED GROUND TRANSPORTATION.
General Motors Research Labs., Warren, Mich.

For primary bibliographic entry see Field 24.
PB-177 523

SIMPLIFIED STATIC PERFORMANCE CHARACTERISTICS OF LOW-PRESSURE PLENUM AND PERIPHERAL JET FLUID SUSPENSIONS,
Massachusetts Inst. of Tech., Cambridge. Engineering Projects Lab.
H. H. Richardson, and K. M. Captain. Jan 68, 55p
Contract C-85-65

Simplified relationships and approximate design curves and nomograms are presented which permit the power, mass flow and stiffness of simple plenum and peripheral jet fluid suspensions to be estimated. Both gravity-loaded and transverse suspensions are considered. The incremental load capacity divided by the design load (force increment) is shown to be a major design parameter for fluid suspensions. Compared with simple orifice-restricted plenums, peripheral jet suspensions are shown to require less power and mass flow and to possess lower stiffness for comparable operating conditions. The advantage in power and flow increases as the force increment increases. A comparison is made between the inviscid peripheral jet performance theory used and experimental data which indicates that the theory gives useful estimates of performance which become more accurate as flow Reynolds number increases. (Author)
PB-177 668

TRENDS IN SUPERCONDUCTIVITY RELATED TO ELECTROMAGNETIC SUSPENSION OF HSGT VEHICLES.
TRW Systems Group, Washington, DC. Washington Operations.
6 Oct 67, 46p* 06818-6009-R000
Contract C-353-66
Report on High Speed Ground Transportation System Engineering Studies Program.

The technology of superconductive magnets was studied because of their potential application to electromagnetic suspension of high speed ground transportation vehicles. The technology was observed to be in the classical period of rapid growth which follows a technological breakthrough. The liquid helium technology was also investigated because it is presently the most feasible technique to maintain the low temperatures required for superconductivity. The electromagnetic suspension system which was proposed for HSGT usage was found to be within the present state of the art except possibly for the proposed current density. (Author)
PB-178 795

A NEW THEORY OF ROLLING CONTACT.
Massachusetts Inst. of Tech., Cambridge. Engineering Projects Lab.
P. Ranganath Nayak, and Igor L. Paul. Apr 68, 156p
Contract C-85-65

The report proposes an entirely new theory of rolling contact. Surfaces are modeled as rough (although rough in this context applies even to ball bearing smooth surfaces which are rough on the micro-scale) and are described statistically. When two rough surfaces are pressed together, their peaks (known as asperities) press against each other and form junctions. Friction in the interface is caused by the shearing of these junctions. An important result of this model is that the relationship between the dimensionless friction force and the dimensionless lateral slip velocity depends on the surface roughness of the wheel and track. This surface roughness is described by a roughness (or smoothness) parameter. The influence of the roughness on the friction is postulated and described. Finally, experimental results are presented which support the conclusions that surface roughness is a relevant parameter in rolling contact and that the force-slip relationship is strongly dependent on surface roughness. (Author)
PB-179 433

AERODYNAMIC STABILITY DERIVATIVES OF A SLENDER BODY TRAVELING IN A PERFORATED TUBE.
Oceanics, Inc., Plainville, N. Y.
For primary bibliographic entry see Field 25.
PB-180 091

DYNAMIC SIMULATION OF AUTO AND PASSENGER RAIL TRANSPORTS.
IIT Research Inst., Chicago, Ill.
For primary bibliographic entry see Field 3.
PB-180 132

FEASIBILITY STUDY FOR A WHEEL-RAIL DYNAMICS RESEARCH FACILITY,
General American Transportation Corp., Niles, Ill.
General American Research Div.
For primary bibliographic entry see Field 9.
PB-182 472

SOME PROBLEMS OF WHEEL/RAIL INTERACTION ASSOCIATED WITH HIGH-SPEED TRAINS.
TRW Systems, Washington, D.C.
For primary bibliographic entry see Field 9.
PB-183 846

HEAVE DYNAMICS OF FLEXIBLE-BASE FLUID SUSPENSIONS,
Massachusetts Inst. of Tech., Cambridge. Engineering Projects Lab.
K. M. Captain, and H. H. Richardson. 15 Jan 69, 111p
Contract DOT-C-85-65

The report presents the results of an analytical and experimental study of the heave dynamics of externally pressurized flexible base fluid suspensions operating over guideways containing either deterministic or random irregularities whose wavelengths are large compared to the suspension pad length. The effects of base flexibility and damping, but not of base mass, on the dynamic behavior of suspended vehicles are investigated and relationships are derived between the critical fluid and mechanical parameters which will maximize ride quality for a given vehicle and guideway characteristic. The suspension is modeled as a dynamic lead-lag spring and it is shown that for any value of lead time constant -- as determined by the vehicle weight and size -- there exists an optimum value for the lag time constant (or cushion volume) which minimizes the peak vertical vehicle acceleration. (Author)
PB-183 987

TUBEFLIGHT POWER-DEMAND TESTS AND INITIAL VALIDATION OF THEORY: 1. ESTIMATED PERFORMANCE OF WHEEL-SUPPORTED VEHICLES TO BE TESTED IN FACILITY T-2. 2. INTERPRETATION OF INITIAL TUBEFLIGHT PROPULSION TEST RESULTS, AND COMPARISON WITH THEORY. 3. TESTS OF WHEEL-SUPPORTED VEHICLES IN THE T-2 FACILITY,
Rensselaer Polytechnic Inst., Troy, N. Y.
For primary bibliographic entry see Field 25.
PB-184 435

ENGINEERING DESIGN STUDY OF ACTIVE RIDE STABILIZER FOR THE DEPARTMENT OF TRANSPORTATION'S HIGH-SPEED TEST CARS,
Westinghouse Research Labs., Pittsburgh, Pa.
W. O. Osbon, and T. H. Putman. Jun 69, 149p
Contract DOT-3-0267
Identifiers: *Suspension systems (Vehicles), *Active ride stabilization systems, Computer aided design, Dimensions, Comfort.

This report describes a simulation study of the application of an active suspension system to the U.S. Department of Transportation high speed cars. The active system is shown to improve the ride quality

markedly. The cars presently are equipped with a passive suspension system utilizing air springs and hydraulic shock absorbers. The basic modification necessary to convert from a passive to an active suspension system is to replace shock absorbers with hydraulic actuators. By control action the hydraulic actuators are made to apply forces between the body and the bolsters which basically are proportional to the body accelerations.
PB-185 008

22. TECHNOLOGY REQUIREMENTS, SURVEYS, AND PROJECTIONS

A PROJECTION OF TECHNOLOGY APPLICABLE TO THE FUTURE HIGHWAY SYSTEM OF THE BOSTON-WASHINGTON CORRIDOR.
Cornell Aeronautical Lab., Inc., Buffalo, NY.
2 Oct 64, 400p CAL-VJ-1913-V-1
Contract Cc6245

The objectives of this study have, therefore, been (1) to review the existing trends in highway-oriented technology, (2) to explore those aspects of existing trends, and developments in the field, that could be stimulated to achieve advantageous developments, and (3) to select certain innovations components and system concepts that, principally on the basis of technical and effectiveness considerations, appear to be promising for further research and development, especially as related to the Megalopolitan region. This study has been of relatively short duration and modest effort (six months and about three engineers). Because of these limitations, the system concepts chosen as worthy of further exploration are outlined in the merest skeletal form --general technical feasibility is based on judgment and experience and in each system case, a great deal of engineering research, preliminary design study, and experimental prototype development will be necessary to 'put meat on the bones' to allow major policy decisions to be made by regional planners.
PB-166 878

SURVEY OF TECHNOLOGY FOR HIGH SPEED GROUND TRANSPORT, PART I.
Massachusetts Inst. of Tech., Cambridge.
For primary bibliographic entry see Field 16.
PB-168 648

HIGH-SPEED GROUND TRANSPORTATION RESEARCH AND DEVELOPMENT: A PRELIMINARY APPRAISAL.
Office of the Under Secretary for Transportation (Commerce), Washington, DC. Transportation Research Staff.
For primary bibliographic entry see Field 9.
PB-168 782

HIGH PRIORITY RESEARCH TASKS FOR HIGH SPEED GROUND TRANSPORT.
Massachusetts Inst. of Tech., Cambridge.
For primary bibliographic entry see Field 15.
PB-169 121

UNIVERSAL DRAG LAW.
Massachusetts Inst. of Tech., Cambridge. Engineering Projects Lab.
For primary bibliographic entry see Field 17.
PB-173 647

TECHNOLOGY FOR HIGH-SPEED GROUND TRANSPORT.
Massachusetts Inst. of Tech., Cambridge.
For primary bibliographic entry see Field 16.
PB-173 658

RESEARCH AND DEVELOPMENT FOR HIGH SPEED GROUND TRANSPORTATION.
Department of Commerce, Washington, DC. Panel on High Speed Ground Transportation.
For primary bibliographic entry see Field 15.
PB-173 911

TECHNOLOGY FOR HIGH SPEED GROUND TRANSPORT.
Massachusetts Inst. of Tech., Cambridge.
For primary bibliographic entry see Field 16.
PB-176 923

23. TERMINALS, TERMINAL SELECTION AND TERMINAL ACCESS

OPTIMUM ALLOCATION OF TRANSPORTATION TERMINALS IN URBAN AREAS.
Research rept.,
Massachusetts Inst. of Tech., Cambridge. Dept. of Civil Engineering.
Barton Emmet Cramer. 1 Nov 66, 63p RR66-60
Contract C-85-65

The report indicates a method of determining the location of a number of transportation terminals in an urban area in such a way that they were most accessible, and thus had the greatest utility from a system customer's point of view. By equating demand distribution with population distribution, and making some straightforward assumptions about travel velocity and path, a simple circular model was constructed. Subsequent theoretical and numerical analyses using a computer program which was developed from the model suggested several important results. There seems good reason to believe that the model, which is based on very modest assumptions and requires vastly less effort to parametrize than the network approach, will generate solutions which compare favorably with more complex models. (Author)
PB-173 684

WASHINGTON-BALTIMORE AIRPORT ACCESS SURVEY. VOLUME I.
Summary rept.
Abt Associates, Inc., Cambridge, Mass.
May 68, 159p*
Contract DT-735133
See also Volume 2, PB-179 574.
Identifiers: *Airport access surveys, National Airport, Friendship Airport, Dulles Airport, Passengers.

This volume presents a summary of the findings of a six-day survey of air travelers, visitors and employees using National, Friendship, and Dulles airports. Information was collected on origins, destinations, purpose of travel, mode of travel to and from the airports, and socio-economic data relating to the travelers.
PB-179 573

WASHINGTON-BALTIMORE AIRPORT ACCESS SURVEY. VOLUME II. BASIC TABULATION.
Final rept.
Abt Associates, Inc., Cambridge, Mass.
May 68, 210p*
Contract DT-735133
See also Volume 3, PB-179 575.
Identifiers: *Airport access surveys, National Airport, Friendship Airport, Dulles Airport, Employees, Passengers, Visitors.

The Washington-Baltimore airport access survey has been documented in four volumes. This volume, which provides the reader with the basic data tabulations, is the second of the series. To aid in correlating the data in the volume to that provided in the others, particularly volume one, an introductory section is provided which contains maps of the Washington-Baltimore region showing the

general geographic boundaries of the study districts, a table of selected areas which provides the numbers of the study districts used, a table of specified times which shows the numbers of the study districts that can be reached by certain specified driving times from the airports, and a dictionary of study district boundaries providing detailed geographic descriptions of the study district boundaries. (Author)
PB-179 574

WASHINGTON-BALTIMORE AIRPORT ACCESS SURVEY. VOLUME III. A CASE STUDY.
Abt Associates, Inc., Cambridge, Mass.
May 68, 85p*
Contract DT-735133
See also Volume 4, PB-179 576.
Identifiers: *Airport access surveys, National Airport, Friendship Airport, Dulles Airport, Passengers, Employees, Visitors.

This volume discusses the Washington-Baltimore airport access survey as a special illustrative case including the important events and problems that arose from survey conception, to execution, to results. Alternatives considered at critical points in the development of the survey are given in some detail along with the reasons for the choices made. This volume will hopefully provide information and background to those who are considering planning other airport access studies. (Author)
PB-179 575

WASHINGTON-BALTIMORE AIRPORT ACCESS SURVEY. VOLUME IV. DATA PROCESSING USERS MANUAL.
Abt Associates, Inc., Cambridge, Mass.
May 68, 247p*
Contract DT-735133
See also Volume 1, PB-179 573.
Identifiers: *Airport access surveys, National Airport, Friendship Airport, Dulles Airport, Passengers, Employees, Visitors, Boundaries.

This document describes the data processing system developed to process the questionnaire data collected in the survey phase of the airport access study. As originally conceived, this was to have been a general purpose system, directly applicable to the processing of survey data for any airport. In the course of its development, however, it evolved into a system directly applicable to the processing of the data for the Washington-Baltimore airport access survey. (Author)
PB-179 576

24. TRACKED LEVITATED SYSTEMS

A TWO-DIMENSIONAL FLUID-SUSPENSION TEST APPARATUS FOR INVESTIGATION OF PRESSURE RATIO, MACH NUMBER AND REYNOLDS NUMBER EFFECTS.
Massachusetts Inst. of Tech., Cambridge. Engineering Projects Lab.
H. H. Richardson, and W. A. Ribich. 1 Nov 66, 53p
DSR-76110-2
Contract C-85-65

The design, instrumentation and evaluation of a small scale two-dimensional test apparatus for investigating the equilibrium and nonequilibrium pressure-displacement-flow characteristics of fluid suspension sealing regions are described. The apparatus is versatile and adaptable to a wide variety of suspension configurations. Dynamic similarity to large scale devices is maintained by varying the ambient pressure level. Ambient pressures from 0.1 psia to 150 psia can be employed in the present apparatus. The system is transparent and permits flow visualization through injection of smoke into the supply flow. Data reduction is automated via direct input of raw data into an IBM 7094 digital computer. Test results are presented for equilibrium and nonequilibrium conditions for tests run at one

Field 24—TRACKED LEVITATED SYSTEMS

atmosphere ambient pressure for a peripheral jet suspension. Nonequilibrium cushion flow versus cushion pressure ratio did not show the discontinuity of slope near equilibrium predicted by all inviscid theories. The slopes of the pressure-flow curves were found to be predicted reasonably well by the inviscid underfired jet theory but predictions of actual magnitudes were in error by large factors. (Author)
PB-173 654

DYNAMICS OF SIMPLE AIR-SUPPORTED VEHICLES OPERATING OVER IRREGULAR GUIDEWAYS.
Massachusetts Inst. of Tech., Cambridge. Engineering Projects Lab.
H. H. Richardson, K. M. Captain, and W. A. Ribich. Jun 67, 55p DSR-76110-4
Contract C-85-65

The simplest appropriate dynamic model for fluid suspensions, a dynamic spring with lead and lag, is used to study the vertical displacement and acceleration of a vehicle moving over a guideway containing deterministic and random irregularities. The analysis is limited to heave motion and to irregularity wavelengths long relative to the suspension length. For any value of lead time constant an optimum lag time constant is shown to exist which minimizes vehicle acceleration and which may be achieved by adjusting the dead volumes in the fluid suspension. The general results are applied to a simple rigid-walled plenum. Relations for acceleration, relative displacement, mass flow and pumping power are presented as functions of cushion geometry, loading, and hover height. The dynamic lead is shown to depend primarily on the vehicle weight and area and to be a primary factor determining maximum acceleration. For typical vehicle weights and sizes it is shown that optimum dynamic lead cannot be physically realized in a simple plenum suspension. Further the results obtained in this simple analysis suggest that it will be very difficult to achieve adequate passenger comfort at HSGT speeds over realistic guideways through use of only primary rigid simple plenum suspensions. (Author)
PB-173 655

STATIC AND DYNAMIC BEHAVIOR OF A FLEXIBLE BASE FLUID SUSPENSION.
Master's thesis,
Massachusetts Inst. of Tech., Cambridge. Engineering Projects Lab.
Barry L. Casey. 1 Nov 66, 111p DSR-76110-5
Contract C-85-65

The object of the thesis is to uncover a set of analytical expressions which will adequately permit the design of a flexible base air bearing and to verify these expressions experimentally. Simplifying assumptions include adiabatic flow through the inlet orifices and in the plenum beneath the diaphragm. Bending and shear stresses in the diaphragm are assumed to be negligible compared to tensile stresses. In the steady-state analysis, an equation is developed which predicts the platform height as a function of plenum pressure and also yields the bearing float limit condition. By averaging and linearizing, a limited amount of dynamic theory is developed which yields the bearing stability limit and completes the analysis. Experimental correlation of the theory is presented as well as a Fortran computer program which performs the necessary computations. (Author)
PB-173 656

PRESSURE-FLOW-DISPLACEMENT CHARACTERISTICS OF A PERIPHERAL JET FLUID SUSPENSION.
Massachusetts Inst. of Tech., Cambridge. Engineering Projects Lab.
H. H. Richardson, W. A. Ribich, and Y. Ercan. 1 Jun 68, 68p*
Contract C-85-65

An experimental investigation of the pressure-flow-displacement characteristics of a peripheral jet fluid suspension is summarized. The effects of nozzle pressure ratio, Reynolds number, base recess and jet nozzle size on equilibrium and non-equilibrium characteristics are presented for a 30 deg. nozzle angle. It is shown experimentally that the effects of geometric scaling can be studied adequately by varying ambient pressure level. Inviscid performance theories were found to overestimate equilibrium cushion pressures from 40% at low jet thicknesses, low Reynolds numbers and high hover heights to less than 5% at opposite conditions. Mass flow rates and power requirements were found to be within 15% of the inviscid Barratt theory for the larger jet widths tested. Theories for non-equilibrium jet behavior were found to be inadequate for predicting pressure-flow and displacement-flow sensitivities needed in dynamic models of peripheral jet devices. Predicted discontinuities in these parameters were not observed experimentally. Experimental values of pressure-flow-displacement sensitivities derived from non-equilibrium performance data are presented. These results suggest that for comparable conditions the peripheral jet suspensions will experience higher maximum heave accelerations than corresponding plenum configurations. (Author)
PB-176 136

STUDY OF THE POTENTIAL OF HOVAIR FOR HIGH-SPEED GROUND TRANSPORTATION.
Final rept.,
General Motors Research Labs., Warren, Mich.
Frederick Jindra. Mar 68, 131p
Contract C-197-66

The object of the program was to study the potential of the air bearing as a support system for high-speed ground vehicles. The tasks required included analytical investigations of performance characteristics of air bearings, analytical investigations of ride characteristics of vehicles with such support, development of dimensional analysis for experiments, and outlining future research and development requirements. (Author)
PB-177 523

THE AEROTRAIN SYSTEM: AIR CUSHION GUIDED GROUND TRANSPORTATION: DESCRIPTION AND PERFORMANCE OF THE EXPERIMENTAL VEHICLE.
Final rept.,
Aeroglide Systems, Inc., New York.
Francois L. Giraud. 1968, 204p*
Contract DT-7-35337
Identifiers: Aerotrains, Guideways, Fortran, Computer analysis.

The report presents selected results of testing the experimental Aerotrain vehicle on the Gometz-laVillette to Limours test track, including technical data on the vehicle and guideway, generalized performance and economic models, and technical specifications for a specific site for application of a full-scale Aerotrain system as an airport link. (Author)
PB-178 961

MOVING GROUND-PLANE WIND-TUNNEL TESTS ON SEVERAL TRACKED AIR CUSHION VEHICLE (TACV) MODELS.
Interim rept.,
TRW Systems Group, Washington, D.C. Washington Operations.
1 Sep 68, 101p 06818-6029-R0-00
Contract C-353-66
Identifiers: Graphs (Charts), *Tracked air cushion vehicles, Pressure distribution.

An experimental wind-tunnel test program conducted jointly by TRW and NASA-Langley has provided supporting air cushion and body aerodynamic data for ongoing analytical and design studies at TRW and elsewhere. Selected results for two of the TACV models tested are presented in

this report. Tests were conducted on a 30-inch-diameter circular air-cushion model and on an elongated model approximately 11 inches wide and 67 inches long. Each model's air-cushion base area was 5 square feet. The models' air-cushions were capable of operating in a peripheral-jet or hybrid-plenum mode. Circular model test results for both the forward-speed and hover state and the peripheral-jet and hybrid-plenum modes are reported. Results for the hover state and peripheral-jet mode are reported only for the elongated mode.
PB-179 893

TRACKED AIR CUSHION VEHICLE DEVELOPMENT.

Status rept.,
Mitre Corp., Bedford, Mass.
Warren L. McCabe, Carl G. Swanson, and Kenneth K. Tang. Oct 68, 16p
Prepared in cooperation with TRW Systems Group, Washington, D.C. Presented at Transport Engineering Conference, Washington, D.C. 28-30 Oct 68.
Identifiers: TACV (Tracked Air Cushion Vehicle), Rapid transit systems, Tracked air cushion vehicles, Aerotrain ground effect machines.

Program results to date, current activities and plans for future work are discussed. System engineering studies performed so far have identified and examined the major alternatives available for a TACV system, and significant R and D requirements. Factors which will strongly affect the design and cost of an operational TACV system include the vehicle-guideway configuration, the effects of cross winds, the relationship between cushion pressure and the free stream dynamic pressure, and the type of propulsion subsystem used. Research activities to advance the state of the art of TACV systems are briefly described. These include the NASA/TRW wind tunnel tests, the suspension and dynamics studies at MIT and NASA, and the experimental French Aerotrain tests. The objective, approach and requirements of the recently contracted design studies for a Tracked Air Cushion Research Vehicle are presented. (Author)
PB-182 290

OBSTRUCTION DETECTION PROGRAM.
R.C.A., Sarnoff Research Center, Princeton, N. J.
For primary bibliographic entry see Field 9.
PB-182 996

TRACKED AIR CUSHION RESEARCH VEHICLE. VOLUME I. RESEARCH VEHICLE PRELIMINARY DESIGN.
Final rept.,
Grumman Aircraft Engineering Corp., Bethpage, N. Y.
Mar 69, 230p FSR-ST-4
Contract DOT-FR-9-0003
See also Volume 2, Pt 1, PB-183 173.
Identifiers: TACRV (Tracked Air Cushion Research Vehicle), Tracked air cushion research vehicle.

The report contains a preliminary design and development plan for a research tool to validate tracked air cushion vehicle technology.
PB-183 172

TRACKED AIR CUSHION RESEARCH VEHICLE. VOLUME II. RESEARCH VEHICLE DEVELOPMENT PLAN. PART I-TECHNICAL PLANS.
Final rept.,
Grumman Aircraft Engineering Corp., Bethpage, N. Y.
Mar 69, 31p FSR-ST-5A
Contract DOT-FR-9-0003
See also Volume 3, PB-183 174.
Identifiers: Management information systems, TACRV (Tracked Air Cushion Research Vehicle), Tracked air cushion research vehicle.

Three major subsystem development tasks are required: (a) Design, build, and test a cushion air control valve; (b) Develop friction and wear data for friction brake facing and skid materials at high speeds; (c) Develop a suitable flexible peripheral jet material. Manufacturing facilities required are 8000 sq ft of shop area with access to detail parts manufacturing, processing, and inspection areas. The GFE required includes a JT8D-9 turbofan, a PLF1A-2 turbofan, the LIM, its turbo-alternator package and power pickups and/or power conditioning equipment. A minimum qualification program has been generated which uses qualified hardware and/or conservative design, reducing the need for testing. Qualification testing is therefore categorized as functional, performance verification, and/or calibration.
PB-183 173

TRACKED AIR CUSHION RESEARCH VEHICLE. VOLUME III. RESEARCH VEHICLE RESEARCH PLAN.

Final rept.
Grumman Aircraft Engineering Corp., Bethpage, N. Y.
Mar 69, 106p FSR-ST-6
Contract DOT-FR-9-0003
See also Volume I, PB-183 172.
Identifiers: TACRV (Tracked Air Cushion Research Vehicle), Tracked air cushion research vehicle, Guideways.

The TACRV program will provide test data on ride comfort, performance, efficiency, and level of noise in operation, for use in the final design of a public demonstration system. The TACRV will be used to obtain test operation data, under actual forward speed conditions, in the areas of air cushion performance, suspension system dynamics, vehicle stability and control dynamics, vehicle/guideway dynamic interactions, linear induction motor (LIM)/vehicle performance and internal cabin and far field acoustics. (Author)
PB-183 174

TRACKED AIR CUSHION RESEARCH VEHICLE DEVELOPMENT PLAN STUDY REPORT.

General Electric Co., Philadelphia, Pa. Transportation Systems Div.
17 Mar 69, 72p 69AT-1003
Contract DOT-FR-9-0004
See also PB-183 178, PB-183 179 and PB-183 180.
Identifiers: TACRV (Tracked Air Cushion Research Vehicle), Tracked air cushion research vehicle, Guideways.

The objectives of this R/V Development Plan are to indicate the schedules for, and to describe the efforts necessary to accomplish the refinement of the vehicle design details, development of subsystems, fabrication and assembly of the research vehicle, and the performance of suitable component and vehicle qualification and performance tests. Its further objective is to include schedule estimates for the production of all ground support equipment, checkout systems, and spares necessary to implement the proposed research use of the vehicle. (Author)
PB-183 177

TRACKED AIR CUSHION RESEARCH VEHICLE RESEARCH PROGRAM STUDY REPORT.

General Electric Co., Philadelphia, Pa. Transportation Systems Div.
17 Mar 69, 83p 69AT-1004
Contract DOT-FR-9-0004
See also PB-183 177, PB-183 179 and PB-183 180.
Identifiers: TACRV (Tracked Air Cushion Research Vehicle), Tracked air cushion research vehicle, Guideways.

The system test program discussed in this report is to provide engineering data, verified analytical tools, and design guidelines for an attractive, high-performance public demonstration TACV and guideway system. The report examines the general

qualities required of a commercial TACV system; the translation of these qualities into technology requirements; and the assessment of the state-of-the-art in regard to these requirements. In each deficient area, several alternative ways of advancing the state-of-the-art are examined. This basic work culminates in a clearer definition of the specific role of the TACRV. This role is then translated into specific experiment areas and instrumentation requirements.
PB-183 178

TRACKED AIR CUSHION RESEARCH VEHICLE PRELIMINARY DESIGN STUDY REPORT.

General Electric Co., Philadelphia, Pa. Transportation Systems Div.
17 Mar 69, 204p 69AT-1002
Contract DOT-FR-9-0004
See also PB-183 177, PB-183 178 and PB-183 180.
Identifiers: TACRV (Tracked Air Cushion Research Vehicle), Tracked air cushion research vehicle, Guideways.

This report presents a preliminary design for a Tracked Air Cushion Research Vehicle (TACRV). The proposed design meets performance, design, and test requirements prescribed by the OHSGT. The research program test requirements emphasize air cushion and suspension research. Additional research program investigations include subsystem interactions, aerodynamics, propulsion, noise, and vehicle/guideway interactions, especially as they affect ride quality and operational guideway design requirements. The experimental program is to provide engineering data and verification of analyses that will be applicable to the design of public demonstration TACV systems. (Author)
PB-183 179

TRACKED AIR CUSHION RESEARCH VEHICLE PRELIMINARY DESIGN STUDY REPORT: APPENDICES.

General Electric Co., Philadelphia, Pa. Transportation Systems Div.
17 Mar 69, 473p 69AT-1007
Contract DOT-FR-9-0004
See also PB-183 177, PB-183 178 and PB-183 179.
Identifiers: TACRV (Tracked Air Cushion Research Vehicle), Tracked air cushion research vehicle, Guideways.

These appendices deal with (a) requirements, (b) aerodynamics, (c) braking, (d) loads and structural design criteria, (e) structural analysis, (f) weight analysis, (g) personnel accommodations, (h) linear induction motor, (j) ground support equipment, (k) electrical system, (m) guideway requirements, (n) suspension dynamics, (p) special sensors and measurement techniques, (q) drawings and specifications, (r) noise, and (s) instrumentation and data handling system.
PB-183 180

A PRELIMINARY DESIGN STUDY OF A TRACKED AIR CUSHION RESEARCH VEHICLE. VOLUME I: GENERAL REPORT.

Final rept.
Aeroglide Systems, Inc., New York.
Francois L. Giraud. Feb 69, 262p
Contract DT-7-35337
See also Volume 2, PB-183 320.
Identifiers: TACRV (Tracked Air Cushion Research Vehicle), Tracked air cushion research vehicle, Rapid transit systems, Guideways.

The first part of this study compares different configurations of high speed air cushion vehicles and guideways. Economical and functional comparisons of the guideway functional cross section favor the double 'L' and inverted 'T'. A comparison of 3 types of suspensions points to the suspended lip as the most suitable design to achieve the comfort requirement, since it allows a simple means of activation. A comparison of different means of propulsion focuses on aerodynamic propulsion with a by-pass ratio of 5 combined with a propul-

sive exhaust into the track gap. The second part of this study aims at describing a vehicle and track to perform a test program. A common vehicle frame equipped with a fan jet can accommodate the existing linear induction motor. Tests of the most interesting track form and structure, tests of all suspensions and trials of alternate means of aerodynamic propulsion with their noise attenuation systems can be performed.
PB-183 319

A PRELIMINARY DESIGN STUDY OF A TRACKED AIR CUSHION RESEARCH VEHICLE. VOLUME II. GUIDEWAY STUDY REPORT.

Aeroglide Systems, Inc., New York.
Dec 68, 112p
Contract DT-7-35337
Prepared in cooperation with Parsons, Brinckerhoff, Quade and Douglas, Inc., New York. See also Volume I, PB-183 319.
Identifiers: TACRV (Tracked Air Cushion Research Vehicle), Tracked air cushion research vehicle, Rapid transit systems, Guideways.

This report describes the development of preliminary design tradeoff studies for a single vehicle aerial guideway to accommodate a vehicle traveling on air cushions at speeds up to 300 miles per hour. Three guideway structure types were studied: (1) the Inverted Tee, (2) the Double L (or Channel), and (3) the Box (or Inverted Channel). Each of these structural types was analyzed for the purpose of determining the most economical construction material, the optimum span length, the tolerance requirements, construction methods and maintenance procedures. (Author)
PB-183 320

MOVING GROUND PLANE WIND TUNNEL TESTS ON SEVERAL TRACKED AIR CUSHION VEHICLE (TACV) MODELS.

TRW Systems Group, Washington, D.C.
1 Mar 69, 220p 06818-6032-RO-00
Contract C-353-66
Report on High Speed Ground Transportation Systems Engineering Study.
Identifiers: TACV (Tracked Air Cushion Vehicles), *Tracked air cushion vehicles, *High speed ground transportation, Rapid transit systems.

Test results are presented for four models. Briefly, the objectives of the program were: (a) Determination of whether a moving ground plane simulation is necessary for valid TACV wind tunnel test results. (b) Determination of the aerodynamic characteristics of air cushions. (c) Determination of the aerodynamic characteristics of TACV bodies. (Author)
PB-183 857

HEAVE DYNAMICS OF FLEXIBLE-BASE FLUID SUSPENSIONS.

Massachusetts Inst. of Tech., Cambridge. Engineering Projects Lab.
For primary bibliographic entry see Field 21.
PB-183 987

25. TUBE VEHICLE SYSTEMS

AERODYNAMIC DRAG ON VEHICLES IN ENCLOSED GUIDEWAYS.

Rept. for Sep 64-Sep 66,
Massachusetts Inst. of Tech., Cambridge. Engineering Projects Lab.
S. William Gouse, Jr., and Joseph Nwude. 6 Dec 66, 59p DSR-76108-1
Contract C85-65
Rept. on Proj. Transport. See also PB-173 647.

The purpose of this study was to investigate the aerodynamic drag on vehicles moving in enclosed guideways. The reason for the study was, and is, that several potential high-speed ground-transport system concepts involve high-speed motion of vehi-

cles in enclosed guideways for significant portions of their travel time. Both analytical and experimental studies have been carried out. The analytical studies commenced by developing a solution for the aerodynamic drag on a vehicle in an enclosed guideway in laminar flow. This analysis was based on an analogy, first suggested by Rayleigh, that exists between the governing equations for unsteady flow resulting when an infinite body is started impulsively from rest and for the steady flow that results from steady motion of a semi-infinite body. The results of this analysis for laminar flow provided a base from which to begin, and were then used in an attempt to predict the drag that would result in turbulent flow. The turbulent flow analytical estimate was based on another approximation or analogy which assumes that for any turbulent flow there exists a laminar flow in which corresponding streamlines in the laminar flow can be found to enclose the turbulent wake in the turbulent flow, and that by making use of an effective eddy viscosity in the laminar flow solution, one can predict the drag coefficient in the corresponding turbulent flow. Experimental studies were carried out using 8 spherical models and 16 cylindrical models in tubes of various diameters. (Author) PB-173 646

A FEASIBILITY STUDY OF THE CRYOPUMPED TUBE TRAIN CONCEPT.
Celestial Research Corp., South Pasadena, Calif.
Raymond L. Chuan, Kenneth W. Rogers, Paul C. Wilbur, P. R. Choudhury, and N. V. Peterson. 11 Oct 66, 136p Celesto-388-101
Contract C279-66

The thermodynamic and gasdynamic characteristics of a saturated vapor in a tube enclosing a high speed train have been analyzed to assess the aerodynamic resistance to motion and possible means of propulsion using the same vapor. It is found that the piston action of the train causes condensation of the vapor ahead of and re-evaporation behind the train, these mechanisms thus providing the equivalent of by-passing the atmosphere in the tube around the train without any significant gap between the train and the tube. The term Cryopumped Tube Train is applied to the concept, since it is the heat sink capacity of the earth which effects the pumping of the vapor in the tube by condensation. The results of the analysis indicate that the total aerodynamic resistance to motion of a train at speeds around 400 mph in a close-fitting subterranean tube, evacuated free of air but filled with saturated water vapor at 13 mm pressure, is about two orders of magnitude below the resistance of a conventional flanged wheel-rail suspension system. Use of the same vapor for cruise mode jet propulsion is found to be feasible, though with very low efficiency. An effective and economical acceleration system to bring a train rapidly to cruising speed by means of low pressure steam catapult is found to be feasible and compatible with the cryopumped tube concept. These theoretical results have yet to be verified experimentally. (Author) PB-173 982

THE AERODYNAMIC CHARACTERISTICS OF A SLENDER BODY TRAVELING IN A TUBE.
Technical rept.,
Oceanics, Inc., Plainview, NY.
Theodore R. Goodman. Jan 67, 50p TR-66-31
Contract C-265-66

Slender-body theory is applied to determine the flow about a slender body of revolution traveling in a tube. A formula for the pressure distribution on an ellipsoid centered in the tube is derived and it is shown that for a body whose diameter is a large percent of the tube diameter the pressures are an order of magnitude greater than they would be for the same body traveling in free air. It follows that a body which passes from a wide to a narrow passage will experience a large impact loading. Formulas for all the static and dynamic stability derivatives are then derived for an arbitrary body of revolution

in terms of its cross-sectional area distribution. These formulas are specialized to an ellipsoid of revolution as an illustrative example, and plots of the results are presented as a function of the ratio of the maximum cross-sectional area of the body to the area of the tube. For the body whose diameter is a large percent of the tube diameter the stability derivatives also become an order of magnitude greater than they would be for the same body in free air. Furthermore, a statically unstable force of attraction to the wall due to proximity to the wall is present which does not exist at all for the body in free air. The inherent aerodynamic instability of a body in free air without controls is thus exaggerated by the presence of the tube walls, and the walls may be said to exert a large effect on the aerodynamic characteristics of the body. (Author) PB-173 997

PROJECT TUBEFLIGHT. PHASE I. FEASIBILITY STUDY.
Final rept., 10 Dec 65-9 Sep 66.
Rensselaer Polytechnic Inst., Troy, NY.
Sep 66, 194p
Contract C-117-66
High speed ground transportation project.

Project TubeFlight is a study of a transportation mode in which aerodynamically supported and propelled vehicles travel at high speed in non-evacuated tubes. The feasibility of a mode of propulsion is studied in which thrust is generated by a continuous transfer of air in the tube from immediately in front of the vehicle to its rear. The use of bladeless fans as thrust generators for propulsion is examined. A study is made of the feasibility of powering the vehicle by high frequency electrical energy. The problems of radiating, propagating through the tube, receiving and rectifying this energy are covered. The inherent stability of a vehicle supported by a ram wing or a jet-flapped wing operating in close proximity to the tube wall is studied. A theoretical analysis of augmented stability and control is made, particularly in relation to the vehicle's roll. A small scale test facility was constructed consisting of an instrumented 12 inch diameter tube 2000 feet long. (Author) PB-174 085

PLANE-FLAME SIMULATION OF THE WAKE BEHIND AN INTERNALLY PROPELLED VEHICLE - PART I - SIMULATION OF A SUPERSONIC VEHICLE BY A DETONATION.
Doctoral thesis,
Rensselaer Polytechnic Inst., Troy, NY. Dept. of Aeronautical Engineering and Astronautics.
John H. Skinner, Jr. Mar 67, 44p TR-AE-6701-Pt-1
Contract C-117-66
Rept. on Proj. TubeFlight.

The development of the flow field behind an internally-propelled vehicle in steady motion at supersonic speed is analyzed by the method of characteristics. The vehicle is simulated by a Chapman-Jouguet detonation propagating in an infinite duct. Friction and heat transfer are accounted for, and the friction factor is related to the heat transfer coefficient through the Reynolds analogy. The characteristic equations are integrated numerically employing a high-speed computer. In the inviscid adiabatic case the flow is nonsteady in all frames of reference. On the other hand, when the effects of friction and heat transfer are included, a region of flow is found to develop which is steady in a frame of reference moving with the detonation front. The steady-flow region starts directly behind the detonation and gradually grows to fill the entire flow field. The flow conditions far downstream from the detonation return asymptotically to their ambient values. (Author) PB-174 730

UNSTEADY FLOW IN TUNNELS.
Massachusetts Inst. of Tech., Cambridge. Engineering Projects Lab.

Forbes T. Brown, and Rasik P. Shah. 30 Sep 67, 108p
Contract C-85-65

Theoretical predictions are made for attenuation, dispersion, and characteristic impedance of long-wavelength small-amplitude waves in turbulent flow in cylindrical lines or tunnels. A lower limit for attenuation and dispersion results from assuming a turbulent viscosity profile across the tube which remains constant throughout the cycle. An upper limit results from assuming a turbulent viscosity profile which fluctuates during the cycle, maintaining the steady-flow values. An experimental apparatus was nearly completed to check the theory and resolve the transition from upper limit to lower limit. The theory indicates that a relatively simple constant-inertance-resistance model is useful at much higher frequencies than in laminar flow, including most problems of normal vehicle acceleration and deceleration in tunnels, but is totally unacceptable at very high frequencies such as those which result when a vehicle passes rapidly through a sharp or gradual change in the tunnel area. (Author) PB-176 138

THE AERODYNAMICS OF TUBE TRAVEL: EFFECTS OF COMPRESSIBILITY AND THE RESISTANCE OF SLENDER CYLINDERS TRAVELING IN A TUBE.
Technical rept.,
Oceanics, Inc., Plainview, NY.
Theodore R. Goodman. Nov 67, 48p TR-67-36.
TR-67-21
Contract C-265-66

Slender-body theory is used to determine the flow about a slender body of revolution traveling inside a tube at subcritical speed in a compressible fluid. It is shown that if the tube diameter is a small percent of the body length and the body is centered in the tube then the axial component of the flow in the annular region between the body and the tube can be approximated by one-dimensional compressible channel flow. Formulas for all the static and dynamic stability derivatives are derived for an arbitrary body of revolution in terms of its cross-sectional area distribution. The dynamic derivatives are shown to be identical with their incompressible counterparts. The static derivatives, on the other hand, are Mach number dependent and, as an illustrative example, these are calculated for an ellipsoid, and the results are normalized with respect to their incompressible counterparts. The resulting compressibility rise is presented graphically as a function of the ratio of the maximum cross-sectional area of the body to the area of the tube for various free-stream Mach numbers. The augmentation factor due to the presence of the tube walls, which had previously been calculated for incompressible flow, is shown to be augmented still further by the effect of compressibility. (Author) PB-176 204

ROLL CONTROL OF A FLUID-SUPPORTED VEHICLE MOVING IN A NON-EVACUATED TUBE.
Rensselaer Polytechnic Inst., Troy, NY School of Engineering.
Dean K. Frederick, and Imsong Lee. Sep 67, 35p
TR-CISD-101
Contract C-117-66
Presented at the Sequicentennial Forum on Transportation Engineering, New York, NY, Aug 29 1967, ASME paper 67-Tran-8.

The problem of controlling the roll angle of a high-speed vehicle moving through a tube was investigated, both for straight portions of the tube and around curves. The dynamics of the vehicle with 6 degrees of freedom were studied by postulating reasonable force characteristics for the support pads and the aerodynamic forces on the fuselage. It was shown that de-stabilizing coupling exists between the roll and lateral modes, whereas the heave, pitch, and yaw modes are essentially uncoupled.

pled and are well-damped. However, the vehicle model studied can be stabilized by the use of a feedback torque about the roll axis proportional to the derivative of the roll-angle error. During a curve, the roll-angle error can be sensed by using a pendulum mounted in the vehicle in conjunction with a rate gyro. For straight portions of the tube only the rate gyro measurement is required. In addition to the feedback torque, the vehicle's roll angle is varied by an appropriately chosen open-loop torque as it passes through a curve. The results of digital and analog simulations are presented. (Author)
PB-176 375

STEADY-STATE SIMULATION STUDY OF THE FLOW INDUCED BY AN INTERNALLY PROPELLED VEHICLE IN AN INFINITE TUBE: SUPERSONIC VEHICLE.
Rensselaer Polytechnic Inst., Troy, NY. Dept. of Aeronautical Engineering and Astronautics. Duane E. Cromack. Jun 67, 30p TR-AE-6704
Contract C-117-66

The flow induced in the wake of an internally-propelled supersonic vehicle or of a disturbance moving supersonically through an infinite tube is analyzed as a steady one-dimensional flow in the frame of reference of the vehicle or disturbance, with full amount of heat transfer and dissipative effects. The governing equations are solved numerically. The results confirm that the flow can be steady if it is everywhere supersonic relative to the vehicle or disturbance. (Author)
PB-176 410

PLANE-FLAME SIMULATION OF THE WAKE BEHIND AN INTERNALLY PROPELLED VEHICLE. PART III. EXPERIMENTAL SIMULATION OF A SUPERSONIC VEHICLE BY A DETONATION.
Doctoral thesis, Rensselaer Polytechnic Inst., Troy, NY. Dept. of Aeronautical Engineering and Astronautics. John H. Skinner, Jr. Nov 67, 41p TR-AE-6708-Pt-3
Contract C-117-66
Rept. on Proj. TUBEFLIGHT. See also Part 2, PB-177 141.

The flow field induced by an internally-propelled vehicle traveling through a tube at a supersonic speed is simulated experimentally by the flow field induced by a detonation. The results indicate that as the vehicle continues to travel at a constant velocity, the effects of friction and heat transfer cause a region of flow to develop which is steady in the frame of reference of the vehicle. This steady-flow region starts directly behind the vehicle and gradually grows to fill the entire flow field as time progresses. (Author)
PB-176 924

PLANE-FLAME SIMULATION OF THE WAKE BEHIND AN INTERNALLY PROPELLED VEHICLE. PART 2. SIMULATION OF A SUBSONIC VEHICLE BY A HEAT SOURCE.
Doctoral thesis, Rensselaer Polytechnic Inst., Troy, NY. Dept. of Aeronautical Engineering and Astronautics. John H. Skinner, Jr. Jul 67, 34p TR-AE-6705
Contract C-117-66 (Neg.)
Rept. on Proj. TubeFlight. See also Part 1, PB-174 730.

The development of the flow field about an internally-propelled vehicle in steady motion at subsonic speed in a tube is analyzed by the method of characteristics. The vehicle is simulated by a heat source releasing heat at a constant rate and moving through an infinite duct at a constant, subsonic velocity. Friction and heat transfer are accounted for, and the characteristic equations are integrated numerically employing a high-speed computer. In a vehicle-fixed frame of reference the induced flow field is initially steady, but friction and heat transfer

soon cause it to become nonsteady. As time progresses, the nonsteady effects slowly decay and the flow field asymptotically approaches a steady state. (Author)
PB-177 141

AERODYNAMIC DRAG ON A BODY TRAVELING IN A TUBE.
Massachusetts Inst. of Tech., Cambridge. Engineering Projects Lab. S. William Gouse, Jr., B. S. Noyes, and M. Swarden. Oct 67, 94p
Contract C-85-65

The purpose of the study is to continue the investigation of the aerodynamic drag on vehicles moving in guideways of varying degrees of enclosure. The reason for the study is that several potential high-speed ground transport system concepts involve high-speed motion of vehicles in enclosed guideways for significant portions of their travel time. Both analytical and experimental investigations were carried out. The analytical studies continued the development of the solution for the aerodynamic drag on a vehicle in an enclosed guideway in laminar flow. Experimental studies were carried out using cylindrical models in circular tunnels of various length and various degrees of wall porosity. A drop testing apparatus was employed in which water was the only test fluid and results were obtained for Reynolds numbers of the order of 100,000. Results to date indicate that for vehicle length-diameter ratios of the order of 15 and above, with tunnel to vehicle diameter ratios of 1.5 and greater, a drag coefficient based on the wetted surface area of the vehicle is independent of the vehicle length-diameter ratio for incompressible flow. Results also indicate that, for incompressible flow, employing a tunnel model with a closed end simulates a tunnel length-diameter ratio of infinity. Tunnel wall porosity, assuming relatively unobstructed motion of fluid outside the porous wall, has a marked effect on decreasing the aerodynamic drag on vehicles moving in enclosed guideways and for the range of variable investigated (clearance ratio as low as 1.4) tunnel wall porosity of 20 per cent is adequate for all the significant drag reduction that is possible. (Author)
PB-177 211

SUMMARY OF RESEARCH AT RPI ON TUBEFLIGHT, (SEPTEMBER 1966-9 NOVEMBER 1967).
Rensselaer Polytechnic Inst., Troy, NY. Jan 68, 34p TR-PT-6801
Contract C-117-66

This report is a summary of the researches performed during the period 9 September 1966 - 9 November 1967 under contract with the Office of High-Speed Ground Transportation of the United States Department of Transportation. Studies under this program focussed on the areas of Propulsion (Chapter I), inherent stability (Chapter II), stability augmentation (Chapter III), electrical power supply (Chapter IV), and small-scale experimentation (Chapter V). Specific problems within each of these areas are discussed in detail in the technical reports which are listed in the Appendix.
PB-177 518

STUDIES ON THE ACTIVE CONTROL OF HIGH SPEED TUBE VEHICLE.
Rensselaer Polytechnic Inst., Troy, NY. School of Engineering. Imsong Lee, Dean K. Frederick, N. Josephy, and F. Treiber. Jan 68, 126p
Contract C-117-66

This document consists of two reports: (A) Stability analysis of a tube vehicle with flexible suspension; (B) A digital computer program for simulation of nonlinear tube vehicle dynamics with six degrees of freedom.
PB-177 519

PROPULSION AND BRAKING OF TUBEFLIGHT VEHICLES.
Rensselaer Polytechnic Inst., Troy, NY. Joseph V. Foa. Mar 68, 110p* TR-AE-6707, TR-AE-6802
Contract C-177-66
Rept. on Proj. TUBEFLIGHT.

This report consists of the following articles: Tube-flight propulsion by bladeless fans; Power demands of tube-flight vehicles; Preliminary evaluation of the braking capabilities of tube-flight vehicles.
PB-177 520

AERODYNAMIC CHARACTERISTICS OF GROUND SUPPORT SYSTEMS.
Rensselaer Polytechnic Inst., Troy, NY. Robert E. Duffy, and George C. Cooke, IV. Jan 68, 119p* TR-AE-6801, TR-AE-6804
Contract C-117-66, Grant NSF-GK-618
Report on Proj. TUBEFLIGHT.

Two reports dealing with the aerodynamic characteristics of ground support systems are presented. The first report 'Aerodynamic Characteristics of a Tube-flight Vehicle Support System' by Robert E. Duffy presents experimental data on an aerodynamic ground-support-system obtained in a moving-wall wind tunnel. The second report 'Jet-Flapped Airfoils in Ground Proximity' by George C. Cooke concerns a study of the subsonic lift characteristics of airfoils in ground proximity with and without trailing-edge jet flaps. This study was restricted to supersonic flow analysis. (Author)
PB-177 521

FLOW PROPERTIES OF A SLENDER BODY TRAVELING CENTERED IN A PERFORATED TUBE.
Oceanics, Inc., Plainview, NY. Theodore R. Goodman. Apr 68, 29p* TR-68-43
Contract C-265-66

The previously derived boundary condition which states the law governing the flow through a perforated wall (see PB-177 766) is applied to solve the title problem for a body of revolution. It is shown that even a moderate amount of perforations can cause the axial perturbation velocity in the annular region to be reduced by an order of magnitude in comparison with the closed wall case. It may be inferred from this that all aerodynamic forces, including drag, can be reduced considerably by perforating the walls. Thus, from the point of view of the body aerodynamics, tube wall perforations will have a beneficial effect on a tube transportation system. (Author)
PB-177 524

STATIC AERODYNAMIC FORCE MEASUREMENTS OF BODIES IN TUBES.
Oceanics, Inc., Plainview, NY. Theodore R. Goodman, and August F. Lehman. Apr 68, 46p* TR-68-45
Contract C-265-66

Experiments were performed in a water tunnel to measure the lift, drag, and pitching moment on models intended to simulate a vehicle traveling in a tube. Bodies of three different thickness ratios were tested, and the heave displacement and angle of incidence was varied. In one series of tests the body alone was tested in a tube. In another series a propeller was placed near the rear of the body in the tube and the thrust of the propeller was made equal to the drag of the body, thereby simulating the condition of self-propulsion. The slopes of the measured lift-displacement and moment-displacement curves at zero displacement, for both heave and incidence displacements, were found to give good agreement with a theory previously derived by one of the authors. These curves remained virtually unaltered when self-propulsion was simulated. (Author)
PB-177 671

Field 25—TUBE VEHICLE SYSTEMS

AERODYNAMIC PROPERTIES OF PERFORATED WALLS FOR USE IN A TUBE TRANSPORTATION SYSTEM.
Oceanics, Inc., Plainview, N.Y.
Theodore R. Goodman. Apr 68, 26p* TR-67-39
Contract C-265-66

For flow in a closed wall tube the boundary condition at the tube wall is the kinematic one of no normal flow. When the tube is perforated it is shown that the average effect of many small perforations may be calculated. From a theoretically derived formula it is shown that many small holes are more effective than a few large ones. It is then shown that there exists an analogy between a body traveling in a perforated tube and a geometrically similar body tested in a tunnel test facility having longitudinal slots. Furthermore, a relationship between the geometry of the holes of the perforated tube and the geometry of the slots of the tunnel test facility is established. (Author)
PB-177 766

AERODYNAMIC ANALYSIS OF VEHICLES IN TUBES.
TRW Systems Group, Washington, DC. Washington Operations.
15 Apr 68, 35p* 06818-6026-R000
Contract C-353-66
Report on High Speed Ground Transportation System Engineering Studies Program.

The aerodynamic characteristics of a vehicle traveling in a tube are an important consideration in the analysis of high speed ground transportation systems. This report presents a list of the important aerodynamic parameters; an analysis of the various flow assumptions available to the researcher; a breakdown of the problem into two regimes, near field and far field; and a detailed description of the numerical analysis of the one-dimensional unsteady flow problem. (Author)
PB-178 796

SCATTERING OF TE (0)SUB01 MODE ENERGY FROM A CENTERED METAL RING (WITH APPLICATION TO ANTENNA ARRAYS).
Rensselaer Polytechnic Inst., Troy, N. Y. Div. of Electrophysics.
For primary bibliographic entry see Field 17.
PB-179 464

HIGH FREQUENCY SOLID-STATE POWER RECTIFICATION.
Rensselaer Polytechnic Inst., Troy, N. Y. Div. of Electrophysics.
For primary bibliographic entry see Field 17.
PB-179 465

AERODYNAMIC STABILITY DERIVATIVES OF A SLENDER BODY TRAVELING IN A PERFORATED TUBE.
Technical rept.,
Oceanics, Inc., Plainview, N. Y.
Theodore R. Goodman. Oct 68, 33p* TR-68-48
Contract C-265-66
Identifiers: Rapid transit systems.

The incompressible potential flow is determined for a slender body traveling off center in a perforated tube. From this, formulas are derived for the stability derivatives of a body having an arbitrary cross-sectional area distribution. These results may be compared with results previously derived for the stability derivatives of a slender body traveling in a tube with a closed wall. In the latter case the stability derivatives could become a large multiple of their free air values, and the more the body filled the tube the greater the multiple. When the wall is perforated, on the other hand, it is found to be always possible to design the perforations in such a way that the stability derivatives take on their free air values regardless of the size or shape of the body. Thus, it becomes possible to make the ratio of the body cross-sectional area to the tube cross-sectional area vary close to unity without paying any aerodynamic penalty. (Author)

PB-180 091

A PRELIMINARY STUDY OF THE COANDA NOZZLE PRINCIPLE FOR PROPULSION OF TUBE VEHICLES.
IIT Research Inst., Chicago, Ill.
For primary bibliographic entry see Field 17.
PB-180 156

A STUDY OF THE RIBLET COUPLER (FOR RECEPTION OF TE (0)01 MODE ENERGY BY A VEHICLE IN A TUBE).
Rensselaer Polytechnic Inst., Troy, N. Y. Div. of Electrophysics.
For primary bibliographic entry see Field 17.
PB-180 278

THE CALCULATION OF PROPAGATION CONSTANTS OF A PERIODICALLY LOADED MULTIMODE CIRCULAR WAVEGUIDE.
Rensselaer Polytechnic Inst., Troy, N. Y. Div. of Systems Engineering.
For primary bibliographic entry see Field 17.
PB-180 279

FAR-FIELD AERODYNAMICS OF TUBEFLIGHT PROPULSION.
Rensselaer Polytechnic Inst., Troy, N. Y. Project Tubeflight.
Joseph V. Foa. Jan 69, 36p TR-PT-6903
Contract C-117-66
Identifiers: Tubeflight project.

Tubeflight is a high-speed tube transport scheme in which the vehicle derives its propulsion from the fore-to-aft transfer of air within the tube. The power required for tubeflight propulsion depends not only on the gasdynamics of the transfer flow but also on the amplitude of the disturbances that are generated by the vehicle in the far field, and these in turn depend on the energy conversion efficiency of the propulsion mechanism. A method is developed for the coupling and solution of the equations governing the flow field for the case of a tubeflight vehicle in steady motion in a very long tube. The method produces useful information on the interrelationships between the speed of travel, the drag of the vehicle, the amplitude of the flow disturbances in the far field, the energy conversion efficiency of the thrust generator, and the power demands. (Author)
PB-183 866

SUMMARY OF RESEARCH AT RPI ON TUBEFLIGHT, 15 FEBRUARY 1968 - 15 JANUARY 1969.
Rensselaer Polytechnic Inst., Troy, N. Y.
Jan 69, 24p TR-PT-6904
Contract DOT-C-117-66
See also PB-177 518.
Identifiers: Tubeflight project, High speed ground transportation.

Project Tubeflight deals with an intercity high-speed ground-transportation scheme in which air-cushion-supported vehicles propel themselves in a novel way in nonevacuated tubes. The report covers effort aimed primarily at the objective of obtaining realistic predictions of the power demands and attainable speeds of full-scale tubeflight vehicles. (Author)
PB-184 317

STABILITY OF A SLENDER ELASTIC BODY TRAVELING IN A TUBE.
Oceanics, Inc., Plainview, N. Y.
D. P. Wang. Feb 69, 54p TR-68-54
Contract DOT-FR-9-0020
Identifiers: High speed ground transportation.

The stability of a slender, axisymmetric, elastic body, supported by two simple spring systems, travelling in a cylindrical tube filled with air is studied. Slender-body theory is used to evaluate the

aerodynamic force acting on the body. Under this aerodynamic loading the elastic body is assumed to obey the equation of motion of a simple beam. A method of solution of the equation of motion is presented for a slender ogive cylinder. It is found that at a given travelling speed instability occurs when the length of the body exceeds a critical value. This critical length is found to be approximately proportional to the inverse of the travelling speed, and to the square-root of the difference of the characteristic cross-sectional areas of the tube and of the body to the third power. (Author)
PB-184 319

TUBEFIGHT POWER-DEMAND TESTS AND INITIAL VALIDATION OF THEORY: 1. ESTIMATED PERFORMANCE OF WHEEL-SUPPORTED VEHICLES TO BE TESTED IN FACILITY T-2. 2. INTERPRETATION OF INITIAL TUBEFIGHT PROPULSION TEST RESULTS, AND COMPARISON WITH THEORY. 3. TESTS OF WHEEL-SUPPORTED VEHICLES IN THE T-2 FACILITY.
Rensselaer Polytechnic Inst., Troy, N. Y.
Joseph V. Foa, N. A. Messina, P. A. Graham, and W. B. Brower, Jr. Feb 69, 116p TN-PT-6802, TR-PT-6905
Contract C-117-66
Also includes Report TN-PT-6901.
Identifiers: Tubeflight project.

To permit correlation between the predictions of PB-177 520 and the results of the small-scale model tests that are to be conducted in facility T-2, the power demands of these models are calculated by a procedure that is essentially the same as that of PB-177 520, except for such changes in the analytical model as are suggested or called for by the conditions of the tests. Experimental power demand data are presented for tests of the RPI MK IIc scale-model tubeflight vehicle in test facility T-2. This is done by use of propeller efficiency data generated through testing in the tubeflight wind tunnel, facility T-3. A description of the Mark IIc (wheel-supported) tubeflight vehicle is given. A series of test runs in the T-2 Facility is reported in which the top speed was about 76 feet per second. This result checks very closely with theoretical predictions for this vehicle. (Author)
PB-184 435

26. TUNNELS AND TUNNELING

ROCK FRACTURE RESEARCH.
Research rept. 1 Nov 65-1 Sep 66,
Massachusetts Inst. of Tech., Cambridge. Dept. of Civil Engineering.
F. Moavenzadeh, R. B. Williamson, and A. L. Z. Wissa. 1 Nov 66, 94p RR-R66-56
Contract C-85-65

The results of flexural tests on granite, marble, gneiss, and schist beams are presented in terms of the maximum stress and the work expended to cause failure. The extent of side cracking is measured by quantitative microscopy and is used to calculate a corrected fracture surface work. Thermal cycling of unnotched beams to 540C, 1280C, and 1800C is found to cause extensive cracking, and the resulting decrease of strength can be measured. The use of surface-active agents to reduce the work necessary to cause failure is found effective. A one percent water solution of aluminum chloride at 90C produces a fifty percent reduction in the fracture surface work value of granite, compared to the room temperature dry condition. A mechanism of stress-activated corrosion may be the principal cause of this reduction in strength.
PB-173 638

DYNAMICS OF FLEXIBLY SUPPORTED TUNNELS AND OTHER ROADBEDS.
Massachusetts Inst. of Tech., Cambridge Engineering Projects Lab.
Forbes T. Brown. 1 Nov 66, 31p DSR-76107-1
Contract C-85-65

Vehicles supported by flexible roadbeds can exhibit violent vibrations near a particular critical velocity. This situation is idealized to a concentrated load traveling on a Bernoulli-Euler beam which rests on an elastic foundation. A floating tunnel design of the type proposed by Edwards is so modeled, and found to have a critical velocity of about 262 miles per hour and nearly negligible damping. Avoidance of excessive vibration by rapidly accelerating or deceleration through the critical frequency is studied with preliminary results. The tentative indication on the particular example is that an impractically high acceleration would be necessary unless changes are made. (Author)
PB-173 645

HYDRAULIC ANALOGY STUDY OF WAVES IN TUNNELS.

Final rept., Massachusetts Inst. of Tech., Cambridge. Engineering Projects Lab. Mikio Suo, and Paul Jacobs. 1 Nov 66, 55p DSR-76111
Contract C-85-65

As a train enters a tunnel at high velocities, a pressure wave is built up ahead of it. The pressures involved may be so high as to cause the train to slow down and to cause damage to the train and the tunnel. In order that trains be used at high velocities, it is necessary to find a way to relieve these pressure waves. A study was made of a technique for measuring these pressure waves and of some data for a typical train configuration. The technique consists of making measurements on a free-surface water table of a model geometrically similar to actual trains. This gives information about the pressure waves around trains travelling on the ground through air. The results indicate that valid information can be obtained from the water table and that the water table can be ultimately used towards reducing the magnitude of the pressure waves. (Author)
PB-173 657

LASER ASSISTED ROCK FRACTURE.

Research rept., Massachusetts Inst. of Tech., Cambridge. Dept. of Civil Engineering. F. Moavenzadeh, R. B. Williamson, and F. J. McGarry. 30 Jan 67, 63p R67-3
Contract C-85-65

The report presents information obtained from initial experiments involving the use of a laser to degrade and deteriorate hard rock samples. The work is being done within the context of a continuing search for more efficient means of excavation and tunnelling in hard rock. The techniques discussed herein should be considered in the context of making hard rock more easily removed by reducing its strength. The laser appears to have an unusual potential for this application. (Author)
PB-174 245

UNSTEADY FLOW IN TUNNELS,

Massachusetts Inst. of Tech., Cambridge. Engineering Projects Lab. For primary bibliographic entry see Field 25.
PB-176 138

STUDY BY HYDRAULIC ANALOGY OF THE PASSAGE OF HIGH-SPEED TRAINS THROUGH TUNNELS,

Massachusetts Inst. of Tech., Cambridge. Engineering Projects Lab. For primary bibliographic entry see Field 9.
PB-176 922

A STUDY OF EXTERNAL AUGMENTATION OF THE VELOCITY OF FLUID JETS.

Bowles Engineering Corp., Silver Spring, Md. 1967, 40p BEC-R-12-21-67
Contract 7-35380

In order to make tunneling operations for future transportation systems economically feasible, a new method must be developed to provide a major step forward in tunneling speed and ease of operation. Attention was directed to tunneling by water jet techniques which promise to overcome the inherent slowness of conventional tunneling methods. Previous work indicates that at high velocities, water jets produce much the same effect on rock as do explosives. A major problem of hypervelocity jet production is dealt with in this effort, that being to provide hypervelocities without requiring extremely high pressures. A new technique involving the impacting of two relatively slow-moving slugs of water to produce a very small but effective fast jet was studied by analysis and very low pressure experiments. The analysis included the effect of slug profile, prediction of fast jet velocity as a function of the slug face impact angle, fast jet mass, optimum slug length, and time between slugs. Special test fixtures were built and tested to experimentally verify the theoretical results. These tests included the high speed photography of the collapse transient, impacting of wax targets and velocity measurement by streak photography. (Author)
PB-177 595

FEASIBILITY OF FLAME-JET TUNNELING. VOLUME I. SUMMARY REPORT.

United Aircraft Corp., East Hartford, Conn. Research Labs. May 68, 52p* UACRL-G910560-10-Vol-1
Contract DC-7-35126
See also Volume 2, PB-178 199.

Analytical system studies were made to determine the configuration of a flame-jet tunneling system and its expected performance. These studies examined the flame-jet tunnel design, haulage system, power system, and shoring and lining problem areas. Similar studies considered in detail various aspects of the environmental control problem, including a determination of the environmental heat, fumes, and noise created by the flame jets, the design of air and water supplies to modify this environment, and possibilities for crew protection against a hostile environment. Three possible alternative modes for life support were designed and evaluated, and one was chosen as the recommended system. Studies were also made to determine the overall cost of flame-jet tunneling, based on the detailed cost estimates made in the component subsystem studies. Total costs of flame-jet tunneling are developed and compared with conventional methods. In an experimental program, a series of tests was made on two 'control rocks' to determine the effect of various burner parameters on spalling rate. For comparative purposes, information was developed on conventional tunneling methods. (Author)
PB-178 198

FEASIBILITY OF FLAME-JET TUNNELING. VOLUME II. SYSTEMS ANALYSIS AND EXPERIMENTAL INVESTIGATIONS.

Technical rept. United Aircraft Corp., East Hartford, Conn. Research Labs. May 68, 380p* UACRL-G910560-10-Vol-2
Contract C-7-35126
See also Volume 3, PB-178 200.

The feasibility of flame-jet tunneling is considered analytically from three points of view, namely technical (or operational), environmental, and economic. An experimental program was performed to provide cutting capabilities of flame-jets in rock types expected on the Northeast Corridor. (Author)
PB-178 199

FEASIBILITY OF FLAME-JET TUNNELING. VOLUME III. CONVENTIONAL TUNNELING METHODS.

Rept. for 1 May 67-15 Mar 68. United Aircraft Corp., East Hartford, Conn. Research Labs.

May 68, 116p* UACRL-G910560-10
Contract DC-7-35126
Prepared in cooperation with Fenix and Scisson, Inc., Tulsa, Okla. See also Volume 1, PB-178 198.

The report has been divided into two sections: (1) Methods for Conventional Tunneling and Shaft Sinking; (2) Boring Methods for Tunneling and Shaft Sinking. (Author)
PB-178 200

HIGH SPEED GROUND TRANSPORTATION TUNNEL. DESIGN AND COST DATA.

TRW Systems Group, Washington, DC. Washington Operations. Mar 68, 265p Rept. no. 06818-W454-R0-11
Contract C-353-66
Prepared in cooperation with Harza Engineering Co., Chicago, Ill.

Five important components of costs of tunneling, shafting and construction of terminals were identified. These cost components significant to tunneling, that is, those that account individually for more than approximately 5 percent of the total cost, are: (1) Excavation; (2) Muck loading, transport and disposal; (3) Tunnel supports; (4) Tunnel lining; and (5) Interface load supports. Similar cost components of shafting and terminal construction were identified. Five characteristics of the HSGT system and three groups of geologic conditions of the site that materially affect the cost components of tunneling, shafting and terminal construction were identified. These significant HSGT characteristics and site conditions are: (1) Tunnel and shaft diameter; (2) Terminal size; (3) Depth; (4) Shaft spacing; (5) Interface loads; and (6) Rock types grouped according to their excavation, supporting and water transmission characteristics. The rock types were delineated according to these groupings on maps of the project area. A study of the unit costs of work was made for each cost component, and the cost data were applied to determine the cost of an arbitrary tunnel system. (Author)
PB-178 201

JET DELIVERY OPTIMIZATION.

Final rept. Bowles Engineering Corp., Silver Spring, Md. Apr 68, 119p BEC-R-4-23-68
Contract 7-35381

The report investigates several ways of improving water jet delivery in order to increase the efficiency of hydraulic tunneling and mining. These approaches are directed toward the reduction of water jet velocity decay by suppressing pressure disturbances and turbulence which cause jet breakup, by such means as the use of turbulence suppressing chemical additives, the design of a minimum transverse turbulence nozzle, and the suppression of air shear on a free water jet by providing the jet with a moving air sheath. In addition, an investigation is made of the use of a Fluidic Jet Modulator to generate liquid slugs which would produce high pressure impulsive shocks when impacting upon a rock face. A survey is made of the various modes of rock fracture in order to relate the results of the investigation to the problems of tunneling or mining. An evaluation is made of each of the separate studies as to its applicability to tunneling and its technical and economic feasibility. Finally, a system is proposed which incorporates the most effective results of the investigation. (Author)
PB-178 437

HYPERVELOCITY JET DRIVER STUDY.

Final rept., Bowles Engineering Corp., Silver Spring, Md. V. Neradka, W. Walston, and R. Turek. May 68, 87p* BEC-R-22-68
Contract 3-0055
See also PB-178 437.

This study investigates analytically a concept for accelerating liquid slugs to high velocities by the use of supersonic gas nozzles. This technique is of interest for developing economic methods for cutting rock during tunnel construction. The merits of this concept are based on the fact that only moderate gas pressures are required to accelerate liquid slugs to velocities which have been demonstrated as suitable for fracturing rock material. To obtain these velocities by liquid nozzles alone, very high hydraulic pressures would be required. This concept, therefore, amplifies the pressure which is used to accelerate the slug to a high value delivered to the face of the rock material. The concept for mechanizing this augmentation is a hypervelocity gun comprising of a constant area section tube for accelerating the slug to sonic speed and a diverging area tube for further accelerating the slug to supersonic gas speeds. Analyses are performed to evaluate the lengths and acceleration times for both sections of the gun under different conditions of supply pressure and temperature and slug sizes. An important aspect of this concept is the requirement to control the hypervelocity jet driver repetitively at a controlled frequency and slug size. The design considerations for such a jet driver control system are considered and a preliminary concept is presented. (Author)
PB-178 506

CRACK INITIATION AND PROPAGATION IN ROCK.

Research rept., Massachusetts Inst. of Tech., Cambridge. Dept. of Civil Engineering. P. Forootan-Rad, and F. Moavenzadeh. May 68, 127p* R68-29 Contract C-85-65 Identifiers: Bifurcation, Intergranular cracks, Graphs (Charts).

Theories of crack initiation, propagation and bifurcation in perfect solids based on energy equilibrium criteria, elasticity theory considerations and particulate body mechanics are reviewed. Modifications of these and their applicability to rock are discussed. Different testing methods used to study the fracture characteristics of rock are reviewed; a bending method was chosen as most suitable for the purpose. A literature review on the effect of heat treatments on rock weakening are discussed. The principles of a continuous duty, high powered gas laser as a heat source are described. The values of the fracture surface energy were determined for four different geometries of a granite specimen; the results show that if a stable fracture is obtained, the value is independent of geometry. Results of the heat treatment and laser treatment studies on marble and granite show the thermal exposure causes a decrease in the value of ultimate flexural strength because of intergranular and transgranular cracks induced in the specimen. (Author)
PB-178 987

REVIEW OF EFFECTS OF HYPERVELOCITY JETS AND PROJECTILES ON ROCK.

Final rept., Missouri Univ., Rolla. Rock Mechanics and Explosives Research Center. George B. Clark, Charles J. Haas, John W. Brown, and Clifford D. Muir. Jun 68, 415p* Contract DC7-35511 Identifiers: Rock mechanics, Tunnels (Underground structures).

New methods are being continuously sought which will radically increase the rates of tunnel excavation. Attention has turned to the use of hyper-

velocity impact as a means of cutting and breaking rock, as well as the use of lasers, electric current, explosive drilling, high frequency vibration, etc. The information in this report was assembled and analyzed to give a state of the art summary of hypervelocity techniques which show promise for use in cutting and breaking rock. These include the use of water jets, metallic jets and hypervelocity projectiles. (Author)
PB-179 022

ROCK TUNNELING WITH HIGH SPEED WATER JETS UTILIZING CAVITATION DAMAGE.

Final technical rept., Hydronautics, Inc., Laurel, Md. R. E. Kohl. Jun 68, 52p* 713-1 Sponsored in part by Department of Transportation, Washington, D. C., Office of High Speed Ground Transportation. Identifiers: Tunneling (Civil engineering), Tunnels (Underground structures).

A test apparatus, capable of producing a 1/4-inch diameter jet up to 500 ft/sec was designed and built. Initial tests with this facility produced erosion intensities of 37 watts/sq. meter. This value was encouraging and demonstrated that the technique had potential. As a result a three-month extension of the contract was granted so that the operating parameters could be optimized thereby maximizing the erosion intensity. During this period the erosion intensity was improved from 37 watts/sq. meter to 670 watts/sq. meter. In addition those relationships such as the time dependence of erosion intensity and its variation with jet velocity were determined. The information was obtained for both a 1/4-inch and 1/8-inch nozzle. Once the behavioral relationships were established attention was directed to means by which the erosion intensity produced could be efficiently used. As a result a nozzle to specimen distance adjustment technique and specimen rotation technique were developed which improved volume removal by two orders of magnitude. Finally, the effect of heat treatment on reducing the strength of rock was briefly examined. (Author)
PB-179 076

THIN DISK TECHNIQUE FOR ANALYZING ROCK FRACTURES INDUCED BY LASER IRRADIATION.

Research rept., Massachusetts Inst. of Tech., Cambridge. Dept. of Civil Engineering. F. Moavenzadeh, R. B. Williamson, and F. J. McGarry. May 68, 91p R68-21, DSR-76103 Contract C-85-65

The report presents results to date in the study 'Laser Assisted Rock Fracture.' Thin disc samples of marble and granite have been irradiated for short intervals with unfocused 10.6 micron (infrared) radiation from a carbon dioxide-nitrogen-helium gas laser. The specimens were exposed to laser radiation of different power levels over various areas of one side. Thermo-sensitive paints applied to the face indicated the radial temperature distribution across the specimen, and the initiation of the crack was detected using electrically conductive silver paints on the other face. Good agreement was found between the experimental data obtained from the temperature at failure and the calculated thermal stresses developed in the specimens. The results indicated that failure occurred when the induced thermal stresses exceeded the tensile strength of the rock. (Author)
PB-179 205

MODELING A JOINTED ROCK MASS. Massachusetts Inst. of Tech., Cambridge. Dept. of Civil Engineering. For primary bibliographic entry see Field 11. PB-180 248

DESIGN OF TUNNEL LINEARS AND SUPPORT SYSTEMS.

Final rept., University of Illinois, Urbana. Dept. of Civil Engineering. D. U. Deere, R. B. Peck, J. E. Monsees, and B. Schmidt. Feb 69, 419p Contract DOT-3-0152 Identifiers: *Tunnel linings, Shotcrete, Arches.

Contents: Introduction; Fundamentals of tunnel support design; Existing theories, design methods, and practices; Tunnel support systems in soil and soft rocks; Tunnel support systems in rock--Factors influencing behavior; Tunnel support systems in rock--Design procedures; Potential developments of tunnel support systems; Shotcrete.
PB-183 799

ROCK BREAKAGE BY LIGHT-GAS GUN PROJECTILES.

Final rept. Feb 68-Jan 69, IIT Research Inst., Chicago, Ill. Victor G. Gregson, Jr., and Madan M. Singh. 22 Jan 69, 129p IITRI-D6000-FR-06 Contract DOT-3-0171 Identifiers: *Tunneling.

The report discusses hypervelocity impact on rock targets using a light-gas gun with Zelux projectiles (solid and water-filled). The specific energies for rock breakage range from 120 to 260 joules/cc (1,400 to 3,200 ft-lb/cu in.) for Indiana limestone, and from 80 to 120 joules/cc (900 to 1,500 ft-lb/cu in.) for Milford Pink granite. Rock descriptions and strength properties are included. Previous work on basalt by Gault (NASA) and Moore (USGS) is included. The specific energies compared to specific energies incurred by other potential drilling techniques indicates that high velocity solid impact is a potential method to increase drilling rates. A potential method is developed to calculate hydrodynamic crater volumes for given impact energies. The general problem is outlined whereby the strong shocks generating the hydrodynamic crater can be extended to include spall and fracture effects. (Author)
PB-184 191

ROCK PROPERTIES RELATED TO RAPID EXCAVATION.

Final rept., Missouri Univ., Rolla. Rock Mechanics and Explosives Research Center. Mar 69, 358p Contract DOT-3-0143 Identifiers: *Rock mechanics, Spalling, Rock disintegration, Excavation.

The purpose of this report is to present an evaluation of rock property measurement in relation to the problems of rapid excavation, to summarize recent theory and representative data, to point out their usefulness and limitations, and finally to indicate some of the pressing needs for further research and development. In most cases the investigators in specific areas of research have presented complete analyses of their work. Where possible, further analysis has been made, primarily in terms of application of results of research. (Author)
PB-184 767

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