NECTP-209

NORTHEAST CORRIDOR TRANSPORTATION PROJECT REPORT

Northeast Corridor Transportation Project

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

APRIL 1970

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THE SECRETARY OF TRANSPORTATION
WASHINGTON, D.C. 20590

May 4, 1970

Honorable Spiro T. Agnew
President of the Senate
Washington, D.C. 20510

Dear Mr. President:

I am transmitting to you a report on the status of the Northeast Corridor Transportation Project. I believe this report breaks significant new ground in the field of comprehensive quantitative analysis of some of the complex long range transportation problems the country now faces.

As is common with innovative and increasingly sophisticated approaches to very broad questions, this initial attempt is by no means conclusive. For this reason, the present study results must be considered tentative. Much further work remains to be done if we are to make the fullest use of the new information and techniques developed in the course of the Corridor Study.

In recognition of the present utility of the Corridor work and of its greatly enhanced future usefulness, I have recently transferred the Corridor group to the Office of the Assistant Secretary for Policy and International Affairs. At the same time, I have requested him to direct close personal attention to the planning and supervision of further Northeast Corridor and related studies.

Sincerely,

John A. Volpe

THE SECRETARY OF TRANSPORTATION
WASHINGTON, D.C. 20590

May 4, 1970

Honorable John W. McCormack
Speaker of the House of Representatives
Washington, D.C. 20515

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Sincerely,

John Volpe

UNITED STATES GOVERNMENT

Memorandum

DEPARTMENT OF TRANSPORTATION
FEDERAL RAILROAD ADMINISTRATION

DATE: APR 20 1970

In reply refer to:

TO : The Secretary

FROM : The Administrator

SUBJECT: INFORMATION: Northeast Corridor Transportation Project Report

I am transmitting this report on the status of the Northeast Corridor Transportation Project along with its supporting contractors' studies. The report contains certain revisions from the draft submitted to you in December 1969. The changes resulted from additional review and analyses of the draft report.

This report, containing the results of the first full exercise of the overall model system, and the analysis and methodology behind it represent a pioneering effort in the field of transportation analysis. The framers of the report have attempted to develop a system with extremely broad application, dealing with all modes of intercity passenger transportation, with the interactions between these modes, and with the impact that alternative transportation systems could have on the general welfare of the Corridor. The application of the Corridor model system and the techniques it represents should materially assist the Department in carrying out long-range transportation policy and program planning.

Expectations are that the present model system enhanced by near term future efforts will significantly improve the Department's ability to deal with the complicated transportation decisions it now faces such as:

....What effect would introduction of V/STOL air modes have on the economic viability of other modes in the Corridor?

....Can the declining rail patronage trend in the Northeast Corridor be reversed through application of new technology and/or service improvements?

....What would be the societal effects of alternative investment policies for the various transportation modes?

The great public interest in this report indicates that it should be released now. Only an early publication date with wide dissemination will permit the interested individuals to comment on the new transportation concepts and techniques contained in the report. The Department will benefit greatly from the informed discussion resulting from release of the report.

In this connection, however, care must be exercised by the reader in interpreting the contents of the report. It should be clearly understood that the conclusions contained in the present report are still somewhat tentative and incomplete in some instances. The conclusions are also strongly dependent upon the initial assumptions employed in developing the model systems and the data they use. Some of the results could change in the course of the further work now planned. For example, the report is rather negative regarding the purely commercial prospects for various new high speed ground transportation systems. On the other hand the total economic, environmental, and social impacts of these modes may justify their implementation even though they might not yield a commercial rate of return. In addition, for these high speed ground modes, the report results are based specifically on analyses of the characteristics of intercity transportation in the Northeast Corridor, and this may not properly represent situations in other corridor areas or for other types of applications within the Corridor.

The analysis is continuing with the specific purposes of identifying quantitatively the ranges of uncertainty in the analytical results, examining investment alternatives not considered in this report, and framing the results in terms which are most meaningful for public investment decision-making purposes. The results of these additional studies will enable the Department to make more definitive conclusions and recommendations which can be made available from time to time.

R. N. Whitman

R. N. Whitman

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CONCLUSIONS

The Northeast Corridor Transportation Project, through a comprehensive systems analysis approach, is engaged in analyzing and evaluating the transportation needs of the Northeast Corridor through 1980. This report presents some conclusions about the prospects of intercity passenger transportation in the Corridor and suggests ways in which transportation developments can be made more responsive to the Corridor's needs.

The following general conclusions about the future of intercity passenger transportation in the Corridor have resulted from analyses and evaluations conducted to date:

-----Auto transportation will continue as the strongly dominant mode of intercity Corridor transportation, at least through 1980, regardless of the improvements which can feasibly be made to other modes.

-----The effectiveness of intercity line-haul common carriers in improving door-to-door passenger service will be seriously limited in the Corridor's larger metropolitan areas by delays and relative slowness of local access to and egress from transportation terminals.

-----Without substantial action by the government agencies responsible for intercity passenger transportation in the Corridor area, the following results are probable in the Northeast Corridor:

(1) Major capabilities for the provision of rail passenger service will not be used;

(2) The potential for short and intermediate haul air transportation may not be exploited;

(3) Downtown-to-downtown intercity passenger transportation will, in large metropolitan areas, contribute to congestion on urban transportation facilities.

(4) Transportation facilities which present to travelers high personal accident hazard, which contribute heavily to air pollution, and which have heavy requirements for land will continue to expand;

(5) Less populated areas of the Corridor--rural and suburban--will lose common carrier intercity transportation service;

(6) The several modes of passenger transportation in the Corridor--auto, bus, air, and rail--will not be coordinated in ways which will improve service and raise efficiency.

The Northeast Corridor Transportation Project has depicted and evaluated several ways by which the Corridor transportation system could be made more responsive to the economic, political and social development of the region. Nine possible and widely different transportation systems which might be made operational in the Northeast Corridor in the 1975-80 period were analyzed and simulated, with the following salient conclusions:*

-----Boston to Washington rail passenger service approximating the level of performance of the Metroliners would achieve more efficient utilization of present rail capacity for mainline passenger service and would realize additional revenue in excess of additional costs. For several reasons, including the high cost of capital to the railroads in the Corridor, it is unlikely that the privately owned railroads in the Corridor will choose to provide such service without public support;

-----Improvements to the existing Boston-Washington mainline of the Penn Central Railroad costing up to $1.3 billion would result in substantially better transportation service to the centers of major metropolitan areas of the Corridor and would yield additional revenues sufficient to cover additional costs, including capital costs of 10 percent per year. These improvements can be made on an incremental basis thus permitting at each step a testing of the attractiveness of better service. Since it appears that the difference between incremental revenue and costs would be greatest at a level of improvement far short of $1.3 billion it seems even less likely that railroads would provide such a level of service without public support;

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*Such conclusions could, of course, change as further data and research results become available.

-----Short take-off and landing (STOL) and vertical take-off and landing (VTOL) aircraft modes would provide intercity transportation services throughout the Northeast Corridor yielding before-tax revenues sufficient to cover all non-government costs including capital charges at 10 percent per year. STOL and VTOL operation would require some improvement in air navigational technology and in environmental impact planning but only small technological improvements for aircraft;

-----Two new high-speed ground modes--one, a completely new rail system, and the second, a tracked air cushion vehicle system--would greatly improve intercity transportation along the spine of the Corridor. At the present stage in the analysis, it appears that neither of these two ground modes would be commercially viable within the next decade if a capital cost rate of 10 percent is required;

-----A combination of vertical take-off and landing (VTOL) air transportation and a high-speed ground mode would provide the widest choice of improved intercity passenger transportation in the Corridor, would generate the largest patronage, and would require the largest operating costs and capital outlays.

The analysis in the Northeast Corridor Transportation Project, to date, has been most useful when applied to the evaluation of the potential commercial viability of the nine alternative systems. An effort was made, however, as will be shown in the body of the report, to appraise each mode in terms of its environmental impact, dependence on improved terminal access-egress, dependability under all-weather conditions, improved safety, and flexibility to service occasional demand peaks. Depending upon the weighting of these considerations by public agencies, relative evaluations of the different systems may change.

The use of comprehensive systems analysis, such as carried on by the Northeast Corridor Transportation Project, can significantly reduce the probability of making capital outlays for transportation which are not responsive to public need or which may constitute inefficient ways of responding to public need.

BACKGROUND OF THE CORRIDOR TRANSPORTATION PROBLEM

The Northeast Corridor* is faced with growing demands for transportation which have been created by an expanding, ever more interdependent economy and an increasingly mobile society. Those who live, work and travel in the Corridor would probably regard such a conclusion as obvious. What is not so clear is how best to deal with the challenge that this pattern of growth presents. The problem is not in knowing that transportation facilities in the region need to be expanded and improved, but in deciding what improvements should consist of; where they should be located; when they should be introduced; and how they should be managed, financed, and operated.

Past Approaches

Traditionally, decisions of this nature have largely been made either by the private sector or, where private enterprise has not been practical or has not functioned in the public interest, by independently exercised local and state initiative, with some modicum of Federal involvement. This approach has worked fairly well in the past. After World War II the explosion in automobile production and ownership, accompanied by a shift of population to the suburbs, quite clearly pointed to the need for an expanded highway construction program. The opportunity to exploit, for civil purposes, the great advances in aviation technology gained during the war stimulated public support of airport and air navigation development.

As a result of emphasis and encouragement through public policy, both air and highway transportation have in the past two decades enjoyed consistent and substantial rates of growth and have unquestionably satisfied great public needs. Strong trends in the growth and distribution of population and economic activity in the Corridor have, however, tended to change the region's needs for transportation. These two trends are (1) the increasing concentration of population and employment in Standard Metropolitan Statistical Areas (SMSA's) defined as communities having populations of 50,000 persons or more, and (2) dispersal of population and employment away from urban cores into the suburbs.

Population and Employment Trends

By 1980, over 46 million people will live in SMSA's in the Corridor and about 8.3 million in rural areas. The distribution of population and employment between suburban and core areas through 1980 is more difficult to predict. While there have been pronounced population shifts into the suburbs in the last decade, there have also been large migrations into the Corridor's urban cores from regions outside the Corridor. Nevertheless, between 1950 and 1960 the major urban cores

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*Figure S-1 shows the Northeast Corridor region as it has been defined for purposes of the Northeast Corridor Transportation Project.

Figure S-1 The Northeast Corridor Transportation Project Region in the Corridor lost about five percent in both population and employment while the suburbs gained over 40 percent. The effects of these changes, even if their pace were slowed, will have important impacts on the Corridor's life patterns for years to come.

Changing Needs for Transportation

The trends of population and employment toward metropolitan areas and from the metropolitan cores to their suburbs are undoubtedly responsible for many of the complaints of congestion and delay persistently leveled against the transportation system of the Corridor. Neither highway nor air transportation in their present forms are well suited to the increasingly tight constraints of space in the Corridor; both modes require for efficient operation relatively large amounts of space per unit of traffic. Air transportation's primary advantage, namely speed, is being seriously diminished for short and intermediate trips within the region by congestion in the air and on the ground. In the Corridor, gate-to-gate times between major airports have remained essentially unchanged over the past dozen years--and have risen in some instances--despite a 30 to 40 percent increase in aircraft cruising speeds.

A comparable situation is emerging in highway transportation. The toll roads built in the early 1950's and the facilities constructed under the Interstate highway program have expanded the flow of intercity highway traffic in the Corridor considerably, especially in suburban and rural areas. But congestion in and around metropolitan centers, particularly during peak periods, has tended to reduce the advantages of freeway travel. New roads and highways, constructed to relieve congestion, have often encouraged new traffic to the point that delays in related parts of the highway network have been increased rather than reduced. Public frustration, a sense of crowding, and concern over wasted resources are all natural responses to this cycle of temporary relief and chronic congestion. Thus, the approaches to transportation problems which seemed to be so obvious 20 years ago do not seem so clearly to meet the Corridor's needs today.

The Impact of Urban Congestion

A major reason for the present inadequacy of short and intermediate intercity passenger transportation is that we have not yet managed to cope effectively with the problems of transportation within large urban areas. Since the Northeast Corridor is preeminently a region of large cities, a very high proportion of all intercity travel in the Corridor involves one or more large metropolitan areas. Hence, the quality of intercity transportation in this region depends in large measure on the relative ease of circulation within metropolitan areas.

The nature and extent of improvements in urban transportation are highly uncertain, and this uncertainty must inevitably impinge upon decisions which might be made about the intercity system. For example, a policy of enhancing, through continued development of urban beltways, the accessibility of suburban (as contrasted to inner-city) portions of metropolitan areas would tend to predispose intercity transport development toward modes such as V/STOL which would be oriented to the metropolitan periphery. If, on the other hand, greater emphasis were placed on enhancing accessibility to the city core through improving and developing radial urban rapid transit, then building intercity high speed ground modes which would pentrate to city centers would be more appropriate.

Problems of Coordination

Uncertainties about the directions which should be followed to make intercity transportation more effective in meeting the Corridor's needs are heightened by the region's loose and largely uncoordinated decision-making structure for transportation. Ten States plus the District of Columbia and well over a dozen major regional agencies have responsibility and authority for transportation planning and investment in the Corridor. To the authority and responsibilities which these agencies have, must be added the interests of the Federal Government and a myriad of private firms. Few statutory procedures exist which could bring coordination to the planning of transportation improvements in the Corridor. The result is that decisions are often made in one jurisdiction without adequate consideration of their effects on other jurisdictions. It is reasonable to assume that the bottlenecks and discontinuities in the Corridor transportation system today will not be dealt with satisfactorily without increased attention devoted to coordination between agencies in the Corridor involved in transportation.

All things considered there are no obvious solutions to the problems of intercity transportation in the Northeast Corridor. Additions to highway and air facilities have come to contribute less and less to the effectiveness of transportation systems in heavily urbanized regions. Railroads, once the mainstay of the Corridor's intercity passenger transportation, have had declining passenger patronage since World War II. The decision-making structure is fractionated and does not focus on transportation as a system, and even if it were to, neither tools nor data have been available for comprehensive approaches to transportation planning.

ADOPTION OF A SYSTEMS APPROACH

Recognition of the growing ailments of the transportation system of the Northeast Corridor and of the shortcomings of existing policies as remedies led in 1964 to establishment of the Northeast Corridor Transportation Project. In a deliberately experimental way, the Corridor project was to be a systematic attempt at determining the intercity transportation facility requirements of a major region of the Nation. In making this attempt, the project was charged (1) to analyze the complex interactions between transportation and structure of economic and demographic development of the Corridor, (2) to forecast the demand for intercity transportation services by mode in the Corridor, (3) to describe the characteristics of transportation services that might be supplied, and (4) in doing all this to give full consideration to the potential of dynamic, innovative transport technology.*

Development of a Model System

In five years, starting at a very inchoate level of knowledge and methodology, the Northeast Corridor project has fulfilled many, although clearly not all, of these assignments. Using systems analysis techniques and newly developed computer capabilities, progress has been made in developing and applying a comprehensive, general approach to regional transportation analysis. The most important achievement of the Corridor project up to now has been to develop, link together, and operate several models in an interactive process which simulates the forces of transportation supply and demand in the Corridor. The resulting system of models permits examination of the effects of changes upon the competitive interrelationships among modes, and also of interactions between transportation and other sectors of the Corridor economy. A dynamic model process of this nature has not been applied before to regional transportation in the U. S. The basic elements of the model system are as follows:

-----An econometric model which forecasts population, income, employment, and land use for each of 131 analysis districts (mostly counties) of the Northeast Corridor.

-----A demand model which predicts intercity passenger travel in the Corridor by city pairs and by modes of travel.

-----Supply models for air and high speed ground modes which are sensitive to changes in output levels.

-----Cost models which, based on parametric relationships, predict elements of mode and system cost.

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*This approach was recommended in an executive agency task force report in late 1962.

-----Impact models which predict the effect of transportation changes on population, employment, income and land use in county-size analysis areas.

-----Supply-demand balancing techniques which make possible simulation of supply-demand equilibrium.

Usefulness of the Model System

The individual models suffer from many shortcomings and hence the results of the model/simulation process should be treated with caution. Nevertheless the performance of the models in evaluating the transportation system alternatives discussed in this report is satisfying both to intuition and to experience. With few exceptions the models produce results which are credible when related to real world situations and their use almost certainly can enhance our ability to make better decisions. Moreover, the process of modeling the Corridor transportation system has substantially raised the level of insights into the workings of the transportation system particularly in application to subareas of the Corridor such as states and counties. It would on the other hand, be a mistake to accept too literally the results of the model simulation process.

The models for forecasting transportation demand have proved their capability to predict the "split" of demand among several competing modes. This allocation of demand among the modes is based not on each mode per se but on three basic characteristics of transportation service; namely, trip time, user cost and frequency of service. By approaching the modal split in this way it becomes possible to predict the response of the travel market to totally new modes such as tracked air cushion vehicles (TACV). Reliance by the model on three characteristics of transportation to determine modal split undoubtedly omits some of the factors which influence travel behavior. In the analysis of transportation alternatives in this report other considerations such as comfort, safety, and fashion have been assumed to be equal among the modes. When these attributes differ to a degree which significantly affects modal split, the Corridor demand model becomes less useful.

The development of techniques to forecast impacts of transportation on population, employment, and other economic variables by area has been the major thrust in the attempt to measure the interaction between transportation and its social, political and economic environment. The Corridor impact models show only small effects resulting from the intercity passenger travel changes evaluated in this report. This was to be expected. Indications are that the impact of changes in freight transportation would be much greater. At this time, however, data on freight movements do not exist in the Corridor or elsewhere upon which to test the predictive capability of the impact models. Reliance for model formulation and calibration on patched and stitched-together data must raise an element of uncertainty about results and suggests strongly the need for continued emphasis on a transportation data program.

The development of the Corridor models and procedures is continuing with the goal of producing a set of tools generally useful for the comparison and evaluation of transportation system improvements. The Corridor models can be applied to Corridor transportation in a longer time frame than has been done in this report; they can, with further development, also be applied to the evaluation of freight transportation systems. It should be pointed out, however, that while the models can, with relatively small but necessary recalibration, be applied to intercity passenger movement in other Corridor-type regions of the U. S., they cannot be used in their present form to predict intra-urban passenger traffic. Intra-urban travel and the behavior patterns of commuters are subject to many other influences than those used in determining intercity transportation.

Application of the Models to Alternative Transportation Systems

It was understood at the outset of the Corridor project that transportation system changes tend to have wide implications for regional development and for many other aspects of public policy beyond the sphere of transportation. It was clearly not appropriate for the Northeast Corridor project staff to decide which of these public policies should be pursued. Therefore, a basic premise of the Corridor project has been that the project would evaluate and report on a number of alternative transportation systems which would be responsive to a wide range of policy options. This strategy was intended to permit responsible officials at the Federal level and in in the Corridor to relate transportation to fundamental policy objectives. For purposes of the evaluations reported on here the following public policy options were emphasized:

(1) Degree of technological innovation--ranging from continued evolutionary development of the present set of modes and services to a quite radical departure involving the introduction of a combination of advanced ground and air modes;

(2) Emphasis on suburban or central city service--ranging from ground modes penetrating the city core via tunnels to air systems largely serving the periphery of metropolitan areas;

(3) Magnitude of capital cost--ranging from minimal investment in new equipment to multi-billion dollar new investment in fixed facilities and equipment;

(4) Service characteristics--ranging from high capacity modes operating on fixed rights-of-way to more flexible systems capable of providing service over a wide area;

(5) Degree of private vs. public investment--ranging from systems which could be sustained by private investment and ownership to systems which would require Government support for their construction and operation;

(6) Requirements for institutional change-- ranging from alternatives which would require only nominal intergovernmental coordination under existing statutory authorization to those which would require new legislation and extensive coordination at Federal, State, and local levels.*

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*See Table S-2 for the relationship between these six policy options and the nine alternative transportation systems analyzed by the project.

ALTERNATIVE PASSENGER TRANSPORTATION SYSTEMS FOR THE NORTHEAST CORRIDOR, 1975-80

The nine alternative systems start with the existing transportation system of the Northeast Corridor projected to 1975-80, and add five new modes in varying combinations with the existing system and with each other--as shown in Table S-1. The designed service pattern of each alternative is generally north-south between Washington and Boston. Each of the high speed ground modes--demonstration rail, high speed rail A, high speed rail C and tracked air cushion vehicles--was designed to serve terminals at Washington and Boston and seven intermediate points in Providence, western Connecticut, New York City, northern New Jersey, Trenton, Philadelphia and Baltimore. The air and highway modes serve more dispersed patterns based on existing networks.

Alternatives I and II

Alternatives I and II would require capital expenditures by 1975 of about $70 million for equipment and grade crossing elimination.

Both alternatives would expand the present fleet of Metroliners and Turbo trains in accordance with increases in demand. Relatively small improvements in roadbed would focus primarily on eliminating highway-rail grade crossings. The annualized equipment cost and roadbed improvement costs would be less than half the additional revenues realized from the DEMO level of operation. (See Summary Table S-4) Although patronage of rail passenger service to Boston-Washington and intermediate points would increase between 1968 and 1975, rail passenger patronage as a whole in the Corridor would decline. The breakdown of the Corridor intercity travel market by modal shares in 1968 and 1975 is shown in the following:

Shares of Corridor Intercity Travel Market by Mode
Percent Passenger-Miles
Alternative I

Year	Auto	Bus	Rail	Air
1968	68	8	13	11
1975	73	9	9	9

Although alternatives I and II do no more for the ground modes than add demonstration rail, even this minimal action would probably require Federal legislative action of some kind. It is not certain that without such legislation the present Metroliner and Turbo train services inaugurated for two years in response to Federally supported high speed ground transportation demonstrations would continue and, in response to demand, expand through 1975.

TABLE S-1 NINE PASSENGER TRANSPORTATION SYSTEM ALTERNATIVES FOR THE NORTHEAST CORRIDOR

ALTERNATIVE	MODAL COMPOSITION
I	Auto, Bus, Conventional Air (CTOL) Demonstration Rail (DEMO)* --125 mph
II	Auto, Bus, CTOL, DEMO Short Take-Off and Landing Air (STOL)--370 mph
III	Auto, Bus, CTOL, STOL High Speed Rail "A" (HSRA)--150 mph
IV	Auto, Bus, CTOL, STOL High Speed Rail "C" (HSRC)--200 mph
V	Auto, Bus, CTOL, STOL Tracked Air Cushion Vehicle (TACV)--300 mph
VI	Auto, Bus, CTOL, STOL, DEMO Vertical Take-Off and Landing Air (VTOL)--265 mph
VII	Auto, Bus, CTOL, STOL VTOL & HSRA
VIII	Auto, Bus, CTOL, STOL VTOL & HSRC
IX	Auto, Bus, CTOL, STOL VTOL & TACV

*Demonstration rail assumes that the present Metroliner and Turbo train services will be expanded and extended through 1975.

TABLE S-2 RELATIONSHIP BETWEEN TRANSPORTATION SYSTEM ALTERNATIVES AND PUBLIC POLICY OPTIONS

Alternatives	New Modes*	Policy Options					
		Degree of Technological Innovation	Orientation to Metropolitan Area	Capital Cost	Service Character-istics	Public Support Required	Institutional Change Required
I	DEMO	None	Center City	Low	Fixed Linear	No	Little
II	Demo & STOL	None	Center City & Suburbs	Low	Mixed	No	Little
III	HSRA	Some	Center City	Medium	Fixed Linear	Yes	Large
IV	HSRC	Some	Center City	High	Fixed Linear	Yes	Large
V	TACV	Much	Center City	High	Fixed Linear	Yes	Large
VI	VTOL	Some	Suburbs	Low	Flexible Dispersed	No	Little
VII	VTOL & HSRA	Some	Center City & Suburbs	Medium	Mixed	Yes	Large
VIII	VTOL & HSRC	Some	Center City & Suburbs	High	Mixed	Yes	Large
IX	VTOL & TACV	Much	Center City &Suburbs	High	Mixed	Yes	Large

*Auto, bus and conventional air are included in all alternatives; STOL is included in alternatives II through IX.

Under alternative I total new public capital expenditures between 1968 and 1975 for intercity passenger transportation in the Northeast Corridor would be $3 billion. Most of this outlay would be for expansion of the existing highway and air modes *

Across the board, alternative I would make only small improvements in the quality of transportation service in the Corridor. Alternative II, as well, would offer only limited improvement in the quality of intercity passenger service in the Northeast Corridor although it would emphasize the provision of STOL service to the periphery of metropolitan areas. Traffic attracted to STOL would tend to reduce the share of CTOL below its share in alternative I. The share of Corridor traffic going to air, auto, rail and bus would change between alternative I and alternative II as follows:

Shares of Corridor Intercity Travel Market by Mode in 1975 Percent Passenger-Miles					
Alternatives	CTOL	STOL	Auto	Rail	Bus
I	9	--	73	9	9
II	3	12	68	8	9

Since STOL service in alternative II (as well as in alternatives III through IX) would be commercially viable, new Federal Government expenditures would be required only to provide supplemental air navigation facilities.

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*All the alternatives assume that current plans for highways and CTOL will be implemented.

Alternatives III, IV and V

Alternatives III, IV, and V would introduce major improvements in city-center-to-city-center high-speed ground transportation. The high-speed ground mode in alternative II would rely on existing railroad rights-of-way; the high-speed ground modes in alternative IV and V would require completely new rights-of-way. Alternative III would require capital expenditure for all new modes of $1.8 billion; alternative IV, $2.8 billion; and alternative V, $3.5 billion.

HSRA would require only moderate technological advance; HSRC would require substantial R & D expenditure to bring rail operating speeds up to 200 mph; TACV would require an extensive program of R & D to achieve 300 mph operating capability.

Alternatives III, IV, and V would utilize centrally generated electric power and would operate underground in urban areas. Therefore, their effect on land use, noise, and air pollution would be minimal.

The share of total intercity passenger traffic in 1975 which would be captured by the high-speed ground modes is shown in the following:

Shares of Corridor Intercity Travel Market by HSGT Mode Percent Passenger-Miles			
Alternative II (DEMO)	Alternative III (HSRA)	Alternative IV (HSRC)	Alternative V (TACV)
8	12	15	18

Forecasts for the three new ground modes indicate that they would not be commercially viable in the year 1975, assuming a capital cost of 10 percent, and would probably not be commercially viable for the 10 to 15 years beyond 1975. In the year 1975, largely as a result of interest charges on the initial investment in right-of-way and track, HSRA in alternative III would incur a deficit of $27 million; HSRC in alternative IV, a deficit of $67 million; and TACV in alternative V, a deficit of $103 million. Thus, at least at the outset, the high-speed ground modes would presumably require substantial public support. This could be achieved through subsidy to a private corporation, establishment of an authority, charter of a public corporation, or through outright Federal ownership.

It should be emphasized that the high speed modes, because of their high capital costs, are highly sensitive to the interest rate chosen and passenger demand actually realized. For example, if the cost of capital were lowered to six percent, the ground modes could be commercially viable in 1975; on the other hand, a rise in the cost of capital above ten percent would intensify the magnitude of the potential deficit. Similarly, if the actual demand were in error by 12 to 25 percent, the deficit would disappear or intensify.

Alternative VI

Alternative VI would add VTOL to alternative II. The performance characterisitcs of VTOL would be responsive to the migration of Corridor population and employment from center city to suburbs. The resulting combination of the existing modes and VTOL would emphasize service to suburban areas. Heliports and flight paths could be located so as to minimize the adverse impact of noise. Where practical, VTOL would be designed to provide service to downtown as well as to the suburbs; however, emphasis in alternative VI would be on frequent service to heliports located on the periphery of metropolitan areas.

Revenues from VTOL service would be sufficient to cover research and development and terminal costs. This analysis did not include some additional expenditure, presumably public, which would have to be made on VTOL for the development and implementation of air navigation facilities and air traffic control techniques. Also, although it was not included as a cost of VTOL operation in alternative VI, research and development to reduce aircraft noise appears necessary. In comparison with the total cost of the VTOL mode, these additional costs do not appear to be large.

Since VTOL in alternative VI could be self-sufficient, presumably service would be provided by one or more privately financed, certificated carriers.

The shares of traffic which would result from alternative VI as compared to alternative II are shown in the following:

Share of Corridor Intercity Travel Market by Mode Percent Passenger-Miles						
Alternative	CTOL	STOL	VTOL	Auto	Rail	Bus
II	3	12	--	68	8	9
VI	2	10	14	60	7	7

Alternatives VII, VIII, IX

These three alternatives would combine VTOL with HSRA, HSRC, and TACV respectively. The resulting systems would greatly improve transportation service to the downtown areas of the cities "on line" between Boston and Washington and, like alternative VI, would provide better service to the suburbs of metropolitan regions in the Corridor.

VTOL would continue to be self-sufficient in all three alternatives. Capital cost for the ground modes would be slightly less than in alternatives III, IV, and V. Annual deficits, however, would increase as shown in Summary Table S-4 Thus, public support would have to be provided for construction and operation of the ground modes.

Total transportation service in the Corridor would be increased substantially in its quality and probably in its use. Projected shares of intercity Corridor passenger traffic under alternatives VII, VIII and IX are shown in the following:

Shares of Corridor Intercity Travel Market by Mode Percent Passenger-Miles							
Alternative	C/STOL	Auto	Bus	VTOL	HSRA	HSRC	TACV
VII	11	58	7	14	10	--	--
VIII	11	56	7	13	--	13	--
IX	10	55	7	13	--	--	15

Second Order Rail Alternatives

The ground modes in alternatives II and III represent the minimum and probably the maximum improved conditions applicable to the existing Penn Central Railroad route between Wahington and Boston. Almost a continuum of possible improvement options exists, however, between these extremes. In order to obtain an indication of the economic feasibility of these improvements, the Corridor model system was applied to nine intermediate levels of improvement between alternatives II and III.

The analysis was conducted by delineating a number of separate projects such as laying welded rail, easing curves, rebuilding bridges, and building new tunnels and bypasses, and determining the costs and running time savings attributable to each project. By using the passenger loadings for each link of the DEMO mode in alternative II, the passenger-minutes saved per dollar of expenditure for each project were calculated and the projects were ranked according to this ratio.

For the analysis, nine levels covering the range of improvements were selected. For each of these levels calculations were made using the NECTP model system to determine additional patronage, gross additional revenues, additional operating costs, annual charges for new investment, and additional net revenues.

The conclusions to be drawn from this analysis are as follows:

1. The maximum benefits to the operator would occur at a level of improvement representing a capital expenditure of $186.5 million (including $78.2 million for vehicles). Annual gross revenues at this level of improvement for 1975 would be $25.9 million more than rail (DEMO) in alternative II, while annual systems costs would be $18.3 million higher than the DEMO costs. The total surplus of additional revenues in 1975 over additional costs annualized for 1975 would be $83 million. This level of improvement results in a 25 percent patronage increase over rail in alternative II.

2. Up to a capital expenditure of $1.3 billion, 1975 annual gross revenues (additional) would exceed annual systems costs (additional). At this investment level, representing a 50 percent increase in patronage over DEMO, annualized additional costs and gross 1975 revenues would be equal.

3. From the level of improvement representing maximum net revenues to the operator to the level of improvements represented by HSRA in alternative III, net revenues would drop. At the upper levels of improvement, costs of capital would become a very significant element of total cost.

Intermodal and Intergovernmental Coordination

Each of the nine transportation system alternatives would require some degree of intergovernmental cooperation for effective planning and implementation. In a broad sense, the efforts represented in this report reflect the need for a coordinated "system" approach to transportation planning. Thus, each alternative should be regarded in a real sense as a system, requiring coordination among the modes if maximum benefits are to be achieved. The degree of coordination needed would vary with the mode in question. Both STOL and VTOL would require coordinated action on the part of the Federal agencies involved (presumably the Department of Transportation and the Civil Aeronautics Board) and the private carrier or carriers, and with the local jurisdictions in which STOL ports or heliports would be located. DEMO and HSRA would require extended cooperation between the Penn Central Railroad and the Federal Government for funding and, perhaps, operation of services. HSRC and TACV both require extensive intergovernmental coordination for acquisition of new rights-of-way and for construction and operation.

All systems would benefit from continuous central coordination by the Federal Government or by a regional agency to assure effective and efficient matching of facilities and services of the modes with each other and with demand as a whole.

Following in Tables S-3 and S-4 are summaries of performance and operating characteristics of the nine alternative systems.

TABLE S-3 SUMMARY OF MAJOR CHARACTERISTICS OF NECTP TRANSPORTATION SYSTEM ALTERNATIVES

Alternatives	New Modes	Sustainable Top Speed, mph	Average Speed* Terminal to Terminal, mph	Average Speed* Door to Door, mph	Total Corridor Intercity Travel,** billion pass. miles
I	DEMO	125	72	46	19.4
II	DEMO	125	72	46	20.3
	STOL***	370	141	63	
III	HSRA	150	109	58	21.1
IV	HSRC	200	152	71	21.7
V	TACV	300	198	79	22.3
VI	VTOL	265	147	74	20.3
VII	VTOL	265	151	70	20.8
	HSRA	150	109	57	
VIII	VTOL	265	152	70	21.5
	HSRC	200	157	70	
IX	VTOL	265	144	70	22.1
	TACV	300	205	78	

* Statistical averages computed for each mode by dividing total passenger hours into total passenger miles. Note the controlling influence of access-egress time on door-to-door speeds.

** Includes auto

*** STOL is included in alternatives II through IX.

TABLE S-4 SUMMARY OF FINANCIAL CHARACTERISTICS
OF NECTP TRANSPORTATION SYSTEM ALTERNATIVES

New Modes

Alternatives	New Modes	Total Capital Cost, $ x 10^6	Incremental Annualized Costs $ x 10^6	Annual Revenues $ x 10^6	Annualized Surplus or (Deficit) in 1975* $ x 10^6
I	DEMO	70	$ 61	$144	83
II	DEMO	69	60	141	81
	STOL**	195	244	244	0
III	HSRA	1590	240	213	(27)
IV	HSRC	2600	355	288	(67)
V	TACV	3340	452	349	(103)
VI	VTOL	1060	318	318	0
VII	VTOL	966	310	310	0
	HSRA	1580	230	175	(55)
VIII	VTOL	971	292	292	0
	HSRC	2590	340	240	(100)
IX	VTOL	966	291	291	0
	TACV	3330	440	292	(148)

* STOL and VTOL service and fare levels were set to achieve break-even operation at a ten percent return on investment; HSRA, HSRC and TACV service levels were set to maximize profits (revenues less costs); DEMO figure represents the difference between incremental revenues and incremental costs to provide DEMO service. It does not reflect any allocation to DEMO service of costs currently borne by the railroad.

** STOL is included in alternatives II through IX.

CURRENT APPLICATIONS AND FUTURE DIRECTIONS

The creation and successful application of the Northeast Corridor Transportation Project model system constitute a significant step forward in multi-modal transportation investment evaluation. A model structure capable of depicting the interactions of the major elements of a transportation system has now been applied to a set of real-world problems in a highly industrialized region.

In addition to the applications and results presented in this report, the model system already is being used to provide inputs to Department of Transportation policy planning and decision-making in a number of related areas. For example, NEC models have supported work on (1) future utilization of STOL and VTOL aircraft; (2) initial planning for TACV demonstration; (3) identification of HSGT research and development priorities; and (4) the rail passenger network problem. In these applications, the model/simulation system has demonstrated a capability for projecting patronage, as well as demographic effects of major transportation system changes, at levels of detail and precision useful for planners.

A complete description of potential applications of the models and methodology would encompass support to almost all regional freight and passenger transportation policy responsibilities of the Department of Transportation itself. Figures S-2, S-3, and S-4 present specific examples of applications of Project capabilities. These are tabulated by time period to portray (1) current applications; (2) new uses after interim improvements in the model are completed by 1971; and (3) longer term developments and applications for 1972 and beyond.

The "Current" columns of the figures show a wide range of current uses of Corridor work, and emphasize the contribution to planning studies now underway*. The following questions taken from the broader more detailed list in the Figures illustrate current project capabilities:

- What effect would introduction of high speed rail service have on the economic viability of STOL in the Corridor?

- What city-pairs would benefit most from STOL service?

- Can the declining rail patronage trend in the NEC be reversed through application of new technology and/or service improvements?

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*Black dots and underlining in the Figures highlight decision points; lack of underlining points out general study work; and boxes delineate present and planned project outputs and methodological developments of the Corridor group.

In future developments, Corridor work will be focused on near term efforts to extend the work at hand and strengthen utilization of Corridor models and data base within the Department. Evaluation methodology will be improved to integrate more fully the external costs and benefits over the life-cycle of the systems. The "1971" columns of the Figures show the progression of Corridor work through time, and show how the applications listed quickly lead to increased use of the model system outputs for decision-making. For example, extended work will contribute significantly to resolution of the following questions:

- Which modal research and development efforts will have largest potential payoffs for short-haul passenger service?

- What are the benefits and costs of improving urban access to intercity transport services?

- What mix of CTOL-VTOL-STOL services should Government investment policy encourage?

- Under what conditions would TACV be commercially successful in the Northeast Corridor?

In the more distant future, as the work is expanded to include examination of other corridors and other modes using improved techniques, many important decisions facing the Department will be affected by the improved ability to predict the impact of alternative courses of action available. Policy issues which would be addressed with expanded methodology are illustrated by the following questions:

- How should investments be phased to balance line-haul improvements with better urban access?

- Can application of new rail technology and/or service improvements reverse rail patronage trends in less congested corridors?

- Should new freight modes be developed and implemented?

- What impact would changes in passenger and freight transportation facilities have on employment, income, land use and population at local and regional levels?

Examples of additional decisions which could be supported by long-term expansion of capabilities are shown as underlined items in the "1972 and Beyond" columns of the Figures.

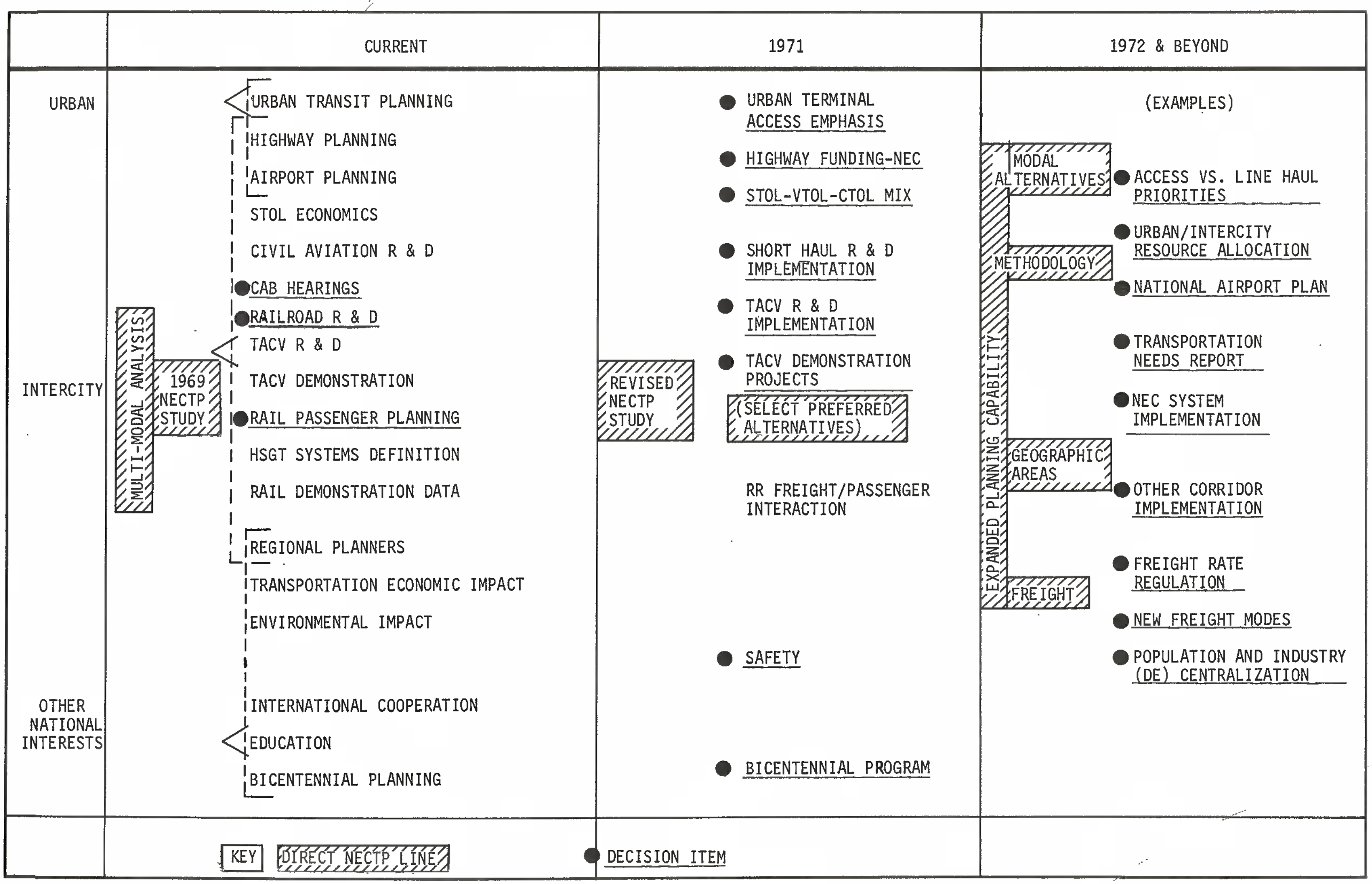

FIGURE S-2 CURRENT APPLICATIONS AND FUTURE DIRECTIONS

	CURRENT	1971	1972 & BEYOND
INTERCITY MULTI-MODAL ANALYSIS	PASSENGER NEW TECHNOLOGIES WHICH NEW TECHNOLOGIES ARE ECONOMICALLY VIABLE? HIGHWAY PLANNING TO WHAT EXTENT CAN INTERCITY HIGHWAY TRAFFIC BE DIVERTED TO COMMON CARRIERS? AIRPORT PLANNING IDENTIFY CTOL AIRPORTS IN NEC WHOSE AIR TRAFFIC MIGHT BE REDUCED BY THE INTRODUCTION OF ALTERNATE MODES. STOL ECONOMIC TASK FORCE WHAT EFFECT WOULD THE INTRODUCTION OF HIGH SPEED RAIL HAVE ON THE ECONOMIC VIABILITY OF STOL IN THE NEC? CIVIL AVIATION R & D WHAT WOULD BE THE BENEFITS FROM ALTERNATIVE R & D EXPENDITURES? ● CAB STOL HEARINGS WHAT CITY PAIRS WOULD BENEFIT MOST FROM STOL SERVICE? ● RAILROAD R & D WHAT SPECIFIC AREAS OF R & D HAVE MOST PAYOFFS FOR RAILROAD PASSENGER INVESTMENTS (SPEED, FREQUENCY, COMFORT, TERMINALS TO EASE ACCESS)? HSGT R & D WHAT SPECIFIC AREAS OF R & D HAVE MOST PAYOFFS FOR PASSENGER INVESTMENTS? TACV DEMONSTRATION WHAT KINDS OF INFORMATION SHOULD THE TACV DEMONSTRATION BE DESIGNED TO PRODUCE? ● RAIL PASSENGER PLANNING CAN THE DECLINING RAIL PATRONAGE TREND IN THE NEC BE REVERSED THROUGH APPLICATION OF NEW TECHNOLOGY? HSG SYSTEM DEFINITION WHAT CONFIGURATIONS AND OPERATIONAL CHARACTERISTICS SHOULD HSG SYSTEMS HAVE? RAIL DEMO DATA WHAT KIND OF INFORMATION SHOULD BE PRODUCED AND WHAT EXPERIMENTS SHOULD BE PERFORMED? FREIGHT	● HSG - V/STOL WHAT MIXES OF TRANSPORTATION ARE MOST APPROPRIATE FOR DIFFERENT REQUIREMENTS? ● HIGHWAY FUNDING WHAT WOULD THE EFFECT OF DIVERSION BE ON HIGHWAY REQUIREMENTS? ● CTOL-VTOL-STOL MIX WHICH MIX OF THESE SERVICES SHOULD GOVERNMENT INVESTMENT POLICY ENCOURAGE? SPECIFICALLY-LOCATION & UTILIZATION OF SUCH SERVICE. ● SHORT HAUL R & D IMPLEMENTATION WHAT R & D EXPENDITURES HAVE THE LARGEST POTENTIAL PAYOFFS FOR PASSENGER SERVICE? ● TACV PROJECTS WHAT CONDITIONS ARE REQUIRED FOR AN ECONOMICALLY SUCCESSFUL TACV MODE IN THE NEC? RR FREIGHT/PASSENGER INTERACTION IS HIGH SPEED, HIGH FREQUENCY PASSENGER SERVICE COMPATIBLE WITH PENN-CENTRAL FREIGHT OPERATION?	● R & D REQUIREMENTS WHICH R & D TASKS HAVE BIGGEST NET PAYOFFS? HOW IS INTERMODAL INTEGRATION BEST ACHIEVED? HOW IS THE UTILIZATION OF SURFACE RIGHTS-OF-WAY BEST DESIGNED TO SERVE MULTIPLE MODES? ● RAIL PASSENGER PLANNING CAN THE APPLICATION OF NEW TECHNOLOGY AND/OR SERVICE IMPROVEMENTS REVERSE THE RAIL PATRONAGE IN LESS CONGESTED CORRIDORS? ● R & D PLANNING & PRIORITIES WHAT PRIORITIES SHOULD BE ASSIGNED TO RESEARCH AND DEVELOPMENT IN FREIGHT TRANSPORT? ● INVESTMENT PLANNING SHOULD NEW MODES OF FREIGHT TRANSPORT BE DEVELOPED AND IMPLEMENTED? ● COMMODITY RATE AND ALLOCATION DECISIONS IS RATE REGULATION NECESSARY? IF REGULATION, SHOULD THERE BE MARGINAL COST PRICING OF FREIGHT RATES? ● REGIONAL IMPACT WHAT IMPACT WOULD IMPROVED FREIGHT TRANSPORT HAVE ON EMPLOYMENT, INCOME, LAND-USE AND POPULATION TRENDS AT LOCAL AND REGIONAL LEVELS?

FIGURE S-3 MULTI-MODAL ANALYSIS APPLICATIONS -INTERCITY

	CURRENT	1971	1972 & BEYOND
URBAN MULTI-MODAL ANALYSIS	URBAN PLANNING WHAT INTERCITY TRANSPORTATION SERVICE IS MOST COMPATIBLE WITH THE MOVEMENT OF POPULATIONS TO THE SUBURBS?	● URBAN PLANNING WHAT IS THE IMPACT ON METROPOLITAN DEVELOPMENT ATTRIBUTABLE TO INTERCITY TRANSPORTATION? 1) CENTER CITY TO SUBURBS 2) NEW CITIES 3) RETAIN GREEN BELTS AND RURAL AREAS 4) OUTSIDE CITIES AND TOWNS	● COORDINATED PHASING OF ACCESS AND LINE HAUL INVESTMENT HOW SHOULD INVESTMENTS BE PHASED TO BALANCE LINE HAUL IMPROVEMENTS WITH BETTER URBAN ACCESS?
	HIGHWAY AND MASS TRANSPORTATION PLANNING WHAT LOADS DOES INTERCITY TRAVEL IMPOSE ON URBAN SYSTEMS? TO WHAT EXTENT WOULD CAPITAL INVESTMENTS IN URBAN TRANSPORTATION SYSTEMS BENEFIT INTERCITY TRAVELERS? TO WHAT EXTENT WOULD CONSIDERATION OF DOOR-TO-DOOR TRAVEL REQUIREMENTS MODIFY URBAN TRANSPORTATION PLANS?	● HIGHWAY AND MASS TRANSPORTATION FUNDING WHAT ARE COSTS AND BENEFITS OF IMPROVING URBAN ACCESS TO INTERCITY SERVICES? ARE SPECIAL-USE TERMINAL ACCESS FACILITIES WORTHWHILE?	● URBAN/INTERURBAN RESOURCE ALLOCATION WHAT DIVISION OF INVESTMENT BETWEEN URBAN AND INTERURBAN TRANSPORTATION PROVIDES MAXIMUM OVERALL BENEFITS?
	AIRPORT PLANNING CAN HIGH SPEED GROUND MODES REDUCE AIRPORT BUILDING REQUIREMENTS?	● STOL, VTOL, CTOL MIX WHAT MIX OF STOL OR VTOL WITH CONVENTIONAL AIR WILL MINIMIZE LOADING OF URBAN FACILITIES?	● NATIONAL AIRPORT PLAN WHAT SET OF AIRPORTS BEST COORDINATES INTERCITY NEEDS WITH URBAN FACILITIES AND GROUND MODE CAPABILITIES?
OTHER NATIONAL INTERESTS MULTI-MODAL ANALYSIS	REGIONAL PLANNERS WHAT TRANSPORTATION NETWORKS ARE COMPATIBLE WITH SPECIFIC REGIONAL PLANS? (NEW ENGLAND REGIONAL PLANNING COMMISSION) (DELAWARE VALLEY REGIONAL PLANNING COMMISSION)? TRANSPORTATION ECONOMIC IMPACTS HOW DOES TRANSPORTATION AFFECT THE ECONOMIC AND DEMOGRAPHIC DEVELOPMENT OF NORTHEAST CORRIDOR SUBREGIONS? ENVIRONMENTAL IMPACT WHAT ARE THE SHORT AND LONG RANGE EFFECTS OF TRANSPORTATION ON THE ENVIRONMENT? (NOISE, POLLUTION, WATERSHED ALTERATION, ETC.) INTERNATIONAL COOPERATION WHAT NEW AND USEFUL INFORMATION CAN BE EXCHANGED WITH FOREIGH PLANNERS? EDUCATION WHAT NEW TECHNIQUES MIGHT FORM A DOT TEXTBOOK ON TRANSPORT MULTIMODAL PLANNING? BICENTENNIAL PLANS WHAT ARE THE FEASIBLE MODES FOR USE IN THE U.S. BICENTENNIAL CELEBRATION?	● SAFETY WHAT ARE THE TRADE-OFFS BETWEEN "COSTLY-SAFE" MODES AND "LESS COSTLY-UNSAFE" ONES? ● BICENTENNIAL PROGRAM WHAT MIX OF MODES WILL COMPRISE A SYSTEM TO BEST REPRESENT U.S. PROGRESS, PROVIDE SERVICE TO VISITORS AND RETAIN LATER UTILITY?	● OTHER CORRIDOR IMPLEMENTATION WHAT INVESTMENT DECISIONS ARE APPLICABLE TO OTHER CORRIDOR REGIONS? ● FREIGHT RATE REGULATION CAN REVISION OF FREIGHT RATES PROVIDE BETTER OVERALL UTILIZATION OF FACILITIES AND ENHANCE REGIONAL GROWTH? ● POPULATION AND INDUSTRY (DE) CENTRALIZATION WHAT TRANSPORTATION NETWORK CONFIGURATIONS ENHANCE DESIRABLE REGIONAL GROWTH PATTERNS FOR POPULATION AND INDUSTRY?

FIGURE S-4 MULTI-MODAL ANALYSIS APPLICATIONS -URBAN AND OTHER NATIONAL INTERESTS

In summary, through the Northeast Corridor work, the Department has taken a step forward in its attempts to resolve a number of the complex problems involved in allocating transportation resources. The new analytical tools and experience gained from the Corridor work will be one of the major building blocks around which a significantly strengthened Departmental multi-modal analysis and planning capability can be constructed.

Further development and application of the model system and methodology will offer major opportunities to improve transportation investment decision-making and the planning and management of the implementation of those decisions. Considering the magnitude of the resources involved, improvements in decisions growing out of the generation of improved information could well lead to significant savings.

TECHNICAL REPORT STANDARD TITLE PAGE

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4. Title and Subtitle	5. Report Date
Northeast Corridor Transportation Project Report	April 1970
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7. Author(s) Robert A. Nelson, Paul W. Shuldiner, Myron Miller, Robert L. Winestone, and Others*	8. Performing Organization Report No. 209
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12. Sponsoring Agency Name and Address United States Department of Transportation 800 Independence Avenue Washington, D. C. 20591	13. Type of Report and Period Covered Status and results of project to date 14. Sponsoring Agency Code

15. Supplementary Notes

*Other members of OHSGT who contributed were Philip J. Barbato, Wilbert E. Cantey, Melvyn Cheslow, Steven R. Ditmeyer, Nancy T. Ebersole, John Gerba, Harold Handerson, Eric H. Hanson, Donald J. Igo, Sung J. Kim, Frank J. Macklin and John C. Nelson

16. Abstract

The Northeast Corridor Transportation Project was charged to determine the inter-city transportation facility requirements of the Northeast Corridor through 1980. The December 1969 report contains the following:

Executive Summary - Contains conclusions, background to the Corridor transportation problem, and study approach.

Chapter 1 - A comparative analysis of the transportation alternatives as to their technical feasibility, economic costs and benefits and other impacts in the year 1975.

Chapter 2 - A discussion of the actions required to implement the transportation alternatives

Chapter 3 - An examination of possible financing and management of new modes included in the alternatives.

Technical Appendices - Include advantages and disadvantages of various organizational alternatives, population growth patterns and the Corridor transportation system, methodology, description of the alternative systems, and exploratory studies and sensitivity tests.

The Corridor Report is supplemented by a set of 17 supporting documents which develop in greater detail the analysis and findings.

17. Key Words	18. Distribution Statement
Northeast Corridor, transportation planning, system analysis, system alternatives, systems engineering, facility requirements, impact analysis, model simulation, congestion, transport innovation, transportation coordination, regional transportation, NECTP, high speed ground transportation, high speed rail, STOL, VTOL, TACV	Distribution Statement: Unlimited

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	227	

Form DOT F 1700.7 (8-69)

As a set, the following listed 17 reports provide detailed information on Northeast 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:

NECTP* REPORT NUMBER	REPORT TITLES	CONTRACTOR
	DESCRIPTION OF THE NORTHEAST CORRIDOR (NEC): TRANSPORTATION PROBLEMS AND PROSPECTS	
210	NEC Transportation: Problems and Prospects	Peat, Marwick Livingston and Co.
211	Status of the Transportation System and Plans for Improving Intercity Transportation in the NEC	"
212	NEC Transportation Facts and Statistics	"
	PROJECT METHODOLOGY	
213	National Bureau of Standards Modeling for the NECTP	NBS
214	HSGT Mode Service Analysis in NEC	TRW, Inc.
215	Air Mode Service Analysis in NEC	MITRE Corp.
216	TRANSOP Model Methodology	TRW, Inc.
217	Access and Demand Data Used in the Development and Calibration of NEC Transportation Models	Peat, Marwick Livingston and Co.
218	Impact Studies: NECTP	CONSAD Research Corp.
230	Passenger Demand and Modal Split Models	Arthur Young & Co.
	MODAL DESCRIPTIONS	
219	HSGT Systems Engineering Study, Tracked Air Cushion Vehicles	TRW, Inc.
220	V/STOL Mode Descriptions	MITRE Corp.
	COSTING PROJECTIONS AND TECHNIQUES	
221	Prospective Costs of Capital in the NEC	Lionel D. Edie, Inc.
222	Cost Analyses for NECTP, Volume I, High Speed Ground Modes	Resource Management Corp.
223	Cost Analyses for NECTP, Volume II, Air and Highway Modes	MITRE Corp.
224	External Costs and Benefits Analyses, NECTP	Resource Management Corp.
225	Theory and Implementation of Cost and Benefit Analysis of Transportation Systems: The NECTP	Resource Management and Mathematica

*Reference to these reports is made by use of the NECTP number.

CHAPTER 1

ANALYSIS OF ALTERNATIVES
FIRST GENERATION MODEL SYSTEM

INTRODUCTION

This chapter discusses the results of the simulated interactions of five new modes combined with conventional air and highway modes in various ways to comprise nine transportation alternatives. The results reflect the meshing of many individual models into a working simulation that will accept as input data: (1) population and income forecasts by subdivisions of the Corridor region; (2) technological and performance characteristics of transportation modes such as speed and vehicle size; (3) cost relationships; and (4) transportation network descriptions. The simulation produces output data such as schedules, fleet sizes, operating costs, revenues, demand characteristics, and impacts of the proposed alternative transportation changes on regional development.

The analyses which follow present selected results from the massive data outputs generated by runs of the model system, and attempt to organize and interpret these results so as to provide answers to questions likely to be of interest to decision-makers. The chapter consists of four major sections:

1. Mode service descriptions. Results of the simulation runs are discussed in terms of modal fares, frequencies, terminal-to-terminal travel times, and terminal access and egress times.

2. Patronage and travel patterns. Simulation results are presented for each of the alternatives in terms of total patronage, average trip distances, and average trunk line and door-to-door speeds. Aggregative results for each alternative and results for individual modes are discussed.

3. Capital expenditures, costs and revenues. Capital expenditure requirements and operator costs and revenues generated by simulation runs are summarized for each alternative.

4. Cost and benefit evaluation. Selected factors not incorporated directly in the model run results and

the potential impact of these factors on evaluation of alternatives are presented. Included are discussions of user costs and benefits, social costs and benefits, and regional socio-economic impacts of each alternative.

The results of exploratory studies which extend and support the analyses are contained in Technical Appendix 5. Included in the appendix are: (1) a report on the study of second-order improvements in rail passenger service; and (2) discussions of the sensitivity of simulation run results to assumptions concerning fare policies, interest rates, access-egress times and other model inputs.

MODE SERVICE DESCRIPTIONS

Because the simulation of supply and demand in the Corridor model system adjusts the modal services to adapt to a competitive environment, the schedules and costs of the new common carrier modes--STOL, HSRA, HSRC, TACV and VTOL--are outputs of the simulation. Fares also are outputs of the air-mode supply-demand simulation. Thus the service characteristics of each mode are unique to each alternative. For purposes of exposition, the principal description of services will be given for each mode as it is first introduced into an alternative.

The Ground Modes

The four high-speed ground (HSGT) modes--DEMO, HSRA, HSRC, and TACV--constitute a progression of successively higher performance capabilities. Table 1-1 shows in detail the block times between stations for the four HSGT modes.

Table 1-2 shows the scheduled frequencies which resulted from the supply-demand simulation. These frequencies reflect the response of the mode to demand and the trade-off between train size and number of trains. The trade-off was determined by the relationship among the cost items; i.e., vehicle amortization costs and vehicle operating costs on the one hand and the patronage response to frequency on the other. Fares were set at $1.50 plus $.075 per mile for all HSGT modes.

TABLE 1-1 HSGT BLOCK TIMES, MINUTES

	DEMO	HSRA	HSRC	TACV
Washington-Baltimore*	32	23	19	16
Baltimore-Philadelphia	65	42	31	21
Philadelphia-Trenton	29	18	12	9
Trenton-Metropark	27	16	—	—
Trenton-Meadows	—	—	20	14
Metropark-New York	21	17	—	—
Meadows-New York	—	—	3	3
New York-New Haven	71	45	—	—
New York-Milford	—	—	27	19
New Haven-Providence	96	53	—	—
Milford-Providence	—	—	37	26
Providence-Boston	43	27	19	17
Total	384	241	168	125

*Lanham station was included in the Washington Market and the Route 128 station was included in the Boston Market. No ticketing was allowed between the suburban and downtown stations or between New York and the northern New Jersey station (Metropark or Meadows).

TABLE 1-2 HSGT FREQUENCY

ALTERNATIVE MODE	I, II DEMO	III HSRA	IV HSRC	V TACV	VI DEMO	VII HSRA	VIII HSRC	IX TACV
Trains per day Wash. - Boston	16	20	32	33	16	18	32	33
Cars per train (day, night)		6, 8	5, 6	3, 7		5, 8	4, 6	3, 3
Additional trains/day								
Phila. - New Haven	15	18			15	17		
Phila. - Milford			30	29			30	29
Cars per train* (day only)		5	4	2		5	3	2

* The Phila. - New Haven/Milford trains did not run at night. Added cars on the Washington - Boston route at night gave sufficient capacity.

The Air Modes

The three air modes--CTOL, STOL, and VTOL--constitute a descending progression in terms of take-off and landing space requirements. CTOL was restricted to the existing set of airports and, because of the prospect of continued terminal congestion, to present routes and schedules.

Conventional Take-off and Landing (CTOL)

In alternative I, CTOL is equivalent to present day air service. Flights from Washington to Boston can be made non-stop, independent of the New York, Providence or Hartford schedules. Block times are not additive and non-stop schedules were not established to be connective.

Table 1-3 shows CTOL block time and frequency in a split matrix. For compactness of presentation, the upper right half contains frequencies and the lower left, block times in minutes; the diagonal is blank. The schedules, in terms of block time and frequency, are everywhere symmetrical in that each non-stop flight between a pair of terminals is matched by one in the opposite direction. This matrix form will be used throughout this chapter without further explanation.

For reasons which will be discussed later, CTOL fares were adjusted for the short-haul nature of NEC travel and coincide, within a few pennies, with the fares for STOL.

Short Take-off and Landing (STOL)

In alternative II, STOL was introduced as a complementary service to CTOL and, for demand estimation purposes, both were treated as a single composite mode, C/STOL. The CTOL route structure was trimmed to eliminate short links which might better be served by STOL aircraft. Table 1-4 shows the CTOL block times and frequencies over the route structure used in alternative II. The same pattern applies for C/STOL in all other alternatives.

In alternatives II through IX, CTOL service was held constant while STOL block times, frequencies, and fares were allowed to vary with patronage. Table 1-5 shows block times and frequencies for STOL-s route structure at equilibrium in alternative II. The number of terminals served emphasizes the geographic dispersion of the STOL service but also points up one of its problems; i.e., the large proportion of city pairs with only two flights (one each way) daily. The low service frequencies resulted from the attempt to serve low demand links with relatively large aircraft. The effect on STOL is either (1) the loss of patronage because of infrequent service or (2) poor utilization of aircraft because of severe peaking throughout the Northeast Corridor

TABLE 1-3 CTOL TIME AND FREQUENCY (ALTERNATIVE I)

Frequency, Trips/Day (above diagonal, FREQUENCY); Time, Minutes (below diagonal, TIME)

	1	3	4	7	12	14	20	22	26	28	29
1. Washington		44	--	--	36	62	--	--	--	--	34
3. Baltimore	21		--	22	18	6	--	--	4	--	4
4. Wilmington	--	--		2	--	6	--	--	--	--	--
7. Philadelphia	--	32	15		32	36	--	2	6	--	30
12. Newark	71	46	--	32		--	--	4	14	--	34
14. New York	77	56	45	36	--		2	22	32	4	112
20. New Haven	--	--	--	--	--	35		2	--	--	4
22. Providence	--	--	--	83	60	53	25		10	--	30
26. Hartford	--	85	--	72	49	45	--	30		--	32
28. Worcester	--	--	--	--	--	62	--	--	--		6
29. Boston	116	60	--	70	68	62	44	24	35	24	

Time, Minutes

*In alternative 1, the time and frequency of departure for CTOL was based upon actual 1965 data. Since no jet aircraft were permitted at Washington National Airport at that time, Table 1-3 contains relatively large trip times out of Washington.

TABLE 1-4 CTOL TIME AND FREQUENCY (ALTERNATIVE II-IX)

Frequency, Flights/Day (above diagonal, FREQUENCY); Block time, minutes (below diagonal, TIME)

	1	3	7	12	14	22	26	29
1. Washington		--	--	34	72	8	10	64
3. Baltimore	--		--	32	18	--	2	16
7. Philadelphia	--	--		--	--	2	14	30
12. Newark	61	50	--		--	4	--	42
14. New York	61	50	--	--		30	--	126
22. Providence	69	--	58	47	47		--	--
26. Hartford	70	64	48	--	--	--		--
29 Boston	75	68	59	52	52	--	--	

Block time, minutes

TABLE 1-5

STOL TRIP TIME & FREQUENCY
(ALTERNATIVE II)

Frequency (Trips Each Way/Day)

	1	3	4	6	7	8	9	10	12	14	15	16	17	18	19	20	22	26	27	28	29
1. Washington		16	6	8	10	8	8	8	8	10	8	6	14	32	0	0	0	0	0	0	0
3. Baltimore, Md.	49		2	4	4	4	4	4	4	6	2	2	10	16	0	0	0	0	0	0	0
4. Wilmington, Del.	58	51		4	2	0	2	2	2	4	2	2	8	4	4	2	0	0	0	0	0
6. Upper Darby, Pa.	62	54	45		0	2	0	4	2	4	2	2	10	4	0	4	0	2	0	0	0
7. Philadelphia, Pa.	65	57	48	57		2	0	4	4	6	4	4	12	4	4	6	0	2	4	0	0
8. Camden, N.J.	66	58	59	45	43		2	4	4	4	4	4	12	6	4	0	0	4	2	0	0
9. Abington, Pa.	65	56	47	60	57	45		2	4	4	2	4	8	4	0	2	0	0	2	0	0
10. Trenton, N.J.	68	60	51	47	44	45	45		2	2	2	2	8	2	2	0	0	0	0	0	0
12. Newark, N.J.	113	68	58	55	52	52	53	48		4	0	0	2	2	4	4	4	8	4	2	6
14. Brooklyn, N.Y.	79	71	61	57	55	54	55	51	44		2	2	0	0	8	6	4	8	4	0	8
15. Levittown, N.Y.	82	74	64	60	56	56	58	54	56	45		4	0	0	4	4	2	6	6	0	4
16. Jersey City, N.J.	76	68	59	55	52	52	53	49	54	43	60		6	0	2	2	0	6	0	0	4
17. Manhattan, N.Y.	78	70	60	57	54	54	55	50	43	54	56	42		0	12	10	6	12	4	2	12
18. Yonkers, N.Y.	75	68	58	56	53	51	55	51	49	62	56	69	61		10	10	6	12	0	0	14
19. Norwalk, Conn.	96	88	69	75	63	62	73	59	52	49	58	51	50	55		4	2	6	2	0	4
20. New Haven, Conn.	99	91	72	68	65	74	65	71	55	52	54	54	53	57	44		4	8	4	0	4
22. Providence, R.I.	113	105	95	92	88	87	89	85	68	65	63	77	66	69	57	55		8	2	0	6
26. Hartford, Conn.	104	95	86	74	70	70	80	76	59	56	55	59	59	63	49	47	52		4	2	10
27. Springfield, Mass.	106	98	89	85	73	73	83	79	62	60	58	71	60	75	52	51	53	45		6	12
28. Worcester, Mass.	114	105	95	92	89	89	89	85	68	75	74	77	66	82	67	65	65	50	48		4
29. Boston, Mass.	118	110	101	97	94	94	95	91	74	71	69	74	72	76	63	61	50	55	54	46	

TIME

Vertical Take-off and Landing (VTOL)

For these first generation investigations, VTOL was characterized as an independent mode, not coordinated with C/STOL. No en route modal interchange was permitted and, in most cases, VTOL and C/STOL terminals were not located together.

Because VTOL intuitively seemed unlikely to create much new total patronage, induced demand was constrained in the supply-demand simulation to 10 percent of the total VTOL patronage.* Thus, VTOL patronage is assumed to result more from diversion of patronage from other modes than from new demand creation.

VTOL was set up as a single Corridor-wide service with all schedules connective. The VTOL mode combines many of the desirable features of air and bus; providing the capability for rapid point-to-point service with great flexibility in route structure. VTOL also allows a wide variety of terminal locations, with terminals not much larger than the vehicle itself. In the treatment of the VTOL mode, the above features were emphasized; i.e., the supply model used the same route selection technique for VTOL as for STOL, terminal design and sites were tailored to the VTOL vehicle size, and the VTOL network was structured like a bus line, with convenient dispersed terminals.

VTOL in alternative VI was even more dispersed than was STOL in alternative II. VTOL served 24 of the 29 NEC superdistricts. Table 1-6 gives a split matrix of block times and frequencies for VTOL which shows the size of the VTOL network. The 86-passenger VTOL vehicle was somewhat better suited to service small-demand terminals than the 122-passenger STOL, but was forced into very high frequencies to serve markets with large demand.

Total patronage in superdistricts with smaller populations appeared unlikely to support both STOL and VTOL service. After several exploratory runs, a less dispersed STOL network was devised reducing the number of superdistricts served by STOL to the 13 as indicated by the asterisks in Table 1-6. The abbreviated STOL network was used in alternatives VI through IX.

The VTOL cost model envisioned a rather spartan type of service. As a result, the indirect operating cost (IOC) was low for VTOL, a counterbalance to its higher vehicle direct operating cost. With lower IOC, the fixed portion of the VTOL fares was made smaller than STOL. Figure 1-1 shows the typical variation of fares with stage length for C/STOL, VTOL, and the ground modes.

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*The precise value of 10 percent for induced demand was arbitrary. No applicable data were available for estimating the demand which would be induced by a new common carrier service.

TABLE 1-6

VTOL TRIP TIME & FREQUENCY
(ALTERNATIVE VI)

Frequency (Trips Each Way/Day)

	1	3	4	6	7	8	9	10	11	12	14	15	16	17	18	19	20	21	22	23	26	27	28	29
* 1. Washington		58	16	28	22	16	20	6	20	20	20	16	14	40	12	--	--	--	--	--	--	--	--	--
* 3. Baltimore, Md.	37		6	14	12	6	12	4	10	10	10	6	6	20	6	--	--	--	--	--	--	--	--	--
* 4. Wilmington, Del.	53	45		2	12	2	2	2	2	4	4	2	2	10	2	2	4	2	--	--	--	--	--	--
6. Upper Darby, Pa.	58	49	35		--	2	--	2	6	6	8	4	4	16	4	14	8	--	--	--	2	2	--	--
* 7. Philadelphia, Pa.	60	52	36	48		--	--	2	6	10	16	12	8	28	6	4	8	--	--	--	4	2	--	--
8. Camden, N.J.	64	55	40	50	48		--	2	4	6	10	16	6	20	4	4	2	--	--	2	2	--	--	--
9. Abington, Pa.	61	53	38	50	49	47		4	6	8	8	4	4	18	4	2	2	--	--	--	12	--	--	--
*10. Trenton, N.J.	67	59	44	38	36	35	35		2	4	6	6	4	14	2	2	--	--	2	--	2	--	--	--
11. Woodbridge, N.J.	75	66	51	45	44	41	43	36		6	--	--	--	--	--	6	4	--	2	--	4	--	--	28
*12. Newark, N.J.	77	68	54	48	46	45	45	39	33		--	--	2	--	--	6	4	--	2	2	6	8	2	8
*14. Brooklyn, N.Y.	83	74	59	54	52	48	51	45	57	61		--	--	2	2	16	10	4	4	2	14	4	4	18
15. Levittown, N.Y.	85	76	62	56	55	51	54	47	60	63	51		--	--	--	14	6	4	8	2	10	2	2	16
16. Jersey City, N.J.	81	73	58	53	51	48	49	43	44	34	61	58		--	2	6	4	4	2	2	6	4	4	8
*17. Manhattan, N.Y.	81	73	57	53	50	47	49	43	35	42	61	58	31		4	22	16	6	8	4	22	8	4	30
18. Yonkers, N.Y.	87	79	64	58	56	54	55	49	48	40	55	53	35	35		10	6	2	2	2	10	4	2	12
*19. Norwalk, Conn.	101	92	71	65	64	60	63	56	49	47	41	39	43	43	37		4	2	4	2	6	4	2	10
*20. New Haven, Conn.	104	95	75	69	67	64	66	65	53	51	45	43	46	46	40	33		4	2	4	4	--	2	14
21. Norwich, Conn.	114	105	85	85	77	74	83	75	69	67	55	52	57	56	52	44	53		--	2	--	--	--	4
*22. Providence, R.I.	125	117	102	97	95	91	94	87	81	73	66	64	68	68	62	55	51	65		--	4	2	--	16
23. Fall River, Mass.	129	121	105	101	98	88	98	91	85	77	70	67	72	72	66	58	55	45	84		2	--	--	--
*26. Hartford, Conn.	112	103	88	77	75	72	74	67	60	57	53	51	54	54	47	41	37	61	45	70		2	4	16
27. Springfield, Mass.	115	106	92	80	78	82	83	77	70	61	57	55	57	57	51	45	49	66	45	81	35		--	6
28. Worcester, Mass.	125	116	102	96	95	91	93	87	80	71	66	64	67	67	61	55	51	65	53	83	43	54		6
*29. Boston, Mass.	133	125	99	105	102	99	101	95	82	79	74	71	75	75	69	62	58	50	38	73	41	49	38	

TIME

FREQUENCY

One way block time, min.

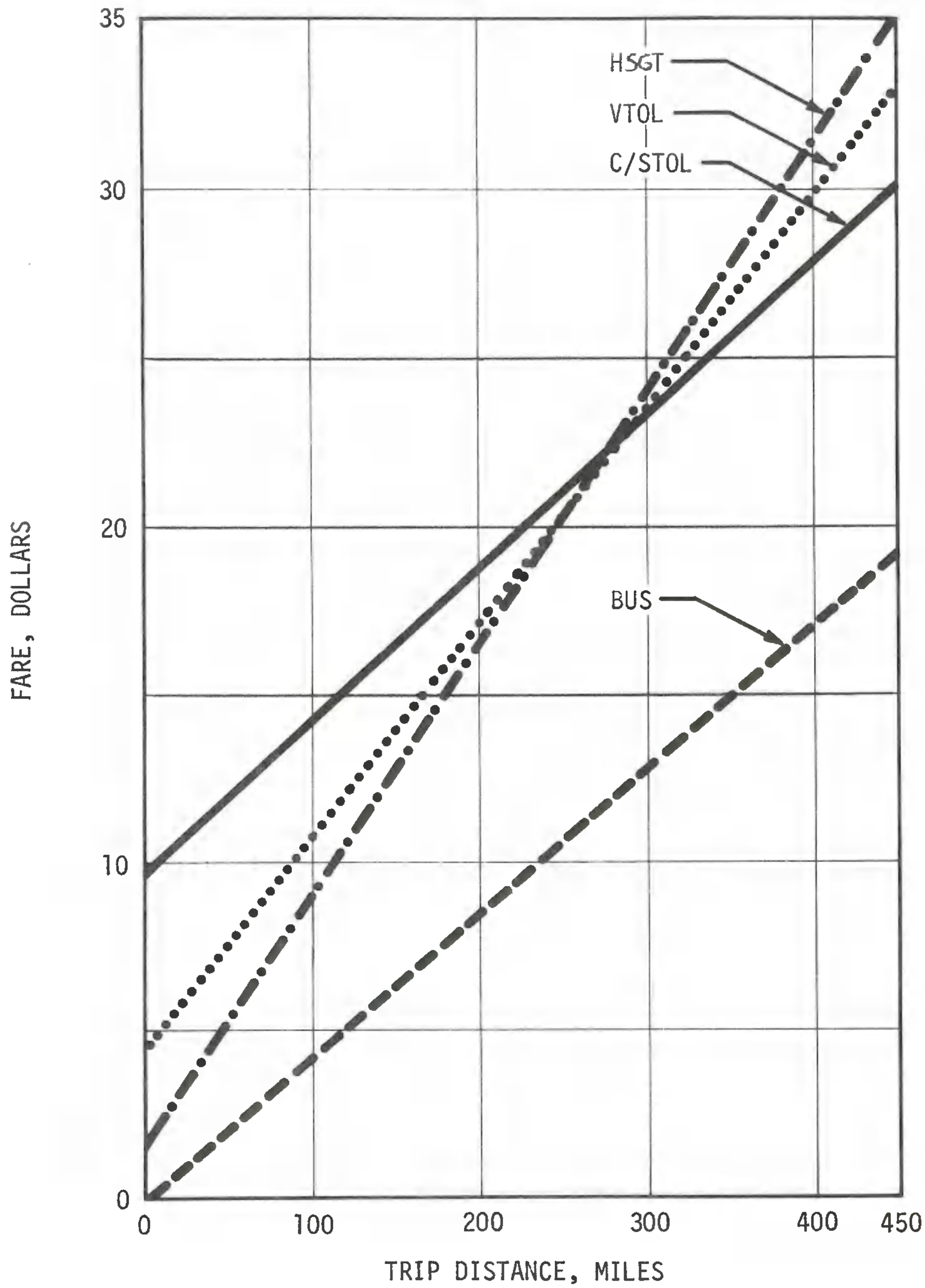

FIGURE 1-1
FARE RATES ALL MODES

Access/Egress

Access/egress times and costs are important characteristics of the service offered by any mode. Present CTOL airports and urban rail terminals are strongly affected by existing urban highway traffic congestion. The ground modes can have new terminals only along their rights-of-way; STOL and VTOL, particularly, enjoy more freedom in terminal location.*

Terminal locations for new modes were set with an eye to access. Table 1-7 lists the average access time from each superdistrict to the nearest terminal of each mode. In nearly every case, VTOL has the shortest access time of any of the high-speed modes in the alternatives. In addition to locational freedom provided by the small terminal size of VTOL, short in-terminal distances and built-in parking tend to reduce passenger terminal delays. Table 1-7 includes an average terminal delay, weighted by patronage, at each terminal for each mode.

PATRONAGE AND TRAVEL PATTERNS

Figures 1-2 through 1-5 show key travel pattern results for the simulation of the 1965 case and the nine 1975 alternatives. These results are discussed in the following paragraphs.

Alternative I

Alternative I illustrates the growth in passenger demand due to population increase over the ten-year period,1965 to 1975. This base case for 1975 serves as a benchmark for comparisons among the alternatives.

Total intercity patronage is forecasted to jump from the 1965 figure of 142.7 million person trips per year to 217.0 million in alternative I, a growth of just over 50 percent. Estimated common carrier demand rose 30 percent while auto demand jumped by about 58 percent. Carrier services remained virtually unchanged between 1965 and 1975 and, therefore, induced demand would be negligible. The forecasted rise in patronage in alternative I would result primarily from population growth.

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*In terms of public acceptance, no mode enjoys complete freedom of terminal location. For example, transportation terminals are generally regarded by the public as bad neighbors, particularly in residential neighborhoods.

TABLE 1-7 MODAL ACCESS/EGRESS TIME* TO NEAREST TERMINAL

TIME, MINUTES

Superdistrict	CTOL	C/STOL	VTOL	DEMO HSRA	HSRC TACV
		MODE			
1. Washington	51	37	26	30	30
2. Cambridge, Md.	140	138	140	140	140
3. Baltimore, Md.	60	33	25	26	26
4. Wilmington, Del.	91	34	34	62	62
5. Atlantic City, N.J.	97	73	73	82	86
6. Upper Darby, Pa.	52	34	34	55	56
7. Philadelphia, Pa.	59	37	30	27	27
8. Camden, N.J.	57	46	46	55	51
9. Abington, Pa.	75	39	39	61	52
10. Trenton, N.J.	97	28	28	20	24
11. Woodbridge, N.J.	60	52	38	38	61
12. Newark, N.J.	48	40	36	48	41
13. Staten Island, N.Y.	54	32	27	30	52
14. Brooklyn, N.Y.	45	37	30	40	40
15. Levittown, N.Y.	75	42	36	75	75
16. Jersey City, N.J.	50	31	31	53	34
17. Manhattan, N.Y.	62	32	32	29	29
18. Yonkers, N.Y.	95	47	47	59	59
19. Norwalk, Conn.	92	45	43	56	52
20. New Haven, Conn.	82	43	43	40	45
21. Norwich, Conn.	89	83	60	87	87
22. Providence, R.I.	51	35	26	23	29
23. Fall River, Mass.	73	66	46	56	55
24. Hyannis, Mass.	140	124	113	120	120
25. Torrington, Conn.	87	65	67	77	77
26. Hartford, Conn.	54	28	28	80	80
27. Springfield, Mass.	60	52	41	120	120
28. Worcester, Mass.	90	42	40	75	72
29. Boston, Mass.	45	40	31	29	29
Average (weighted by throughput)	58.9	39.3	34.5	42.6	41.7

*Note: Time is applied at each end of trip: e.g., CTOL, Washington to Boston, 51 + 45 = 96 min.

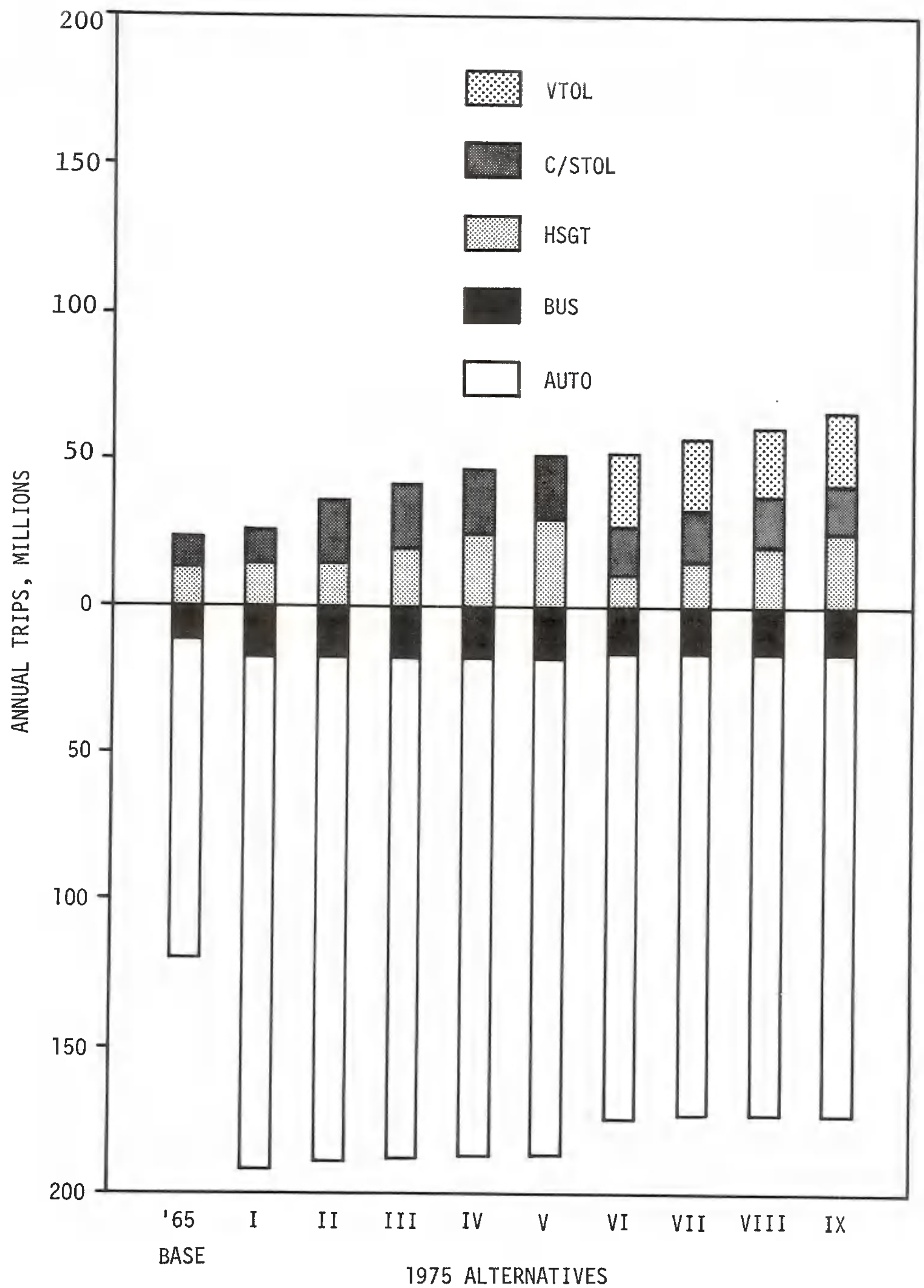


FIGURE 1-2
PATRONAGE BY MODE
BETWEEN MARKET AREAS

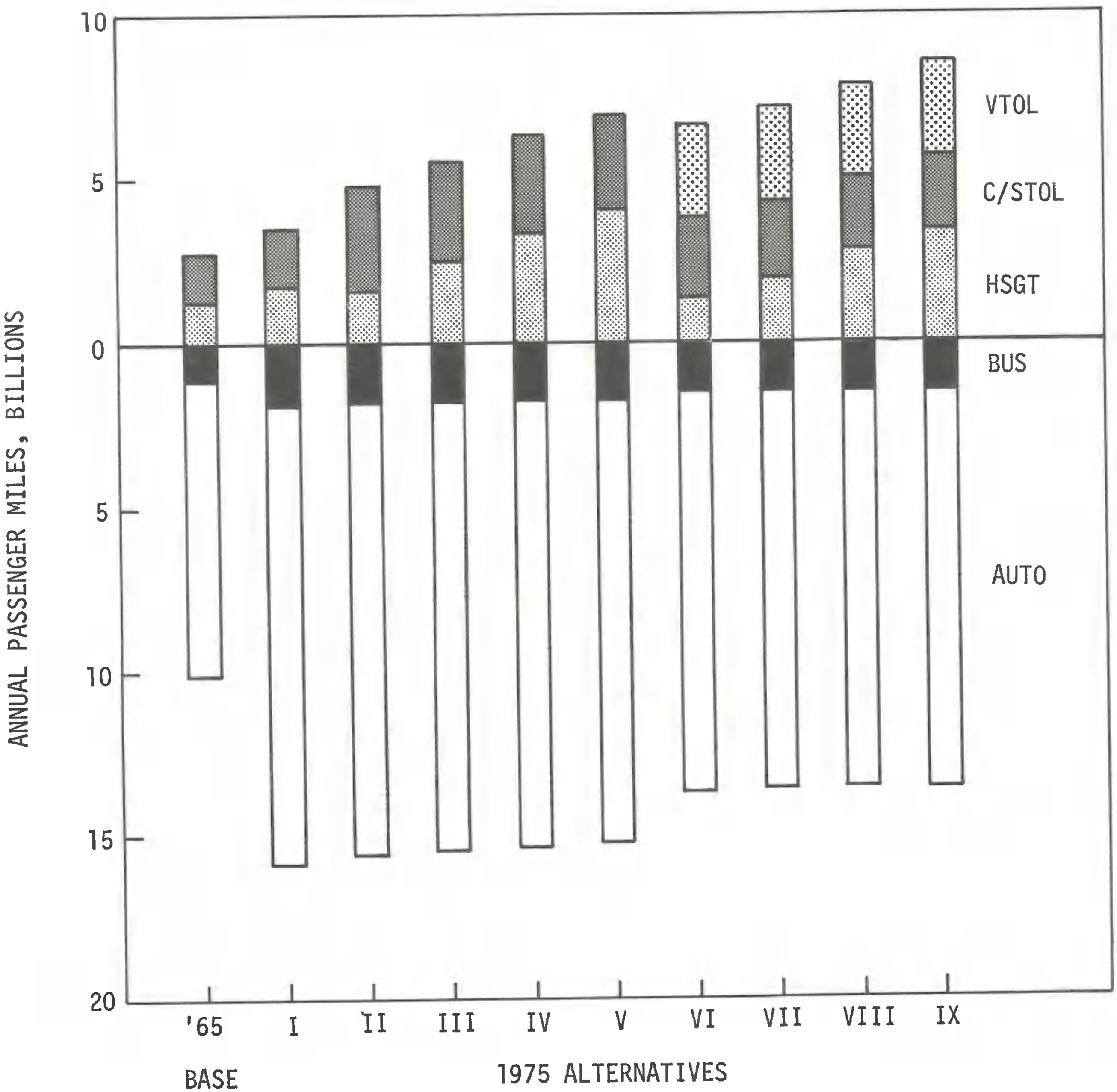
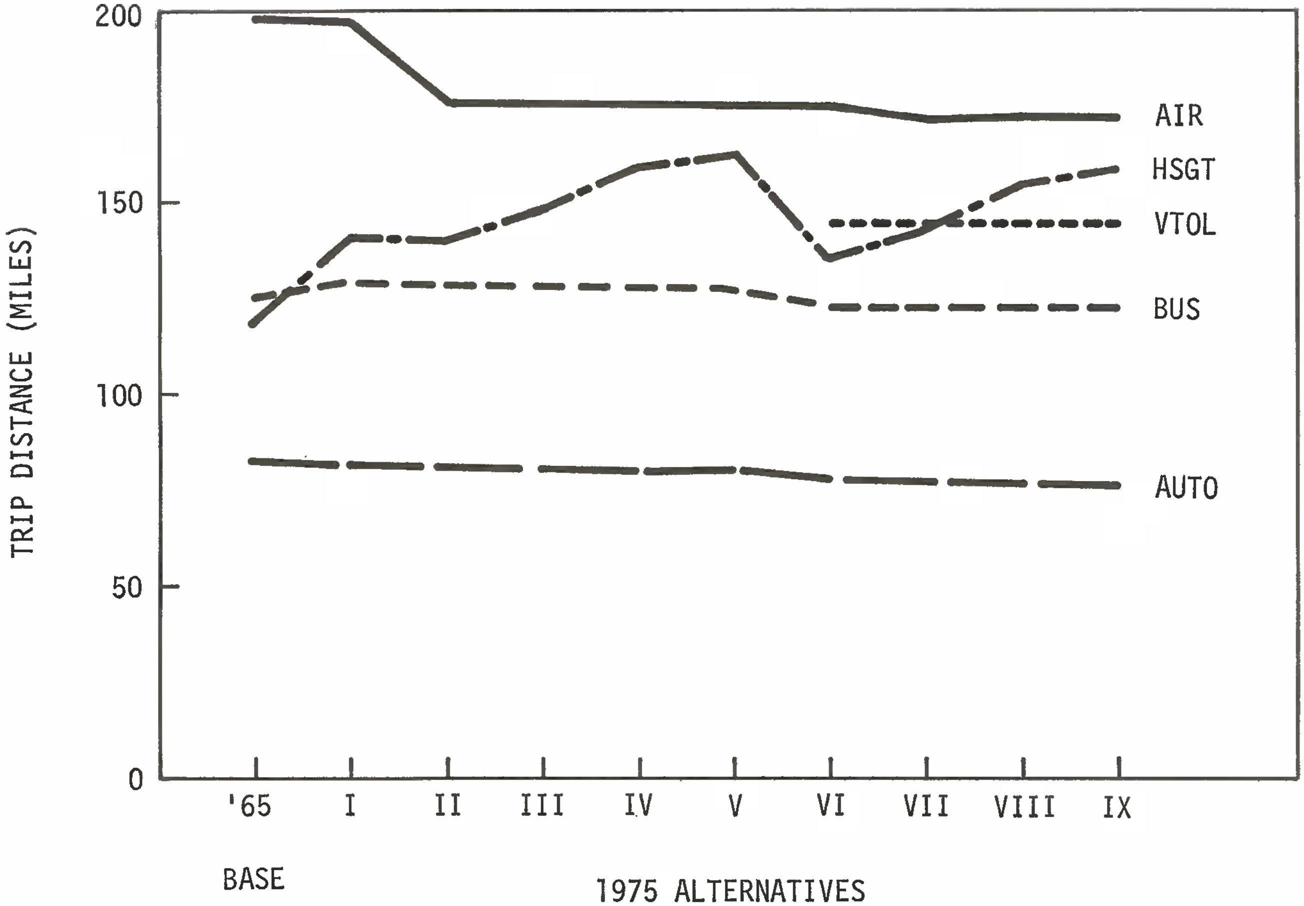
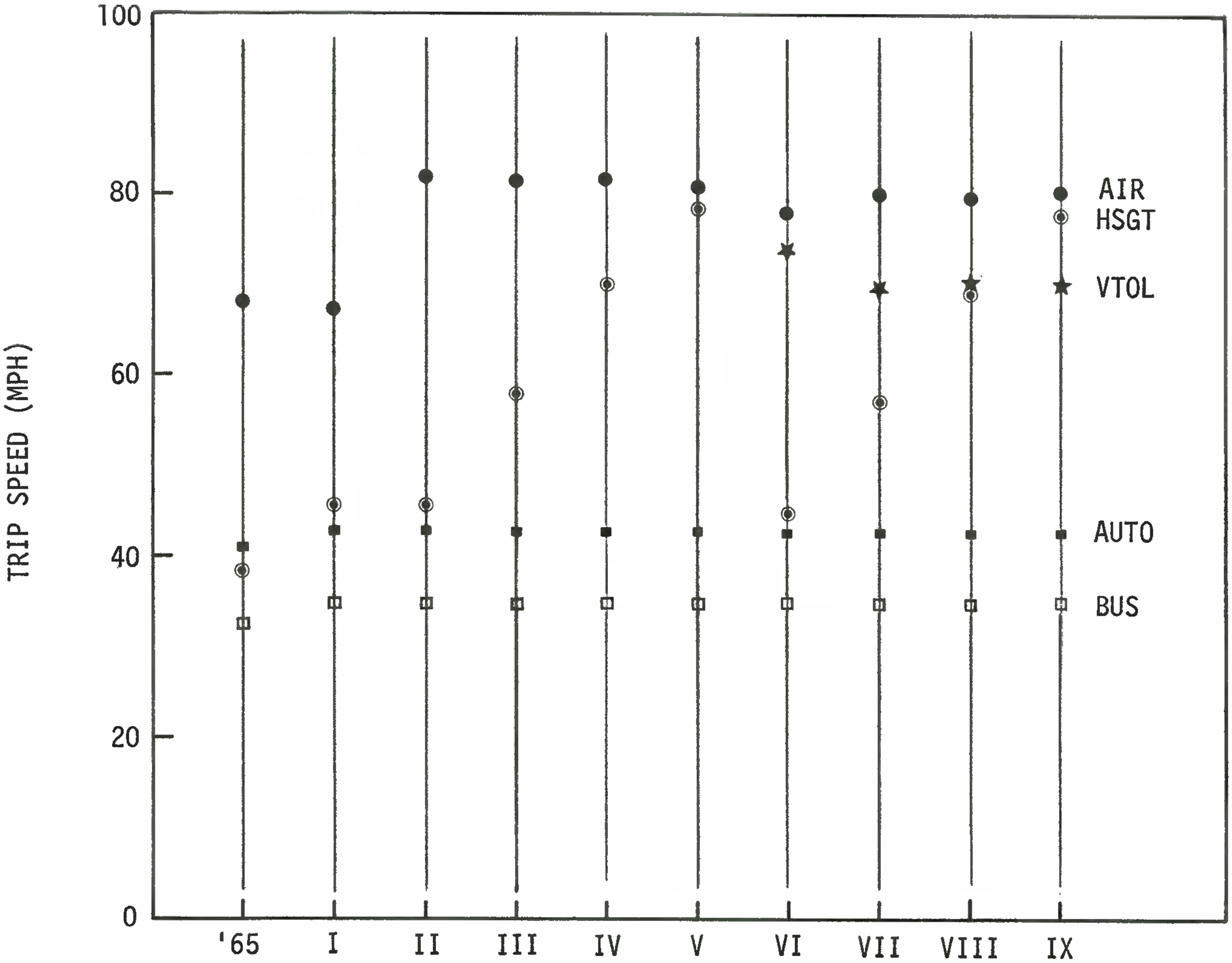


FIGURE 1-3
ANNUAL PASSENGER MILES BY MODES
(BETWEEN MARKET AREAS)



	'65	I	II	III	IV	V	VI	VII	VIII	IX
COMMON CARRIER AVERAGE	142	151	151	152	156	158	145	146	149	151
NEC AVERAGE	97	95	97	99	101	102	97	98	100	102

FIGURE 1-4
AVERAGE TRIP DISTANCE
(BETWEEN MARKET AREAS)



	BASE	1975 ALTERNATIVES								
	'65	I	II	III	IV	V	VI	VII	VIII	IX
COMMON CARRIER AVERAGE	44	47	52	56	61	64	57	59	62	65
NEC AVERAGE	42	44	46	47	49	51	48	49	51	52

FIGURE 1-5
DOOR-TO-DOOR SPEED OF AVERAGE TRIP
(BETWEEN MARKET AREAS)

Within the patronage totals, the market shares changed significantly over the decade 1965-1975. All modes participated in the patronage growth caused by the expanding population, but the highway modes--auto and bus--increased their relative shares of the market. With completion of the planned Interstate system, the 1975 highway network would improve markedly over its 1965 counterpart. Assuming that local congestion would not nullify the improvements to the highway network, auto and bus service would improve. Between 1965 and 1975, auto would jump from 76.6 percent to 80.1 percent of the market, while bus would improve its share from 7.5 percent to 7.9 percent.

In contrast to the growth of highway travel, patronage of CTOL in alternative I declined as a result of airport congestion. The CTOL market share fell from 6.2 percent to 5.3 percent as its total patronage increased from 8.8 to 11.5 million passengers per year.

Rail presented an apparent paradox. In spite of the service improvement provided by DEMO, the rail market share fell from 9.6 percent to 6.7 percent as rail patronage totals increased only 1.2 million passengers over the 13.8 million of 1965. The explanation lay in what was happening to the total rail network. Following the trends of the last 20 years, alternative I assumed the complete disappearance of intercity rail service everywhere in the Corridor except for the links served by DEMO.* On all city pairs served by DEMO, rail held its own or improved its market share over 1965. As a result, the character of rail patronage was altered. The average rail trip distance of 118 miles in 1965 increased to 141 miles in 1975 as rail took on premium-service attributes. Rail trunk-line speed increased from 52.7 mph average in 1965 to 72.4 mph in 1975 and the average fare was increased from 4.9 to 8.5 cents per passenger-mile. Alternative I thus trimmed the rail network to a single spinal line, improved the speed, and increased the price significantly.

A notable feature of the travel forecast for 1975 was the large proportion of time on common carrier trips spent in access/egress. The worst situation occurred for CTOL in which 177 mph block speed (in itself poor performance for 600 mph jets) became an average 68 mph door-to-door. Only 31 percent of the average CTOL trip time was actually spent in the air. The DEMO passenger spent about 53 percent of his trip time on the train, while the bus passenger spent 62 percent on the bus.

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*The NECTP does not advocate the discontinuance of these rail lines. The assumption of the disappearance of short intercity rail links merely extends present trends and emphasizes the point that these unprofitable services will die unless something is done to alter the trends. It should be clear, however, that a simple subsidy for existing services will not alter the declining patronage trend.

Alternative II

Alternative II added dispersed STOL service to the CTOL of alternative I. The result was spectacular patronage for STOL. The combined C/STOL service nearly doubled air patronage, the C/STOL share rising from 5.3 percent to more than 9 percent of the total market. The growth was principally at the expense of auto. STOL served many of the short links and the suburban zones not previously enjoying direct high-speed service, and in this it competed with auto. DEMO lost only a few hundred passengers and retained most of the profitable operation of DEMO in alternative I.

Terminal Load Shifts

A major effect of STOL on CTOL in alternative II is the diversion of patronage away from the CTOL terminals. Table 1-8 compares the volumes of NEC passengers for CTOL terminals in alternative I with the split between CTOL and STOL in alternative II. In every market area, the addition of STOL results in an increase in patronage for the combined C/STOL mode but results in a decrease in the terminal loadings for CTOL. Presumably this result could be beneficial by permitting a decrease in CTOL terminal congestion and/or allowing a shift of CTOL flights to more profitable, long-range service outside the Corridor.

The average trip for all modes in alternative II was 96.9 miles at a door-to-door speed of 46.3 mph. It is noteworthy that STOL door-to-door speed was 82 mph. The improved access/egress of STOL raised the C/STOL airborne time to 40 percent of the trip time.

In some respects, alternative II exhibited travel patterns similar to those of 1965. The average trip distance was nearly the same for both years and the split between auto and common carrier was identical for both years. The average 1975 passenger under alternative II traveled faster on all modes, however, and at considerably greater expense on common carriers than in 1965.

Alternatives III, IV, and V

By providing for higher speeds, alternatives III through V offer a significant improvement in transportation service over alternatives I and II. Fares were kept constant for the three ground modes--HSRA, HSRC, and TACV--and, as service improved, the simulation results showed corresponding increases in patronage. The growth of patronage of the ground modes with increases in speed is illustrated by the increasing fraction of total trips on HSGT shown in Figures 1-2 and 1-3.

TABLE 1-8 TERMINAL THROUGHPUT (AVERAGE ARRIVALS PER DAY)

	ALTERNATIVE I CTOL	ALTERNATIVE II CTOL	ALTERNATIVE II STOL
1. Washington	4980	2127	5336*
3. Baltimore, Md.	2151	921	2782
4. Wilmington, Del.	----	----	1493
6. Upper Darby, Pa.	----	----	1723
7. Philadelphia, Pa.	6142	699	2345
8. Camden, N.J.	----	----	1896
9. Abington, Pa.	----	----	1701
10. Trenton, N.J.	----	----	1484
12. Newark, N.J.	2855	1590	1981
14. Brooklyn, N.Y.	7031	2621	2685
15. Levittown, N.Y.	----	----	1697
16. Jersey City, N.J.	----	----	1367
17. Manhattan, N.Y.	----	----	5300
18. Yonkers, N.Y.	----	----	2091
19. Norwalk, Conn.	----	----	2156
20. New Haven, Conn.	----	----	1836
22. Providence, R.I.	1738	801	1478
26. Hartford, Conn.	3174	477	2738
27. Springfield, Mass.	----	----	945
28. Worcester, Mass.	----	----	448
29. Boston, Mass.	3334	2160	3205*

*Over two STOL ports.

Note: Departures are assumed equal to arrivals for all terminals.

Figure 1-6 shows that as the sustained top speed of the high speed ground modes increases from DEMO to TACV, door-to-door speed increases at a much lower rate than block speed. The descending curve in the figure represents the fraction of the total trip time spent on the high speed ground mode, with the remainder being spent in access and egress. Obviously, long access/egress times prevent the full utilization of the high speed capabilities of these modes.

Despite access problems, high speed ground modes provided services which were well accepted. In alternative IV, HSRC had the highest proportion of total trips of all the common carrier modes--more than 11 percent of the total traffic. TACV in alternative V did even better, capturing 13 percent. In an overall sense, the ground modes were successful in extending the average trip distance, and in increasing average trip speed.

<u>Alternative VI</u>

The addition of VTOL to alternative II had a competitive impact on every mode. Most notably, auto dropped from 76.7 to 70.1 percent of total trips. The common carrier split increased from 23.3 percent of total patronage in alternative II to 29.9% in alternative VI. The strong competition of VTOL with auto was largely a result of the dispersed VTOL route structure which placed direct VTOL service in most of the superdistricts. VTOL also had a fare policy which favored short trips.

In alternative VI, VTOL was the most popular common carrier mode, with 10.4 percent of total patronage, and more than a third of common carrier patronage. C/STOL, DEMO, and bus all suffered decreased patronage from VTOL competition. As noted earlier, STOL was constrained to a less dispersed route structure in alternative VI than in alternative II. Thus, the C/STOL run results between alternatives II and VI are not strictly comparable. The average trip length for C/STOL decreased slightly, indicating a loss to VTOL of some of the longer suburb-to-suburb trips carried by the more dispersed CTOL in alternative II. Trip lengths on DEMO, bus, and auto were likewise shortened, as VTOL took its place in the Northeast Corridor travel market.

Figure 1-7 compares the distribution of trips with distances for all the modes of alternative VI. The strong peaking of auto in the 40-80 mile range is evident. (The 0-40 interval was suppressed because 0-40 mile trips were not considered intercity.) STOL peaked in the 80-120 range as did DEMO and VTOL. The CTOL peak at 200-240

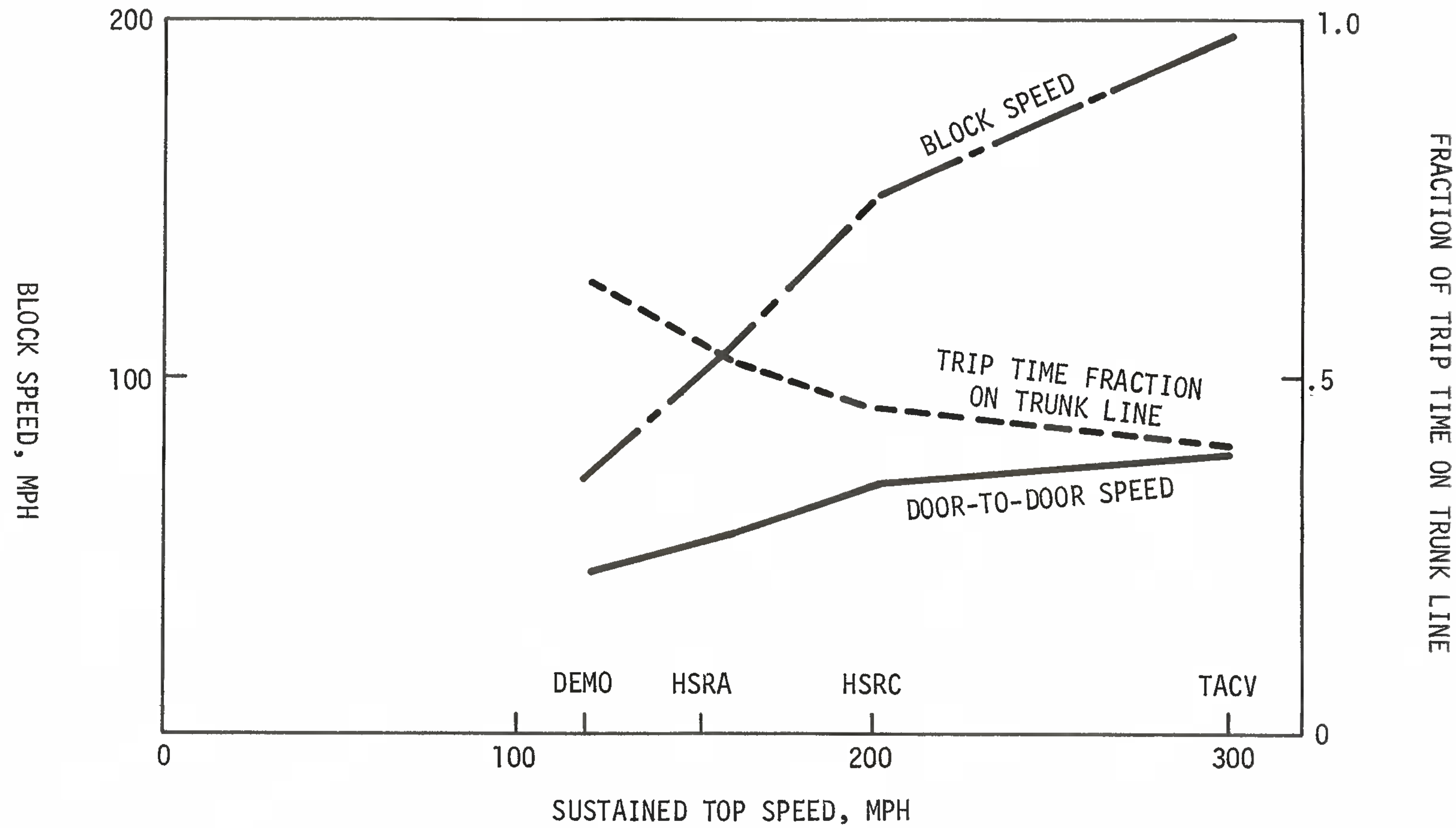

FIGURE 1-6
SPEEDS OF HSGT MODES

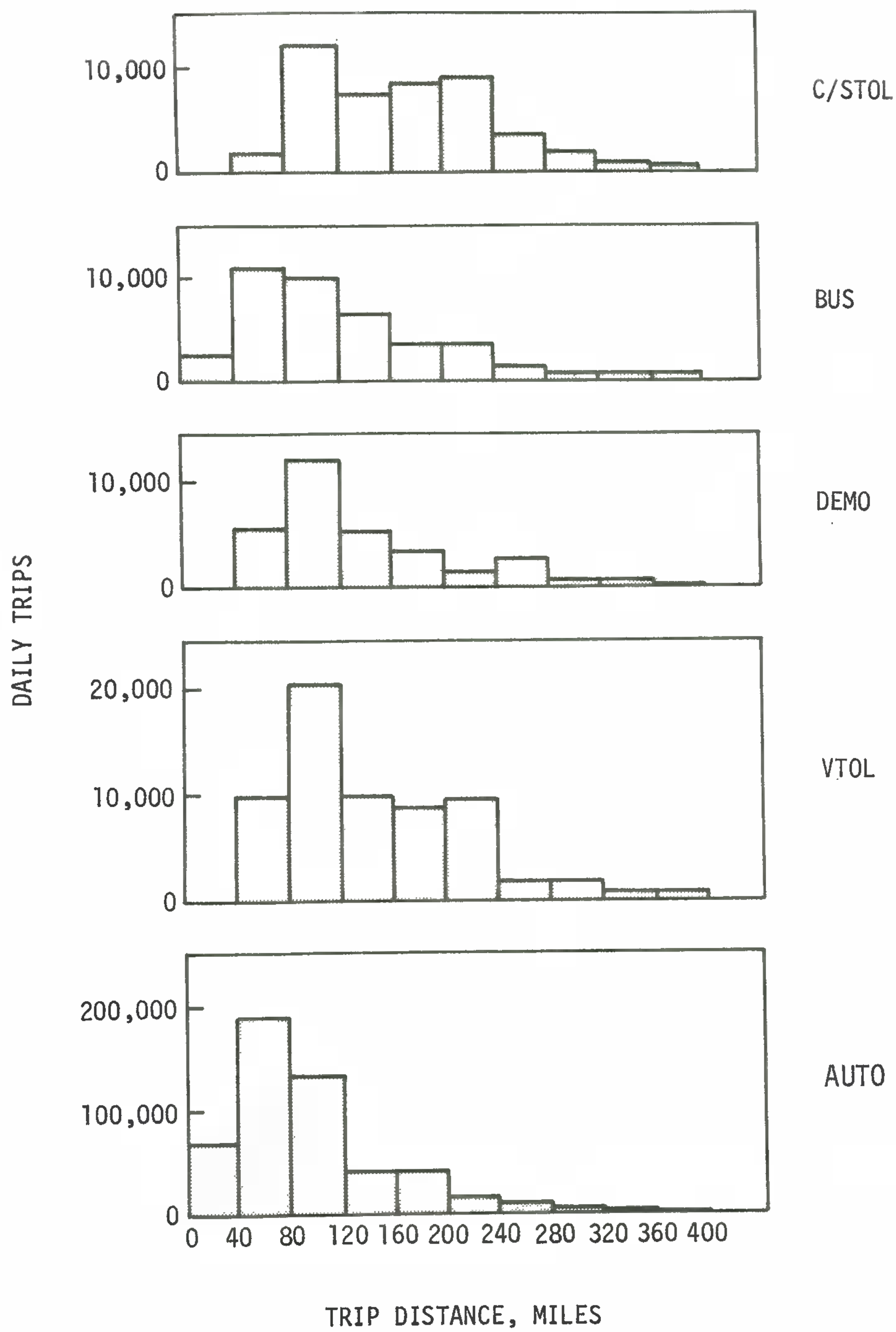

FIGURE 1-7

PATRONAGE BY TRIP DISTANCE (ALTERNATIVE VI) corresponded with the New York-Washington and New York-Boston distance.* The dominance of auto for short trips was apparent, but auto fell to less than half the traffic at 175 miles, and only about 5 percent of the auto trips were in excess of 200 miles.

Alternative VII, VIII and IX

Unlike the other alternatives, VII, VIII, and IX introduced no new modes, but took account of VTOL competition with the ground modes. Against VTOL competition, only the highest performing high-speed ground transportation mode--TACV--assumed the role of the dominant common carrier. TACV took about 11 percent of the total traffic compared with 10 percent for VTOL, principally as a result of the lower block time offered by TACV. The other modes fell behind VTOL in the modal split.

Both VTOL and the ground modes suffered from the Northeast Corridor problems of urbanization and local traffic congestion. The spinal configuration, necessary because of the costly right-of-way needed for high-speed ground transportation, required extensive local access networks about each terminal and added a large increment of access/egress time to the decreasing trunk line time of the higher performance modes. By locating terminals in the suburbs, dispersed VTOL (or STOL) reduced access times but, in so doing, lost frequency.

The last three alternatives provide high quality intercity transportation service throughout the Corridor. Average trip speed and distance rose from 49 mph and 97 miles in alternative VI to nearly 52 mph and 102 miles in alternative IX. Between alternatives VII and IX average trip times decreased from 2.14 hours to 1.97 hours. The high-speed ground transportation modes reduced the average common carrier fares per passenger-mile from 9.3 cents to 9.2 cents between alternatives VI and IX. To the user, then, increasing high-speed ground transportation performance brought increasing benefits in terms of accessibility, time saving, and fare decreases.

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*All modes shows the influence of the strong Washington-New York and Boston-New York markets. Since distances shown in Figure 1-7 include access-egress, the DEMO peak for these trips is in the 240-280 mile category.

CAPITAL EXPENDITURES, COSTS AND REVENUES

This section summarizes the capital expenditure requirements; the operating costs, including capital charges; and the revenues, for each mode and alternative. The principal results are shown in Tables 1-9 and 1-10. In calculating modal costs, the following assumptions were made:

1. The economic life of assets was established at 35 years for all fixed facilities, 14 years for ground mode vehicles, 12 years for air vehicles and an infinite period for land.

2. The return on capital was set at 10 percent as recommended by the Bureau of the Budget. The return on land acquisition cost was set at 8 percent.

3. Property and excise taxes were included in operating costs. No provision was made for corporate income taxes in order to put all modes on the same basis for comparative purposes.

The financial summary tables indicate that transportation improvements are associated, as would be expected, with high capital costs. Total revenues of common carriers plus automobile user costs, increased from $962 million for alternative I to $1,550 million for alternative IX. With the exception of alternative VI, total revenues plus auto costs increased monotonically from alternative I through alternative IX, as innovative modes were added.

As shown in the tables, all of the high speed ground modes except DEMO incurred losses at the demand levels generated.* Losses increased as the required investment increased; i.e., HSRA incurred smaller losses than HSRC which, in turn, had smaller losses than TACV. It should be noted, however, that the same fare levels were maintained for HSRA, HSRC, and TACV even though service improved. Each high speed ground mode shows the effects of the addition of VTOL to the mix of competing modes. In the case of HSRA, the annual loss doubled when VTOL competition was introduced; annual losses for HSRC and TACV increased by approximately 50 percent.

In contrast to the high speed ground modes, the STOL and VTOL modes were able to achieve breakeven positions in the supply-demand simulation for each of the alternatives in which they were included. Revenues covered costs, including capital charges.

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*DEMO costs include direct and indirect operating expenses plus capital charges for the incremental investment required. No estimates are presently available of the proper charges to be allocated to the DEMO mode for use of existing facilities.

TABLE 1-9 SUMMARY: CAPITAL EXPENDITURES, COSTS AND REVENUES FOR EACH NON-VTOL ALTERNATIVE (millions of dollars)

Alternatives	Capital Expenditures* 1969-75	Revenues 1975	Operating Costs 1975	Surplus or (Deficit) 1975
Alternative I				
DEMO	$ 70.1	$144.1	$ 61.4	$ 82.7
CTOL	405.6	183.6	169.8	13.8
BUS	90.4	78.7	63.7	15.0
AUTO	—	555.7	555.7	—
Total	566.1	962.1	850.6	111.5
Alternative II				
DEMO	$ 68.7	$140.9	$ 60.1	$ 80.8
STOL	450.7	243.8	243.8	—
CTOL	150.0	79.3	69.2	10.1
BUS	88.4	77.0	62.3	14.7
AUTO	—	580.6	580.6	—
Total	757.8	1121.6	1016.0	105.6
Alternative III				
HSRA	$1,591.1	$212.7	$240.0	$(27.3)
STOL	447.1	241.9	241.9	—
CTOL	148.5	75.3	68.5	6.8
BUS	87.3	76.1	61.6	14.5
AUTO	—	575.7	575.7	—
Total	2,274.0	1,181.7	1,187.7	(6.0)
Alternative IV				
HSRC	$2,599.8	$288.1	$355.5	$(67.4)
STOL	437.2	238.5	238.5	—
CTOL	144.3	75.4	66.6	8.8
BUS	86.1	75.1	60.8	14.3
AUTO	—	571.2	571.2	—
Total	3,267.4	1,248.3	1,292.6	(44.3)
Alternative V				
TACV	$3,339.5	$349.0	$452.0	$(103.0)
STOL	417.4	235.1	235.1	—
CTOL	140.3	68.3	64.3	4.0
BUS	85.4	74.4	60.2	14.2
AUTO	—	568.3	568.3	—
Total	$3,982.6	$1,295.1	$1,379.9	$ (84.8)

*Public expenditures on airports, air traffic control facilities, and highways are excluded.

TABLE 1-10 SUMMARY: CAPITAL EXPENDITURES, COSTS AND REVENUES FOR ALTERNATIVES CONTAINING VTOL
(millions of dollars)

Alternatives	Capital Expenditures* 1969-75	Revenues 1975	Operating Costs 1975	Surplus or (Deficit) 1975
Alternative VI				
DEMO	$ 59.5	$ 117.3	$ 52.1	$65.2
VTOL	1,064.0	318.0	317.1	.9
STOL	281.0	199.8	199.8	—
CTOL	113.0	59.6	53.6	6.0
BUS	72.8	63.6	51.4	12.2
AUTO	—	522.5	522.5	—
Total	1,590.3	1,280.8	1,196.5	84.3
Alternative VII				
HSRA	$1,576.0	$ 175.4	$ 230.0	$(54.6)
VTOL	1,020.0	301.8	309.8	(8.0)
STOL	308.8	195.8	195.8	—
CTOL	107.9	62.5	49.9	12.6
BUS	73.1	63.8	51.5	12.3
AUTO	—	519.1	519.1	—
Total	3,085.8	1,318.4	1,356.1	(37.7)
Alternative VIII				
HSRC	$2,585.4	$ 240.3	$ 340.1	$(99.8)
VTOL	971.0	292.3	291.5	.8
STOL	289.1	193.9	193.9	—
CTOL	108.8	50.9	50.3	.6
BUS	72.6	63.4	51.3	12.1
Auto	—	509.4	509.4	—
Total	4,026.9	1,350.2	1,436.5	(86.3)
Alternative IX				
TACV	$3,333.8	$ 292.4	$ 440.0	$(147.6)
VTOL	966.0	291.8	290.4	1.4
STOL	418.0	192.9	192.9	—
CTOL	109.7	54.6	50.6	4.0
BUS	72.5	63.2	51.1	12.1
AUTO	—	508.5	508.5	—
Total	$4,900.0	$1,403.4	$1,533.5	$(130.1)

*Public expenditures on airports, air traffic control facilities, and highways are excluded.

Markedly different cost characteristics for the air and high speed ground transport modes underlie these results. The high speed ground modes have high "threshold" costs involving land acquisition, right-of-way preparation, guideway construction and other fixed plant installation which must be incurred before service can be offered. These threshold costs account for 65 percent of total annual costs for HSRA; 73 percent for HSRC; and 71 percent for TACV. Thus the high speed ground modes are very dependent for economic viability upon demand and are strongly affected by variations in patronage.* When demand for ground service declines in the simulation due to increased competition, the relative decrease in costs is much smaller than the decline in revenue, and net losses increase appreciably. In contrast to the ground modes, the STOL and VTOL modes have very small proportions of fixed costs, (e.g., approximately 20 percent of annual costs of VTOL are fixed). Thus the STOL and VTOL systems, which are not burdened by large threshold costs, are much more flexible, and could be "tailored" or "sized" to changing demand.

The following paragraphs summarize significant financial simulation results for each alternative:

Alternative I

1. DEMO showed an $82.7 million surplus over costs. (DEMO costs included only incremental expenditures for capital assets and operations.)

Alternative II

1. DEMO again showed a surplus, in this case $80.8 million, reflecting a small diversion of patronage to the new STOL mode.

2. The introduction of STOL had the greatest impact upon CTOL; revenues for CTOL decreased by 56 percent from alternative I.

3. Capital expenditures for STOL amounted to $450 million, but capital expenditures for all other modes decreased, so that total common carrier capital expenditures increased by only $192 million over alternative I.

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*In DEMO the percentage changes in revenues and costs were the same. In this instance, both are functions of patronage.

Alternative III

1. HSRA operated at a $27.3 million loss; the introduction of HSRA reduced revenues of other modes by very small amounts.

2. HSRA capital expenditures of $1,591 million tripled total common carrier capital expenditures, compared with alternative II.

Alternative IV

1. HSRC operated with a $67.4 million loss. Despite the increases in performance characteristics over HSRA, the introduction of HSRC resulted in very small relative decreases in revenues of other modes.

2. HSRC required capital expenditures of $2,600 million; total common carrier capital expenditures increased approximately $1 billion over alternative III.

Alternative V

1. The TACV deficit was $103.0 million. As in the cases of HSRA and HSRC, there was a relatively small impact on the revenues of other modes.

2. Capital expenditures for TACV were $740 million larger than for HSRC, and total common carrier capital expenditures increased by $715 million over the comparable figure for alternative IV.

Alternative VI

1. VTOL was introduced as a break-even mode. It diverted significant amounts of patronage from other modes. The largest impact was upon CTOL; revenues for the CTOL mode decreased by 25 percent.

2. Capital expenditures for VTOL were $1 billion. Total common carrier capital expenditures were roughly double those of alternative II.

Alternative VII

1. Introduction of VTOL resulted in a boubling of the loss incurred by HSRA in Alternative III, in which there was no VTOL competition.

2. VTOL revenues were decreased by only 5 percent from alternative VI, as a result of competition from HSRA.

3. Total alternative VII capital expenditures were $3,085 million, approximately double those of alternative VI and 35 percent higher than capital expenditures for alternative III.

Alternative VIII

1. HSRC in competition with VTOL showed a loss of $99.8 million, which was about a 50 percent increase over the HSRC loss in alternative IV, without VTOL competition.

2. VTOL revenues were decreased by eight percent from alternative VI to alternative VIII, as a result of the introduction of HSRC.

3. Capital expenditures reflected the change from HSRA to HSRC, increasing by approximately $1 billion.

Alternative IX

1. TACV with VTOL competition lost $147.6 million. This represented a 50 percent increase in the annual loss incurred by TACV in alternative V, without VTOL competition.

2. VTOL revenues remained almost constant compared with alternative VIII.

3. Total common carrier capital expenditures were $4,900 million, reflecting the increased expenditure associated with TACV.

COST AND BENEFIT EVALUATION

The use of the NECTP model system to analyze the performance of nine transportation alternatives for the Corridor in the year 1975 has permitted a detailed comparison of these systems in the market and environmental setting of the Corridor at that time. The analyses have attempted to show how each of the systems would respond to different growth patterns in the region and to a range of policy options. The results produced, however, offer only limited information about what has gone before in time and what can be expected to follow. The analyses say little about what cost and revenue relationships would be for post 1975-80.

The analyses also do not profess to judge the overall economic viability of individual modes. The air, bus, and rail carriers involved in the alternatives have extensive operations in addition to Corridor intercity passenger service. The evaluation, moreover, does not attempt to measure the costs of congestion which might result from a failure to adjust the existing system to increased demand. In the following sections the effects of these limitations are considered:

1. In the evaluation of transportation alternatives, benefits (revenues) and costs have been annualized for the year 1975 to permit comparison of the nine systems on the basis of economic viability for that year. The evaluation does not, however, permit comparison of the systems from a current vantage point in time. This could only be done by discounting back to the present the life cycle streams of benefits and costs of the component modes in each of the systems.

   The Corridor project has assumed that the present social rate of discount of 10% suggested by the Bureau of the Budget could be used as the cost of capital for purposes of calculating the operating costs of each mode. If this rate of discount were applied to the stream of life-cycle benefits and costs of the new modes in the nine alternatives, the results would clearly favor the air modes because: (1) the present value of benefits accruing from the ground modes 30 to 40 years hence would be very small, (2) the flexibility of the air modes permits adjustments over time of capital expenditures to changes in demand, and (3) the capital costs of the ground modes would be incurred immediately and, therefore, would be subject to very little discount.

The cost structures of the new air modes are characterized by high ratios of operating costs (direct and indirect) to annual capital costs. In VTOL, for example, operating costs are more than twice as large as annual capital costs.

Cost structures of this kind offer flexibility in situations of uncertainty as to patronage and costs of capital. Hence, a decision to invest in an air mode would buy time during a period of uncertainty. It would also avoid the heavy drain on resources involved with a mode requiring large capital investment.

The long-run cost structures of the ground modes reflect the availability of important economies of scale and low costs of handling additional traffic once the fixed facilities have been built. The ratios of operating costs to total annual costs are low; for example, the operating costs for HSRA (even with present work rules) are only 33 percent of total annual costs for this mode. This means that if traffic turned out to be higher than predicted, the additional patronage could be handled by one of the ground modes at relatively low cost and, as a result, the ground mode deficits would be reduced.

2. Small changes in the allocation of common costs between freight and passenger service, and between intercity and commuter services, could sharply affect the viability of all modes. A shift of allocated costs toward freight on the Penn Central, for example, could make HSRA service profitable.

3. Congestion is a difficult phenomenon to measure. In highway transportation, for example, it reflects as much motorists' tolerances of traffic delays as it does physical limits of capacity. Capacity itself, is not easy to measure or to predict. It will vary with weather conditions and traffic patterns. It can be changed by public action in setting speed limits or by excluding certain classes of vehicles from facility use. In the Northeast Corridor, as stated earlier, the prospect of increased congestion in the NEC hangs over both air and highway transportation, but it does not threaten the high speed ground modes. If intolerable levels of congestion materialize in the Corridor in the next several years, the ground modes would become more attractive. In this respect, however, the impact of both STOL and VTOL on air traffic congestion could be minimal if improved air traffic control procedures and techniques were adopted.

User Costs and Benefits not Accounted for in the Analysis

The relationship between modal costs and revenues is a major consideration in the evaluation of the nine alternative systems for the Corridor. In the simulation, supply-demand equilibrium is reached through a demand model which is sensitive to only three characteristics of transportation service: trip times; fares; and departure frequencies. While there is strong empirical evidence that these variables can be used to forecast most of the response of travelers to different levels of transportation service, there is still a residue of response which is attributable to other service characteristics. Two of these characteristics, safety and variability of arrival times, appear to be of some significance to travel decisions and are, therefore, discussed in the following*:

1. While the present demand model does not distinguish between modes on the basis of accident hazard, potential travelers may do so to some extent. It is, therefore, important that the relative safety of the several modes be considered in the evaluation of each alternative system. The expected rates of deaths and injuries for each of the new and conventional modes in 1975 are shown below in Table 1-11. The projections indicate that the high speed ground modes would have markedly lower accident-related fatalities and injuries, in comparison with both the conventional modes and the new air modes.

2. The demand model assumes that travel decisions are made without consideration of the relative reliability of the several modes in meeting scheduled arrival times. This assumption is probably incorrect, but little data exists with which to determine either the distributions around scheduled arrival times for each of the modes or the impact which these distributions have on travelers' decisions.

   The small quantity of data available suggests that ground transportation, which in the Northeast Corridor is relatively unaffected by weather or congestion, would provide greater schedule reliability than air transportation. In a recent three month period, for example, the Penn Central Metroliners completed almost 90 percent of their runs within five minutes of schedule and were

*Transportation planners often calculate user time savings of transportation improvements and regard these time savings as benefits. With several modes competing in the supply-demand simulation, trip time has a strong influence (time elasticity of demand =-2.0) on modal choice in the market and hence on carrier revenues. Therefore, to include time savings as additional user benefits in this analysis would be redundant.

TABLE 1-11 EXPECTED RATES OF PASSENGER DEATHS AND INJURIES FOR 1975, BY MODE

	1975 rate* per 100 million passenger miles	
Mode	Fatalities	Injuries
Auto	2.40	85.4
Bus	0.24	6.6
CTOL	0.30	2.4
STOL	0.60	4.9
VTOL	1.60	15.0
DEMO	0.10	0.9
HSRA	0.10	1.0
HSRC	0.10	0.9
TACV	0.08	0.4

*Automobile rates are based on adjusted national data for 1967; bus rates are based on national intercity bus experience, 1964-1969; CTOL rates are based on experience of U. S. Certified Route Air Carriers, 1967; STOL rates are scaled upward from current CTOL experience; VTOL rates are set at one-third the 1967 rate for domestic carrier helicopters, to allow for improvement over time; rates for DEMO, HSRA, HSRC and TACV are based on adjustments to national passenger rail experience in 1967. See NECTP-224.

more than 15 minutes late less than seven percent of the time. In contrast, air traffic delays at major Corridor airports have increased substantially in the past few years. See Table 1-12.

Social Costs and Benefits

It is important in comparing transportation alternatives to consider relative costs and benefits which are imposed on the community, but which are not reflected in prices for transportation services. Such costs are not borne or received by users. Costs of this kind include accidents, noise and air pollution. Social benefits are less easily identified, but are generally subsumed under such categories as regional economic growth,* improved resource utilization, personal mobility, community life patterns, and national defense.

This discussion does not attempt to enumerate all the social costs and benefits which may result from the nine alternatives. Many of these impacts deserve more attention than has been afforded them so far by the Corridor project. Several have been considered tangentially in other sections of this report. In this section focus is placed on two classes of impact: (1) accidents, noise and air pollution, which seem to be of greatest concern, at present, to the community; and (2) regional economic impacts, which have often been used to justify transport investment.

Accidents

The social costs of accidents are comprised of human and material resources lost in property damage, injury and death. The sums of these costs are shown in Table 1-13 by mode for each of the nine alternative transportation systems. The much higher total cost of accidents in alternativesVI through IX reflect the presence of VTOL in these four alternatives. The high ($241,000) value placed on the capitalized life earnings of air passengers, as contrasted with ground passengers ($92,000), and the relatively high fatality rate predicted for VTOL combine to raise the accidents costs of this mode.

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*In the 1975 evaluations, regional economic impact was treated as an externality. In successive cycles of the NECTP model system which takes account of changes over time, this growth would become internal to the analysis. To the extent that economic impact and other consequences begin to influence decision-makers on resource allocation, the impacts begin to fall out of the category of "externality".

TABLE 1-12 AIR TRAFFIC DELAYS AT FOUR MAJOR AIRPORTS IN THE NORTHEAST CORRIDOR

Airport	Air traffic delay*					
	Aircraft delay, aircraft-hours per year x 10^3		Passenger delay, passenger-hours per year x 10^3		Typical peak-hour aircraft delay, minutes	
	1966	1970**	1966	1970**	1966	1970**
JFK	24	95	1170	6290	35	110
La Guardia	4	16	110	550	10	28
Newark	6	22	170	830	16	43
National***	8	10	242	357	16	19

*Delays are recorded only for aircraft more than 15 minutes over schedule.

**Estimated by FAA, based on existing facilities.

***Projected 1970 delays at Washington National Airport reflect the restrictions on the number of operations per hour imposed by FAA.

Source: Federal Aviation Administration, Alternative Approaches for Reducing Delays in Terminal Areas, Clearinghouse for Federal Scientific and Technical Information, Number AD 663 089, November 1967.

TABLE 1-13 PREDICTED ACCIDENT COSTS IN 1975, BY MODE, FOR NORTHEAST CORRIDOR TRANSPORTATION SYSTEM ALTERNATIVES

Alternative	Accident Costs in Millions of Dollars per year*					
	C/STOL	VTOL	High Speed ground	Bus	Auto	Total
I	1.8	--	4.4	1.3	32.0	39.5
II	5.0	--	4.1	1.3	31.5	41.9
III	5.1	--	1.8	1.3	31.3	39.5
IV	4.9	--	2.5	1.2	31.0	39.6
V	4.6	--	2.1	1.2	31.0	38.9
VI	4.9	20.5	4.4	1.3	27.7	58.8
VII	3.7	17.5	1.5	1.1	27.4	51.2
VIII	3.8	17.5	2.0	1.1	27.4	51.8
IX	3.8	17.5	1.8	1.1	27.4	51.6

*The capitalized value of the life earnings of air passengers, because of the heavy concentration of business travel, was taken to be $241,000, while the ground mode deaths were capitalized at $92,000, based on the national average of earnings. Accident costs per million passenger miles were:

Auto	$2,267	DEMO	$2,590
Bus	702	HSRA	758
CTOL	976	HSRC	784
STOL	1,840	TACV	523
VTOL	6,033		

Noise

Noise is a problem with all modes of transportation, particularly those operating in settled areas. The problem of noise can be ameliorated by:

1. Reducing the noise level at the source;
2. Isolating the modes from the environment by placing ground modes underground and by utilizing water or open field approaches for air modes; and
3. By insulating buildings in the vicinity of transport modes against noise.

All three procedures involve some costs. So far as new modes in the nine alternatives are concerned, STOL and VTOL pose particular problems, but there are also noise considerations for the high speed ground modes. The noise levels which would be produced by each of the new modes is shown in Table 1-14. The HSGT modes consistently exhibit the lowest noise levels; they also make extensive use of tunnels in central business district areas, thus further reducing noise problems. It was not possible to determine with satisfactory accuracy the costs of reducing the effect of noise levels generated by the air modes either by insulating nearby buildings or by reducing noise at the source.

TABLE 1-14 NOISE LEVELS PRODUCED BY NEW MODES

Mode	Perceived Noise Level (PNdB) 100 feet from noise source*
DEMO	95
HSRA	95
HSRC	95
TACV	107
STOL**	130
VTOL**	115

*A range of 75-85 PNdB is considered a typical continuous background noise level in downtown commercial areas.
**Applicable only during landing and take-off.

Source: NECTP-224

Air Pollution

All of the modes of transportation considered in the nine alternatives cause some degree of air pollution. Estimated quantities emitted by each of the modes are shown in Table 1-15 Since the impact of a given quantity of pollution depends upon the size of area over which it is spread, on the nature of the pollutants and on various climatic conditions, the raw estimates in Table 1-15 should not be regarded as measures of toxicity.

The three electrically-powered high speed ground modes generally create somewhat less pollution per million passenger-miles than do the air modes, and considerably less than the highway modes. All of the common carriers fall far short of the auto in terms of the total quantity of pollutants emitted in a year. The effect of a given quantity of pollutants is in part determined by the proximity of the source to settled areas; thus, the possibility of locating electric power generating plants in remote areas improves the favorable pollution characteristics of the high speed ground modes.*

TABLE 1-15 ESTIMATED QUANTITY OF POLLUTANTS EMITTED BY INTERCITY TRANSPORTATION IN THE NEC IN 1975

Mode	Estimated quantity of pollutants emitted by intercity transportation in NEC	
	Pounds per million passenger-miles	Pounds for the year 1975
HSRA*	1100	2,260,000
HSRC*	1200	3,360,000
TACV*	3400	11,600,000
C/STOL	3000	6,870,000
VTOL	3400	9,730,000
Bus	24000	33,600,000
Auto	30000	363,900,000

* Pollutants emitted at the electric power generating plant

Source: NECTP Report Number 224

* The potential advantage of remote power generation is somewhat lessened by power transmission losses requiring additional fuel to be consumed, per unit of useful power.

Regional Economic Impact

A regional impact model has been developed for use in predicting the socio-economic consequences of alternative transportation systems.* The impact model allocates regional population and employment levels among the areas of the Corridor, and estimates land use and income distributions within each for alternative transportation systems, subject to predetermined control totals. The redistributive actions of the model are presented at successively lower levels of aggregation of areal units for the Corridor. Model results indicate that improvement in passenger service will have a greater effect on population distribution that on employment distribution. No generalizable changes in land use or income distribution, as a result of improved passenger service, were indicated. While the magnitudes of the predicted geographic redistributions must be interpreted with caution, the predicted patterns of change appear realistic.

Measuring Socio-Economic Impact

Socio-economic effects of changing passenger transportation facilities were measured by comparing the impacts of two alternative transportation systems. The first, or reference case, is a modified version of alternative I (designated alternative I-A), in which 1965 rail was used instead of 1975 DEMO. The second transportation system for which impact measures were obtained is alternative V, which was chosen as representing the case of maximal impact short of the addition of VTOL aircraft. Because of the assumption that the implementation of new passenger systems would occur about 1975, the socio-economic impact of these systems would not be observable until the 1980-1990 period.

Growth in the Core Area

A gross measure of impact is the change in the proportion of total employment and population in the core portion of the Northeast Corridor brought about by the new passenger systems. Projections of this impact are shown in Table 1-16 for the years in which the transportation system designs would begin to take effect.

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*See NECTP-218.

TABLE 1-16 RATIO OF EMPLOYMENT AND POPULATION IN THE CORE PORTION TO THE TOTAL NORTHEAST CORRIDOR REGION

Year	Employment (x 1,000)		Population (x 1,000)	
	Alt I-A	Alt V	Alt I-A	Alt V
1980	15,692 86.6%	15,692 86.6%	44,624 85.0%	44,606 85.0%
1985	16,384 86.1%	16,379 86.1%	47,580 86.3%	47,516 86.2%
1990	17,114 85.7%	17,107 85.7%	48,163 83.2%	47,994 82.9%

This aggregative measure of impact indicates that the introduction of new passenger systems would have negligible effect in changing the proportions of economic activity between the core and fringe areas* within the Northeast Corridor. As the economy of the entire Corridor grows, the fringe area will increase its share of the total, but this increase would be relatively unaffected by proposed transportation systems.

Decentralization Within the Core Area

A second, and less aggregative, measure of impact than that described above is the shift in location of economic activity and population within the core area itself brought about by improved passenger transportation. Measures of these shifts at the superdistrict level of

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*See NECTP-218 for definitions of the Northeast Corridor core and fringe areas.

areal detail were obtained for alternatives I-A and V.* The impact of alternative V versus that of alternative I-A indicated a clear tendency toward decentralization along the north-south axis of the Corridor. Superdistricts in the central portion of the axis (from Trenton, New Jersey to Norwalk, Connecticut) exhibited relative declines in employment and population as a result of the implementation of alternative V, while superdistricts at the northern and southern ends of the Corridor had increases in employment and population links over those projected for alternative I-A.

The amount of decentralization projected is small because the location of firms, particularly manufacturing establishments, is much more dependent on transportation costs of freight than of passengers. Systematic improvements in the freight transportation systems were not analyzed at this time. However, the results of two sets of simple sensitivity tests of the impact model to changes in freight versus passenger transport system impedances did show greater tendency for employment levels to be affected by freight system changes. These results are given in the support document, NECTP-218.

Suburbanization Within Superdistricts

A third measure of impact relates to the relative shift of economic activity from central cities to suburban areas within the various superdistricts comprising the Corridor. Central city projections for 1990 are summarized in Table 1-17 below.

TABLE 1-17

ECONOMIC ACTIVITY LEVELS WITHIN CENTRAL CITIES
IN THE CORRIDOR FOR 1990

	Alt. I-A	Alt. V	% Difference
Employment (x 1,000)	6,651	6,635	-0.2
Population (x 1,000)	13,011	12,746	-2.0

*A superdistrict is a collection of economically and demographically homogeneous counties. The Northeast Corridor is divided into 29 "core" superdistricts and 11 "fringe" superdistricts. Projected 1980 and 1990 population and employment levels for each of the 29 core superdistricts are presented in Technical Appendix 5.

In summary a tendency for improved passenger transportation to decentralize economic activity within the core portion of the Northeast Corridor is observed in using the impact model. The amount of decentralization projected is relatively small, as would be expected at these gross geographic levels. As further areal detail is brought to bear, there is further disaggregation of the various impacts.

CHAPTER 2

ACTIONS REQUIRED TO IMPLEMENT ALTERNATIVES

Recognizing that life-cycle benefit-cost analyses ought to be conducted prior to decisions on any major system change, this chapter examines the actions necessary to implement each of the nine alternative transportation systems for the Northeast Corridor considered in this report. Particular stress is placed on actions which would be required by the Federal Government.

Implementation of each alternative would require the following:

Alternative I

Continuation of present policies and programs supporting expanded service by conventional air and highway modes.

Expansion of present Metroliner and Turbo train service by either private or public means to meet the increases in demand for rail passenger service forecast for 1975.

Alternative II

Private development of short-take-off-and-landing (STOL) air service would require some Federal actions to insure that suitable STOL aircraft are manufactured and certificated for NEC operations, and that supplemental air navigation facilities are provided. Certification of one or more air carriers by the Civil Aeronautics Board might be needed for particular route segments.

Table 2-1 shows a timetable for development of STOL air service in the Northeast Corridor on the basis of the lead time required to achieve full STOL service. The table shows a complete cycle from start of work to completion of a new system--about seven years. However, a number of options are open in addition to providing a wholly new system. The 122-passenger STOL is well into prototype testing, and is three years from delivery. The 48-passenger STOL is in final design, and is two years from delivery. Several military designs for STOL aircraft are now in production and could be modified for civilian use and ready for certification within one year.

Similar options exist for the choice of navigation and approach systems, and even for choice of terminals. STOL could start partial service very rapidly with existing equipment and sites, assuming no delays in certification or organization of the prospective service.

TABLE 2-1. TIMETABLE FOR DEVELOPMENT AND IMPLEMENTATION OF STOL AIR SERVICE IN THE NORTHEAST CORRIDOR.

Task	Years to Full Service: 0 1 2 3 4 5 6 7
Research and development	New low noise, low pollution gust-insensitive aircraft
Vehicles	
Prototype design, manufacture and testing	122 passenger (210-G)
Final design	48 passenger (DHC7)
Manufacture	DHC5 (Buffalo)
Navigational aids and airport approach systems	
Prototype design, manufacture and testing	New low altitude, all weather precision navigation
Final design	Decca/ILS
Manufacture and installation	Existing aids and systems
Terminals	
Site selection and acquisition	New major site; Existing small airport
Planning, design and construction	Existing CTOL
Service	
Start partial service	▲
Start full service	▲

Key: Arrows designate present(1969) state of development for each task item.

Alternative III

In addition to steps for CTOL and STOL described above, the present Penn Central line between Washington and Boston would need to be upgraded over substantial portions of the existing right-of-way to permit 150-mile-per-hour HSRA operation. Required upgrading would include substantial work on the present track, catenary, and signal systems; new bridges across the Bush, Susquehanna, and Hackensack Rivers; curve and grade-crossing eliminations; an improved route into Boston; and construction of a new tunnel and station at Baltimore.

A decision would be needed regarding the respective roles of the Federal, state, and local governments and the Penn Central Railroad in accomplishing this alternative.

The tasks and estimated time required to provide an operational HSRA are shown in Table 2-2.

Alternative IV

In addition to those items required for air and highway in alternatives I and II, alternative IV would require a completely new right-of-way for a 200-mile-per-hour HSRC passenger railroad serving the centers of seven of the largest Corridor cities and four suburban park-and-ride terminals.

An intensive R&D program would be needed to insure development of a safe, comfortable 200-mile-per-hour rail system.

Extensive right-of-way acquisition would have to be initiated at an early stage to enable HSRC to be operational during the 1975-80 time period.

A decision would be needed on how a new high speed rail mode on new right-of-way would be organized, financed, and operated.

The tasks and estimated time required to provide an operational HSRC are shown in Table 2-3.

TABLE 2-2. TIMETABLE FOR DEVELOPMENT AND IMPLEMENTATION OF HSRA IN THE NORTHEAST CORRIDOR.

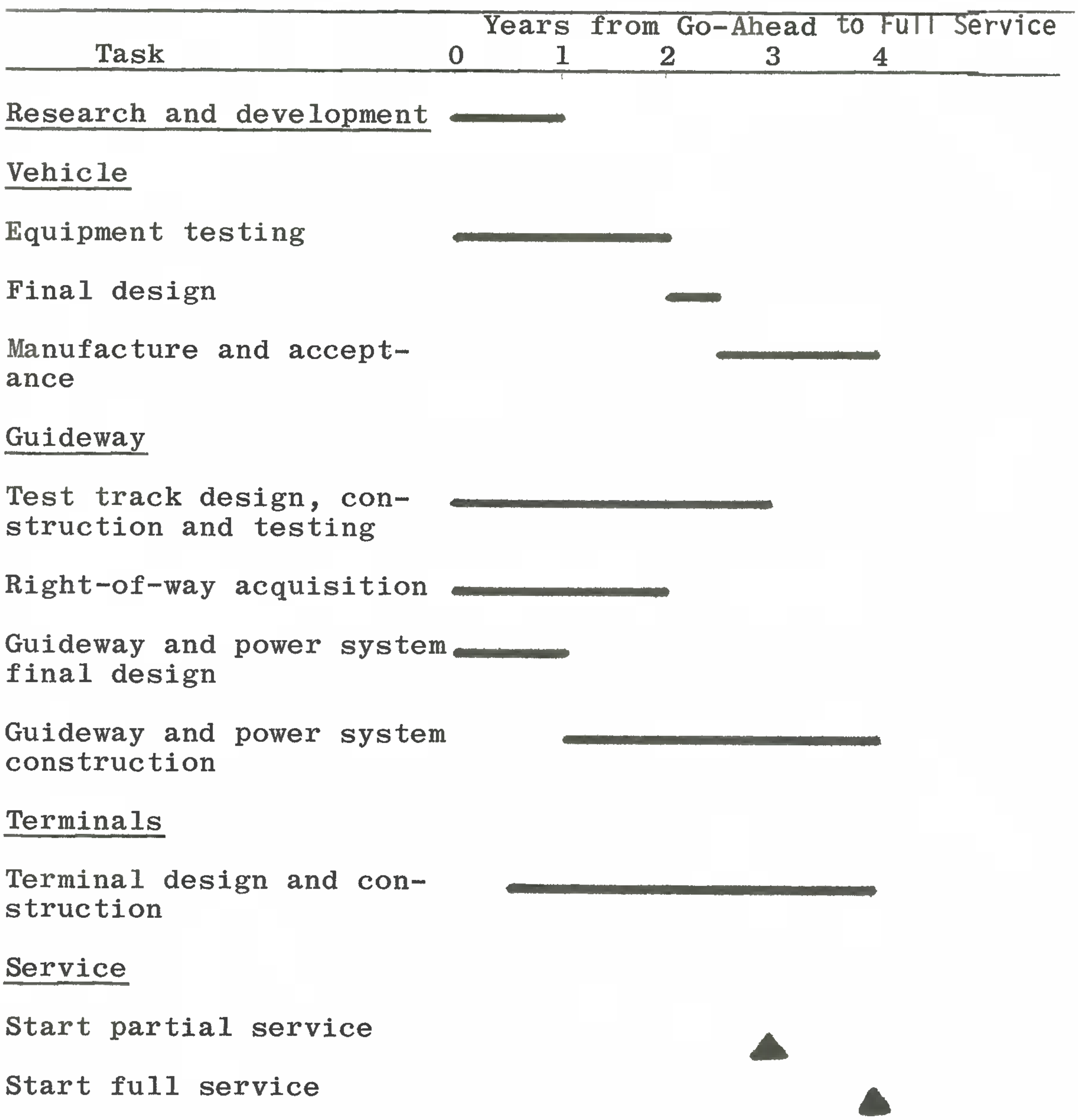


TABLE 2-3. TIMETABLES FOR DEVELOPMENT AND IMPLEMENTATION OF HSRC AND TACV IN THE NORTHEAST CORRIDOR.

Task	Years from Go-Ahead to Full Service 0	1	2	3	4	5	6	7
Research and development	—	—	—					
Vehicle								
Prototype design manufacture and testing		—	—	—				
Final design			—	—	—			
Manufacture and acceptance testing					—	—	—	—
Guideway								
Test track design construction and testing		—	—	—				
Right-of-way acquisition	—	—	—	—				
Guideway and power system final design and specification			—	—	—			
Guideway and power system construction			—	—	—	—	—	—
Terminals								
Terminal design and construction			—	—	—	—	—	
Service								
Start partial service							▲	
Start full service								▲

Alternative V

As with alternative IV, alternative V includes a high speed ground transportation mode (TACV) operating on a new right-of-way. TACV was assumed to serve the same terminals as were served by HSRC.

Since no 300-mile-per-hour TACV exists today, operations of this mode in 1975-80 would require an immediate and intensive program of R&D to insure its availability. The implementation schedule presented for this alternative assumes that a tracked air cushion research vehicle program has been in progress for 3 years prior to the go-ahead decision for the operational vehicle.

Extensive right-of-way acquisition would need to be initiated at an early stage to enable TACV to be operational during the 1980 time period.

A decision would be needed on how a new innovative mode such as TACV would be organized, financed, and operated.

The tasks and estimated time required to provide an operational TACV are shown in Table 2-3.

Alternative VI

Alternative VI is similar to alternative II, except for the addition of vertical-takeoff-and-landing air service.

Intensive R&D is required to insure that VTOL would have low noise and pollution effects and would operate efficiently and reliably.

Modified air navigational facilities would have to be developed and provided along with special heliports and other VTOL ground facilities.

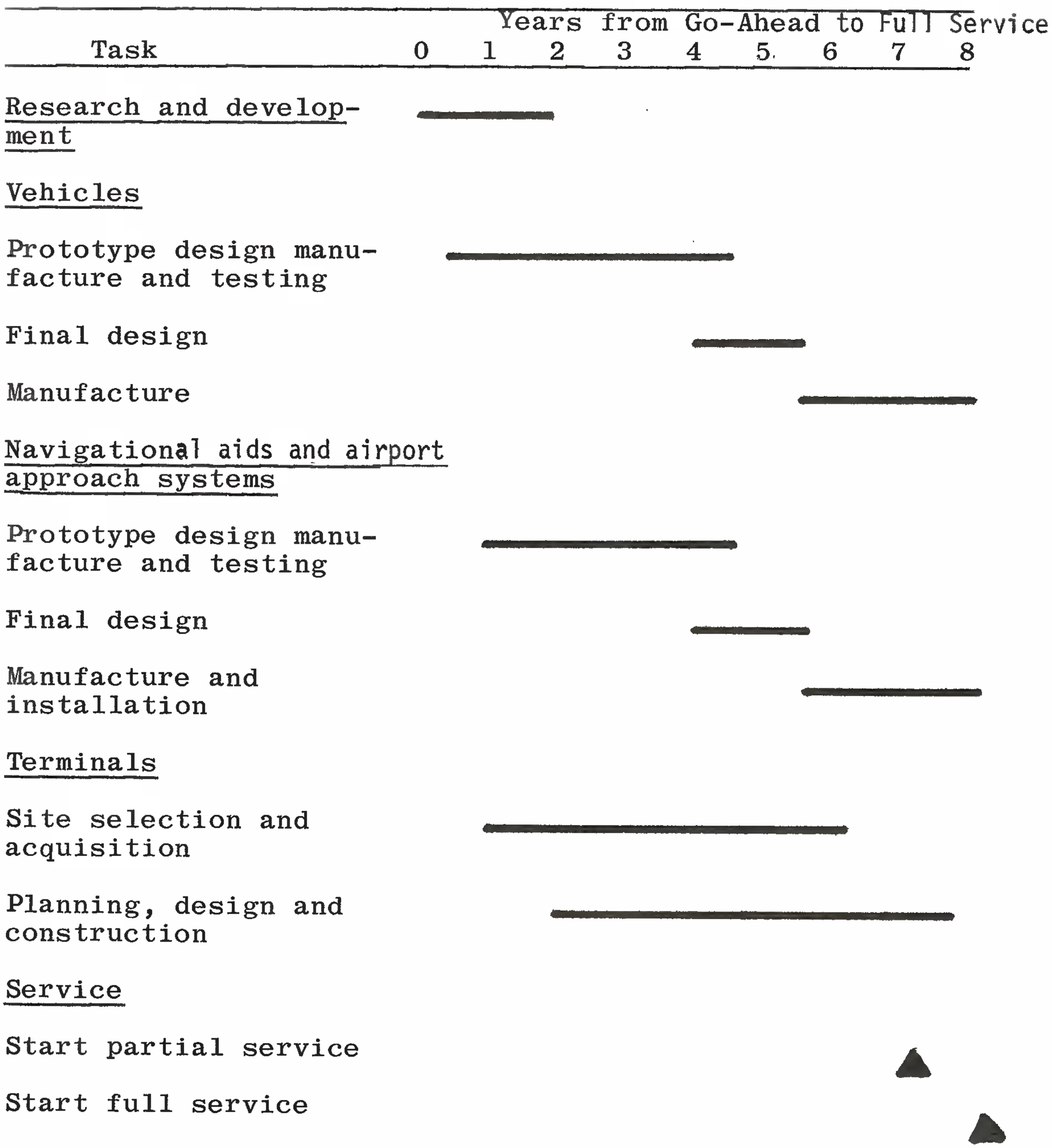
A decision would be required by the CAB on VTOL certification.

The tasks and estimated time required to provide an operational VTOL are shown in Table 2-4.

Alternative VII, VIII, and IX

Alternative VII requires for implementation the combination of tasks listed in AlternativesIII and VI; Alternative VIII, those listed in Alternative IV and VI; and Alternative IX, those listed in Alternatives V and VI.

TABLE 2-4. TIMETABLE FOR THE DEVELOPMENT AND IMPLEMENTATION OF VTOL IN THE NORTHEAST CORRIDOR.



CHAPTER 3

MANAGING AND FINANCING NORTHEAST CORRIDOR TRANSPORTATION IMPROVEMENTS

INTRODUCTION

The adoption of one or more of the new intercity modes evaluated in the Northeast Corridor project model and simulation system would require both public and private decisions on management and finance. As discussed earlier, the project has not completed life-cycle benefit-cost analyses of each new mode; therefore, observations about the requirements for financing cannot be conclusive. Nevertheless, simulation-modeling results for the year 1975 and supporting analyses discussed in Appendix 3 offer some indications of whether or not new modes would be economically viable. In this respect it should be noted that the model simulations maximized service for the air modes rather than profit and, thus, profit potentials for air might be larger than shown in this report.*

Generally the 1975 evaluation shows the new air modes to be viable and the new ground modes not to be viable. The STOL and VTOL modes' promise of financial self-sufficiency, even assuming that their operators would have to provide air terminal financing, could attract private capital. Conversely, the ground modes, on the basis of analyses carried out so far, show little likelihood of meeting total costs for some years beyond 1975.** Hence, public support in some form would probably have to be forthcoming if an alternative containing a new ground mode were to be adopted.***

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* Wherever possible in the Corridor analyses and evaluations, costs were attributed to the services which occasioned them. The only exceptions were the portions of air costs currently paid for from Federal funds and some current costs for rights-of-way used for the Demo rail service. No shifts in passenger demand or carrier costs due to new legislation have been assumed.

** In order to achieve uniformity over all modes, the supply-demand equilibrium was run with 10 percent return on investment before corporate income taxes as a cost of capital. It is uncertain whether this prospective return would attract equity capital to the airlines. It might, however, permit borrowing.

*** It appears that all new modes considered in this report would be able to cover direct costs, including capital payments, by the 1990's.

After comparing the financial results of the new modes, this chapter reviews the capabilities of the existing carriers to manage and finance new regional passenger transportation service. Where it appears that private management and finance could not carry responsibility for a new system, alternative forms are explored. A final section examines the status and trends in government finance which are pertinent to public funding of a deficit-prone regional transportation service.

FINANCIAL RESULTS OF SYSTEM ALTERNATIVES

Table 3-1 below summarizes the before-tax results of simulated operations of the nine alternative transportation systems, based on 1975 levels of activity.

TABLE 3-1

PROSPECTIVE 1975 FINANCIAL RESULTS
NEW MODES IN ALTERNATIVE NORTHEAST CORRIDOR TRANSPORTATION SYSTEMS
($ MILLION)

Alternative Number	New Modes	Surplus or (Deficit)* for New Mode(s)
I	DEMO	82.7**
II	DEMO***	80.8***
III	HSRA	(27.3)
IV	HSRC	(67.4)
V	TACV	(103.0)
VI	DEMO, VTOL	65.2
VII	HSRA, VTOL	(54.6)
VIII	HSRC, VTOL	(99.8)
IX	TACV, VTOL	(147.6)

* The evaluations included rates-of-return figures as required by U. S. Bureau of the Budget Circular A-94. A 10 percent rate of return was initially applied to new system investments, with a 35- year amortization period assumed for plant; 14 years for vehicles; and a perpetual return of 8 percent per annum on land. VTOL and STOL were run to break-even points, so residual surplus/deficit figures are zero.

** Surplus figures on DEMO result from subtracting additional costs from additional revenues of DEMO service.

*** STOL, which appears in alternatives II through IX, is considered to be a new mode, but its revenues have been combined with CTOL.

USE OF EXISTING CARRIERS AS ORGANIZATIONAL BASE FOR NEW MODES

At present, six airlines, one railroad, and two major bus lines--all privately owned and operated--provide the bulk of commercial inter-city passenger services in the Northeast Corridor. The airlines are Allegheny, American, Eastern, Mohawk, National, and Northeast; the railroad company is the Penn Central*; the bus companies are Greyhound and Continental Trailways.**

Whether any of the private carriers would be both interested in, and capable of, providing the necessary financial resources to under-take the new or expanded Corridor transportation services considered in the NECTP analysis is uncertain. Existing carrier resources matched against the scale of investment necessary for a new service do not at present seem adequate.

Airlines

Recent airline financing has largely been through the use of chattel-type debt instruments on airline equipment. Arrangements for financing have been relatively easy because of comparatively short repayment cycles and the favorable prospect of resale of the equipment in the event of repossession; although special-purpose equipment, such as V/STOL aircraft for which there might be a more limited market for resale, would pose higher risks with correspondingly higher capital costs. In general, equipment obligations constitute a relatively easy and readily available means of finance.

On the other hand, the airlines expect to go into the capital markets for more than $18 billion within the next five years.*** This much new financing constitutes a substantial problem for exist-ing carriers and probably limits their capability to consider the simultaneous establishment of new services.

Nevertheless, if V/STOL appears profitable, despite prospects that airline financial capabilities will be strained in the next few years, the existing Corridor carriers will almost certainly make an

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* Other rail carriers in the Corridor are primarily commuter.

** Financial analyses of Corridor carriers are also found in Chapter VI of NECTP-221.

*** Estimate submitted to the Subcommittee on Aviation of the Senate Commerce Committee, June 1969, by the Air Transport Association.

effort to obtain necessary new capital. If the carriers do not make such an effort the Civil Aeronautics Board might well certificate new firms for Corridor services, assuming that new private firms would find it worthwhile to provide the service.

Railroads

The improvements in high speed ground service represented in HSRA and HSRC, and TACV as well, would involve sizable new investments in rights-of-way and fixed structures. The railroads are already burdened by relatively large current charges on road and structure mortage debt. Moreover, some of the mortgages on real property contain "after-acquired" clauses which would impose prior claims to revenue and prior liens on new property. Thus, revenues on Corridor passenger services might be drawn off to support operations elsewhere on the railroad with no recourse available to contributors of new capital. It is, therefore, probably accurate to say that existing rail carriers are totally incapable of financing either major road and structure improvements on existing rights-of-way or new rights-of-way and guideways.

Rail passenger equipment has been financed by the same sort of chattel instruments as those characteristic of airline equipment debt, and hence, capital for high speed ground equipment would be more available -- provided the equipment has realizable value for resale.

Alternatives III, IV, V, VII, VIII, and IX; i.e., all those with greatly improved high speed ground modes, would show deficit operations in the year 1975. By contrast, the DEMO service simulated in alternatives I, II, and VI were not charged for the use of existing facilities, and showed healthy operating surpluses for passenger service between Washington and Boston. For reasons discussed just above, however, it is virtually certain that capital for even the modest fixed improvements in these alternatives would not be available to the Penn Central Railroad from private capital markets. If by some such means as a rail passenger service corporation, the costs and revenues of Corridor passenger service could be segregated from the rest of the railroad's operations, private capital might be forthcoming. With this approach, it might even be possible for facilities such as stations to be put beyond the reach of the after-acquired clause.

ORGANIZATION FOR THE ESTABLISHMENT OF NEW MODES

The nine alternative transportation systems covered by the NECTP analysis fall into three general categories: those based (1) on new ground modes, (2) on new air modes, and (3) on combinations of the two. (Multi-mode transportation companies are not likely to appear by 1975 and so entities will be considered as operating one mode only.*) There are five basic organizational structures which could be used for management and finance of the new modes. They are (1) a private corporation (e.g., Penn Central Company), (2) a public-private corporation (e.g., Comsat), (3) an interstate compact (e.g., Port of New York Authority), (4) a Federal corporation (e.g., Tennessee Valley Authority), or (5) a Government department or agency (e.g., Alaska Railroad of the Federal Railroad Administration).**

Innumerable adjustments or variations can be made within, between, or among these general organizational categories. The relative profitability of a new mode has a definite bearing on the kind of organizational structure which would be suitable for its operation and management. Hence, a decision to use one or another of these forms for a new mode appears to be primarily a function of the financial requirements of the mode. Other factors such as the degree of public control over the establishment and operation of a given system, may also be of importance in the selection of an organizational structure. Another factor of organizational importance would be the time required to establish any given management system. For example, the interstate compact, as compared with other organizational forms takes a relatively long time to establish. Given the decision to seek a compact, however, the possibility of using an interim organization such as a Federal-agency structure, might be considered pending Federal and state agreement to the compact. Similarly, it might be desirable, for the purpose of raising money and for implementing operational procedures, to use a Federal corporate structure as an interim step to a public-private corporation.

Developing New Air Modes

With the prospect of profitability for new air modes, there may be no need for any significant additional public financial aid other

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* Neither the Interstate Commerce Commission (ICC) nor the Civil Aeronautics Board (CAB) encourages multi-modal companies.

** A matrix of these organizational forms, with a description of their important differences, is included as an appendix to this chapter.

than that provided under existing Federal programs (i.e., the maintenance of airways, air traffic control and guidance for airport approaches). Because this service has relatively good prospects for profit, it could be established by private capital. It may need public support in several aspects, however, such as in the provision of terminals. Terminal facilities for VTOL should be in areas of easy access, which may already be developed. It may, therefore, be difficult to acquire necessary land at reasonable prices even though terminal expenses are not a large portion of the total investment required for this service. Private corporations, or other organizational structures reflecting a closer association with government (such as interstate compacts and puglic corporations), could be vested with eminent domain powers.

Developing New Ground Modes

Unlike the new air modes, present analysis does not predict that new ground modes will be free of deficits. Two new ground modes (HSRC and TACV), require large capital investments in land as well as in construction, terminal facilities, and hardware. Under existing statutes, there is no way to provide public support for new intercity ground systems; thus, consideration should be given to organizational alternatives that can accept government financial assistance with a minimum of difficulty such as public-private corporations, interstate compacts, Federal corporations, and Federal agencies. They are, as was mentioned earlier, distinguishable with respect to the extent of direct Government participation and the immediacy with which they could be implemented.

Labor considerations are of particular concern to ground modes, especially where wages are a large percentage of total operating expenses. Use of one of the organizational structures which provide for direct governmental participation might allow innovations to be made in existing employer-employee relationships. There is, however, a general reluctance to change existing labor patterns where the employees affected are not actual employees of a governmental agency. For example, an interstate compact bill for the Northeast Corridor proposed by Senator Claiborne Pell would guarantee the maintenance of existing labor patterns. Also, in the operations of the Alaska Railroad, labor rules and regulations are modeled after the current labor rules and regulations of the State of Washington, despite the facts that Alaska Railroad employees are Federal workers and the organization of the railroad is governed by Federal statute.

Alternatives with Two or More New Modes

The managerial and financial factors involved in the simultaneous implementation of two or more of the modal improvements described here are straightforward for most of the parties directly concerned. One of the objectives in the Department of Transportation Act of 1966 was to coordinate transportation in the United States.* There are nevertheless, large areas in which transportation is not well coordinated. For example, a new air service would be allowed to operate if the Civil Aeronautics Board determined that it was necessary to public convenience and necessity and would not harm existing air services. The Board could make this determination without consultation with the other transportation agencies, regardless of what the effect of its decision would be on other modes. Cross-effects between ground and air carriers are not taken into account by the existing regulatory bodies. All of this is to say that new legislation is necessary if the problems of coordination raised by alternatives VII, VIII, and IX are to be dealt with.

One simplifying assumption has been made in considering labor arrangements and the cost of improved ground service. The designs of high-speed rail and TACV modes are assumed to incorporate savings resulting from the use of improved technology with the minimum staffing requisite to the design specifications. Thus, present manning for rail services was not used as the guide for new services.** This departure from current rail labor practices implies that negotiations would need to be undertaken with the labor groups involved to reach agreement on new operating practices prior to initiation of a new ground service.

Some measure of coordination could be achieved by the Congress in approving one of the governmental organizational forms. The Congress could, for example, free a corporation or other entity from selected aspects of existing transport regulation or could reassign responsibility for such regulation. Legislative action of this sort might encourage experimentation in fares and services.

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* Public Law 89-670 (80 Stat. 931)

** See Report No. NECTP-222.

Each of the new ground modes, as was noted earlier, has large land requirements, and the power of eminent domain will, no doubt, be necessary. Still, special limitations may be placed on its use by the Congress. For example, enabling legislation might allow land acquired by eminent domain to be used to build a terminal but not allow a hotel or shopping center to be attached to the terminal facility.

Government participation may relieve the affected enterprise of the various tax liabilities. For a new enterprise with large start-up costs as well as low profit expectations, tax savings could be a factor of considerable importance.

ORGANIZATIONAL STRUCTURES TO ACCOMODATE PUBLIC FINANCIAL SUPPORT

Certain aspects unique to public organizational alternatives are discussed in the following pages.

General Complicating Factors

Consideration of the proper organizational form is complicated by the number of different interest groups (private, local, state, and Federal) whose concerns must be represented and resolved in negotiations prior to the establishment of an operating entity, even if the primary financial backer is the Federal Government. Congressional action may require a considerable period of time, and broadening of participation to bring in the state and local levels compounds any already existing delays. For example, the time frame for implementation of an interstate compact which requires the concurrence of several states tends to be at least two years. Furthermore, there is some reason to believe that Congressional approval of other organizational forms might require even more time, depending on the political climate.

Interstate Compact

In situations where sizable state resources will be used in a given enterprise and where its operation will measurably affect the public interest of the state, there is a solid argument for state or local government participation. Probably the interstate compact form is best known among the available organizational structures as an entity which can ideally balance local, state and Federal interests within the framework of an express agreement. This organizationalform also affords the best opportunity for effective state-local control in the management and operation of an enterprise which is regional (interstate) in nature.

The very fact that a compact formally attempts to balance interests is also the cause of its principal shortcoming--the relatively long time required for its adoption. Negotiations between the prospective parties in interest tend to be long and time consuming.

Public Corporation

The public corporate form of organization, whether public-private or Federal, implies a larger degree of Federal than state participation or control. Both the public-private corporation and the Federal corporation can be implemented more quickly than an interstate compact. While there may be as many different types of interest as in the compact situation, fewer actual parties must give assent to bring about final approval. The Congress, of course, will obviously have the most significant voice in the formation of a public corporation.

Although state and local government may have less to do with day-to-day operations of public corporations, provisions can be made for these governmental bodies to participate in policy-making through membership on the board of directors.

Federal Agency

As a practical matter, the development of a ground mode through the use of an established Federal agency or through the creation of a new one is probably not feasible. National policy appears to be opposed to the idea of a Federal Government agency entering into an area which has been served by the private sector. In addition, development and operation of a new transportation system by the Federal Government might well provoke the charge that the Government, with its enormous resources and powers, was unfairly competing with private capital. However, direct Government operation could be shown as being in the public interest if it were argued that the Government operation would be replaced at some time in the future by an organizational structure on a more equal footing with private firms.

GOVERNMENT FINANCES AND THE SUPPORT OF NEW MODES

If financial support from public funds becomes necessary to establish a new regional transportation service, the relative availability of resources at various levels of government is an important consideration in obtaining such support. The following material on the status and trend of government finances as they affect the Corridor provides a basis for judging which sources are most appropriate for developing a new regional service.

Local government does not appear to be a likely source for major support of any service which would be regional in its impact, even if local finances were less burdened than they appear to be. Regional financing and management are possible, particularly with cooperative funding provided by more than one level of government; but organizational machinery does not yet exist in an acceptable form for a region to raise funds to implement a new Corridor service. It is apparent, therefore, that public support must come largely from Federal and state sources.

General Trends in Government Finances

Government receipts as a whole are an increasing proportion of the Gross National Product (see Table 3-2). Annual tax collections by all governments nationwide have increased twenty-five fold over the past forty years. Federal individual and corporate income taxes, as a percentage of total Federal receipts, are at an all-time high--83 percent. Like the national debt, this relationship appears to be a legacy of World War II financing. State income taxes are now double their prewar percentage and equal nearly a quarter of state tax receipts. Most of this relative increase has come in the last twenty years and is a reflection of the expanding revenue requirements of state and local governments.*

Consumption-type taxes at the state level and property taxes at the local level still make up by far the major part of tax revenue for the non-Federal governmental sector. Rate schedules for these taxes typically flatten out rapidly and, therefore, have only limited progressivity; i.e., both are much less sensitive to income levels than Federal taxes.

The percentage of Federal funds expended by states and localities has also grown dramatically (see Table 3-3). Concurrently, Federal grants for such major budget categories as education, welfare and highways have provided needed funds, but the matching requirements have at the same time put additional pressures on state and local fiscal ability (see also Tables 3-6 and 3-7).

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*See also materials such as the Joint Economic Committee study, State and Local Public Facility Needs and Financing (December 1966).

TABLE 3-2

GOVERNMENT RECEIPTS, TOTAL AND AS PERCENTAGES OF GROSS NATIONAL PRODUCT, SELECTED DATES

Year	GNP	Total Government	Federal	State and Local
	($ billion)		(percent)	
1946	208	51	19	5
1948	258	59	17	6
1958	447	115	18	8
1968	866	264	20	10

Source: National income accounts.

TABLE 3-3

GOVERNMENT RECEIPTS AND FEDERAL TRANSFERS

TO STATES AND LOCALITIES, SELECTED YEARS.

Year	Total government receipts ($billion)	State and local receipts as a percent of total government receipts*	Federal transfers as a percent of total state and local receipts
1946	51	25	8.5
1948	59	30	11.4
1958	115	36	13.5
1968	264	40	17.2

Source: Office of Business Economics, and Bureau of the Census survey data.

*Including receipts from federal transfers.

Calendar year 1947 began a relatively level period for Federal debt but a rapid growth period for state and local debt. At that time, gross Federal debt was nearly fifteen times that of the states and their municipalities. Twenty years later, Federal debt was only three times the level of state and local debt. During the interim, Federal debt grew 40 percent--but state and local debt increased nearly 700 percent. Tables 3-4 and 3-10 give summary views of Gross National Product and government debt levels and the directions in which they are tending.

State and Local Expenditures

Federal civil spending, although it has risen since the beginning of the century, is still less than one-third of state and local expenditures (including intergovernmental transfers). Federally-collected revenues currently fund one-tenth of state educational expenditures, nearly one-third of state highway expenditures, and more than one-half of state and local welfare expenditures.

Despite the sizable Federal role in state and local funding, the U. S. Advisory Commission on Intergovernmental Relations has found that metropolitan areas in the industrial regions of the nation, particularly their center-city cores, are falling increasingly behind in the level of expnditures needed to provide adequate levels of public service.* Many of these lagging areas are within the Northeast Corridor.

Unfortunately, these industrialized metropolitan regions are also among the most heavily taxed in terms of the Federal income tax, but they receive relatively less back from the Federal Government in terms of intergovernmental transfers. The most recent definitive figures from the Department of the Treasury indicate that the Northeast Corridor states, including the District of Columbia, currently account for over 40 percent of total Federal revenue collections. In contrast, the area receives 25 percent of Federal grants-in-aid, and 17 percent of Federal grants to individuals.

The net difference between Federal tax collections and Federal direct transfer payments to state and local governments, to private institutions and to individuals in the Northeast Corridor during fiscal 1968 was nearly $54 billion. The comparison is made most clearly in Table 3-5 by comparing the last two figures of the middle column, "Percentage Returned," for the Corridor and the U. S. as a whole.

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* See, for example, Report A-31, Fiscal Balance in the American Federal System; Metropolitan Fiscal Disparities (October 1967).

TABLE 3-4

GROSS NATIONAL PRODUCT AND FEDERAL DEBT, SELECTED YEARS
($ billion)

Year	Average GNP for the year	Gross Federal Public Debt, July 1	Debt/GNP (percent)
1946	$ 208.5	$269.9 *	129.4 **
1949	256.5	252.8	98.6
1959	483.7	284.8	58.9
1969	933 ***	353.8	37.9
1979	1760 ***	440 ***	25

Source: Office of Business Economics, and Treasury Department.

* Pre-Korean period maximum.
** Absolute maximum.
*** Estimated, November 1969.

TABLE 3-5

FEDERAL REVENUE COLLECTIONS AND DIRECT GRANTS BY STATE IN THE NORTHEAST CORRIDOR (FISCAL 1968)

State	Collection Net of Refunds	Percentage Returned As Grants to State and Local Governments, Individuals or Private Institutions	Net Difference
Connecticut	$ 2.9 billion	10.1%	$ 2.6 billion
Delaware	1.1	5.7	1.0
Maryland *	3.8	17.4	3.1
Massachusetts	4.4	15.4	3.7
New Hampshire	0.4	21.4	0.3
New Jersey	5.4	9.3	4.9
New York	29.0	7.4	26.9
Pennsylvania	9.8	11.0	8.8
Rhode Island	0.7	17.1	0.6
Virginia	2.3	17.0	1.9
TOTAL CORRIDOR	$ 59.9 billion	10.1%	$ 53.9 billion
Total U. S. **	$142.3	17.2	117.8

Source: Treasury Department.

*Including the District of Columbia, since taxes withheld by employers in the Washington area are less distorted if totals for these two jurisdictions are combined.

**Adjusted to omit international postings, but including $2.1 billion in customs; $4.4 billion in highway user receipts; and $27.9 billion insurance, retirement, and disability trust funds.

In fiscal 1968, the Corridor states produced 42 percent of Federal revenue collections and received 33 percent of Federal outlays (see Table 3-6).

TABLE 3-6 NORTHEAST CORRIDOR STATES NET FEDERAL REVENUE COLLECTIONS AND PROGRAM OUTLAYS, FISCAL 1968

State	Federal Revenue Collections Net of Refunds*	Federal Outlays**	Index of Receipts from the Federal Level Compared to Net Federal Revenue Collections
	($ billion)		
50 States	153.0*	186.5**	100
Connecticut	2.9	3.9	102
Delaware	1.1	0.3	21
Maryland***	3.8	12.1	243
Massachusetts	4.4	5.0	87
New Hampshire	0.4	0.6	114
New Jersey	5.4	6.0	85
New York	29.0	19.4	51
Pennsylvania	9.8	8.0	63
Rhode Island	0.7	0.7	76
Virginia	2.3	4.8	160

Source: Treasury Department and Executive Office of the President

*Omits international postings but includes $2.1 billion in customs; $4.4 billion in highway user receipts; and $27.9 billion in insurance, retirement, and disability trust funds.

**Includes more than 980 program, activity, or appropriation items; and includes loans and the book value of nonmonetary donations.

***The District of Columbia totals have been combined with Maryland totals in the Treasury figures because of heavy commutation and government-facility-location interactions between the two jurisdictions.

The state and local expenditures for education, highways and public welfare are, collectively, approximately two-thirds of total state and local budgets. They have increased their share of a vastly larger budget total since the Second World War (see Table 3-7). Although these outlays would be twice their 1960 level in another decade, current trends indicate that highway spending would drop from 20 percent to less than 10 percent of state and local expenditures, while education would rise from one-third to over one-half of the total fiscal burden (Table 3-8 gives recent highway figures for the Corridor states).

In the Nation as a whole, only two components of state and local revenues and expenditures have remained reasonably stable since the mid-50's--property tax revenues and highway expenditures. All other major fiscal components of state and local finances are expanding at an increasing rate. If the trends among these components follow their behavior over the past decade, Federal transfers by 1980 will amount to nearly 30 percent of all state and local general revenues--double the amount collected from property taxes.

TABLE 3-7 LEADING GENERAL EXPENDITURES OF STATE AND LOCAL GOVERNMENTS, SELECTED YEARS (including receipts from the Federal Government)

Year	Amount ($ billion)	Education, Highways, and Public Welfare (Percent)
1946	12.4	52
1949*	19.1	64
1959	45.3	68
1967-68**	101.3	65

*Interpolated from Bureau of the Census survey figures.

**For twelve-month period ending June 30, 1968. Earlier data are for state and local fiscal years ending during the calendar year indicated.

TABLE 3-8

CORRIDOR STATE RECEIPTS
FROM FEDERAL SOURCES AND HIGHWAY EXPENDITURES
IN RELATION TO GENERAL EXPENDITURES

State	Receipts From Federal Sources as a Percent of Total State General Revenues			Highway Expenditures As A Percent of Total State Direct General Expenditure		
	1962	1967 (Percent)	1968	1962	1967 (Percent)	1968
Connecticut	17	21	25	34	26	24
Delaware	12	16	19	31	23	22
Maryland & D. C.	20	25	26	23	18	17
Massachusetts	21	22	23	31	22	23
New Hampshire	33	29	32	45	33	33
New Jersey	20	21	23	34	32	35
New York	14	18	19	27	22	20
Pennsylvania	18	21	23	32	30	32
Rhode Island	21	27	29	24	27	30
Virginia	22	25	23	41	42	38
All States of U. S.	19	26	26	22	28	26

Source: Calculated from U. S. Bureau of Census data

A rapid rate of growth in state and local spending is foreseen in the Corridor states over the coming decade (see Table 3-9). Operating expenditures and debt service on borrowing for capital expenditures will require an expanding flow of current revenue. Staffing, debt service, and new maintenance programs will all be major financing problems facing state and local governments. While projections of growth in program expenditures have been made for the NECTP which show compound growth rates varying between 8 and 12 1/2 percent, a figure of nine or ten appears most reasonable for current purposes, and is in keeping with experience over the past decade.

TABLE 3-9 ALTERNATIVE NORTHEAST CORRIDOR ECONOMIC CONDITIONS, 1980

Assumptions	Compound Growth Rate 1970-80 (percent)	Estimated State and Local Governmental Expenditures ($ billion)
Real growth rate declines to 4% prices grow at 5%	9.0	87.7
Growth rates approximate period 1961-1968	9.8	95.8

Source: Lionel D. Edie & Co. For additional details, see Report No. NECTP-221

Rapid growth in state and local debt can be attributed to a combination of factors; replacement of obsolete facilities and those for which maintenance was too long deferred; expansion of facilities to meet population increases; additional facilities for new or improved services to meet rising expectations; and matching funds to take advantage of Federal grant programs. A survey of transportation-related construction plans conducted in the Corridor for the Project (NECTP-211) suggests that a continuing rise in debt at a progressive rate will be necessary if existing plans and recognized needs are to be fulfilled. High current interest rates will probably be only a temporary deterrent to expanded state and local borrowing over the coming decade.

TABLE 3-10 NET GOVERNMENT DEBT, SELECTED YEARS
($ billion)

Year	Federal*	State and Local
1929	16.5	13.6
1932	21.3	16.6**
1939	42.6	16.4
1945	252.5***	13.4
1949	217.6	19.1
1956	224.3	44.4
1959	241.4	58.0
1968	291.9	128.6
1980****	380	373

Source: Council of Economic Advisers, and Office of Business Economics

*Corresponds to "Federal Government and agency" as reported in Budget of the U. S.

**Maximum until 1948

***Maximum until 1962

****Linear extrapolation, 1956 base.

SUMMARY

The results of the Northeast Corridor analyses performed to date indicate that expanded Metroliner service and VTOL would be the most viable transportation services that might be introduced during the next decade. Aside from these two possibilities and the STOL service which has been assumed to be introduced in any event, public-sector support for intercity passenger transportation will most likely be necessary.

The alternative forms of organization available for the management of new transportation services are related to the likelihood of profit-making or deficit operations. New air modes were examples of prospectively profitable investments and, therefore, could rely on traditional organizational forms. Possible new ground services, almost certain to require some public support on a continuing basis, would need new organizational bases.

One of the major state expenditures, highway programs currently loom large, but they are a declining proportion of an expanding budget that is increasingly directed toward social programs. Whether or not highway or other capital construction programs will continue at approximately their current level, the debt level of the Northeast Corridor states is certain to experience severe upward pressure over the coming decade--barring dramatic shifts in revenues or the level of government at which programs are handled.

The inhabitants of the Northeast Corridor states pay relatively more in taxes than they receive back, either in terms of intergovernmental transfers or in Federal outlays. Thus, they are obliged to raise relatively more of their own funds for state and local expenditures than other sections of the nation.

The funding of new transportation activities will, therefore, face stiff compeitition at the state and local level from expected demands for existing programs. Without aid from Federal sources, state and local financial capability appears to be inadequate for undertaking major new transportation ventures.*

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*Empirical evidence coming out of the Corridor Project suggests that intercity travel is sensitive to family incomes over $10,000 per year. This evidence, combined with recognition that Federal taxes are much more progressive with respect to incomes than state and local taxes, suggests that Federal expenditures for Corridor intercity transportation improvements would relate costs to benefits more closely than less progressive tax programs at the state level.

TECHNICAL APPENDIX I

ADVANTAGES AND DISADVANTAGES OF VARIOUS ORGANIZATIONAL ALTERNATIVES

The following material compares some important aspects of the various organizational alternatives that are available as the basis for a regional transportation activity.

ADVANTAGES AND DISADVANTAGES OF VARIOUS ORGANIZATIONAL ALTERNATIVES

	Organizational Characteristics	Private Corporation	Federal-Private Corporation
1.	Ease of implementation, and formation, (political and legal difficulties).	Formation--Generally fast and easy.	Possibly time consuming. Many complex interests (financial and otherwise) must be considered; and the various parties may require a rather complicated and sophisticated level of negotiation to reach agreement. Federal Government may have significant interests and concerns if large Federal participation (financial or otherwise) is required.
2.	Time required for formation and/or implementation.	Less than one year.	One year minimum.
3.	Financing and capital raising considerations, (also availability of subsidies and incentives).	Sale of stocks and bonds. Ability to borrow limited only by market response.	Sale of stocks and bonds. Federal guarantees for loans may be avail able, making bonds more attractive. State guarantees for loans are probably illegal or unconstitutional in most states. Direct Federal monies may be available for certain purposes.
4.	Degree of Federal Government participation in decision and policy-making activities.	Limited.	Probably in proportion to amount of financial assistance provided by the Federal Government.

	Organizational Characteristics	Private Corporation	Federal-Private Corporation
5.	Degree of State government participation in decision and policy-making activities.	Limited.	(Same as private corporation.)
6.	Subjection of activities to existing Federal regulations.	Complex; covering a wide range of areas from safety to fares and rates to labor regulations.	Congress may, through enabling legislation, hold the corporation free from some or all existing applicable regulations and the jurisdiction of any or all regulatory agencies.
7.	Subjection of activities to existing state regulation.	State regulation would be fully applicable (eg. zoning and land use; service requirements).	Congress could by special legislation hold the corporation free from certain types of local regulation. The norm has been to make the corporation subject to state regulation.
8.	General tax liability.	Fully liable except in those areas where forgiveness or other relief is available from the relevant taxing authority(s).	Generally same as private, however, special tax immunity provisions for Government operations may be applicable.
9.	Extent to which entity could be expected to engage in research and planning activities.	May tend to be limited in that private transportation companies by their very nature tend to make short range decisions based on dictates of sound business judgment without reference to broad areas of public concerns and needs.	Generally same as private. Degree of participation by government (financial or otherwise) especially Federal, may increase scope of planning and research considerably.

Organizational Characteristics	Private Corporation	Federal-Private Corporation
10. Labor considerations.	Subject to existing labor regulations, policies and practices which affect private corporations in the transportation industry.	Generally same as private. Legislative enabling laws could alter existing labor management relations to make them more responsive to current commercial conditions in the industry.
11. Tort and contractual liabilities.	No sovereign immunity. Full corporate liability.	Sovereign immunity is very unpopular with the legislatures and the courts. In the absence of a specific provision to the contrary, sovereign immunity is generally said to be waived.
12. Ability to accept Federal or state financial aid.	Could accept government aid. Note, however, general reluctance on part of government to use public monies for private ventures. Further, some states by their constitutions may be specifically prohibited from granting such aid. Some states have provisions, alternative measures, or institutional prohibitions in certain specified situations.	(Same as private corporation.)
13. Eminent domain.	No power to exercise without specific statutory exception.	Generally a legislature, either Federal or state may grant this power subject to certain limitations depending on the public nature of the services to be provided.

	Organizational Characteristics	Interstate Compact	Federal Corporation
1.	Ease of implementation, and formation, (political and legal difficulties).	Time consuming. Requires positive state action plus Congressional approval. Cities and counties directly affected may have a considerable impact on certain specific terms.	Requires Congressional approval. This process can be time consuming.
2.	Time required for formation and/or implementation.	Two years minimum.	One year minimum.
3.	Financing and capital raising considerations, (also availability of subsidies and incentives).	Issuing of bonds. (Such issuings are not affected by state debt limitation provisions). Bonds may have Federal guarantees and/or may be free from income taxes. <u>Note:</u> Federal guarantees usually are not available where tax dispensation is given.	Operating revenues; direct Federal appropriations; Treasury borrowing; Trust fund.
4.	Degree of Federal Government participation in decision and policy-making activities.	Can be significant depending on provisions of the charter.	Near total to total. <u>Note:</u> This entity would probably be somewhat less responsive to the President and the Congress than the Federal agency option.

	Organizational Characteristics	Interstate Compact	Federal Corporation
5.	Degree of State government participation in decision and policy-making activities.	(Same as above.)	Congress conceivably could grant states some significant area of responsibility or authority but such is not generally the case.
6.	Subjection of activities to existing Federal regulations.	(Same as Federal Private Corporation.)	Probably only advisory at most.
7.	Subjection of activities to existing state regulation.	(Same as above.)	(Same as Federal-private corporation.)
8.	General tax liability.	Generally none. Note: Some payments may be made to governmental entities in lieu of taxes.	Congress could make the corportation free of all tax liability. A payment in lieu of taxes may be made to the government entities affected.
9.	Extent to which entity could be expected to engage in research and planning activities.	Potential for coordinating research and development effort with broad, far reaching regional planning objectives is high.	Funds and authority for research, development and planning are generally available. This fact makes possible extensive efforts in planning and research.

Organizational Characteristics	Interstate Compact	Federal Corporation
10. Labor considerations	Compact agreement can establish labor relations and in doing so can either require application of those policies and standards already existing in the private sector or it can institute new and novel policies to reflect the current conditions in the industry.	Employees of such corporations are considered to be similar to Federal departmental employees and labor relations proceed on that basis.
11. Tort and contractual liabilities.	(Same as Federal-private Corporation.)	(Same as Federal-private Corporation.
12. Ability to accept Federal or state financial aid.	No difficulty, if such funds are in fact available.	(Same as interstate compact.)
13. Eminent domain.	Compact terms can dictate the degree to which this power is available.	Available if deemed in the public interest; just compensation is required.

	Organizational Characteristics	Federal Agency
1.	Ease of implementation, and formation, (political and legal difficulties).	Probably difficult if significant additional legislation is required.
2.	Time required for formation and/or implementation.	One year minimum.
3.	Financing and capital raising considerations, (also availability of subsidies and incentives).	Federal appropriations; Trust funds; operating revenues. Note that no matter what the source, Congress determines the budget of this entity.
4.	Degree of Federal Government participation in decision and policy-making activities.	Total.

	Organizational Characteristics	Federal Agency
5.	Degree of State government participation in decision and policy-making activities.	Probably only advisory at most.
6.	Subjection of activities to existing Federal regulations.	Probably only advisory at most.
7.	Subjection of activities to existing state regulation.	Subject to local regulation in areas where no conflict exists with Federal power and purposes. If conflict state regulations would be preempted.
8.	General tax liability.	None. Note: Payments by Federal agencies to local entities in lieu of taxes is not unknown.
9.	Extent to which entity could be expected to engage in research and planning activities.	Broad authority limited only by specific legislation and availability of appropriations.

Organizational Characteristics	Federal Agency
10. Labor considerations.	Federal employment regulations are applicable.
11. Tort and contractual liabilities.	Sovereign immunity available. However, some relief may be provided by special legislation affecting tort and contractual claims against the U. S. Government.
12. Ability to accept Federal or state financial aid.	While outside aid is rarely forthcoming, there are no impediments to acceptance.
13. Eminent domain.	(Same as Federal Corporation.)

TECHNICAL APPENDIX 2

POPULATION GROWTH PATTERNS AND THE CORRIDOR TRANSPORTATION SYSTEM

POPULATION AND EMPLOYMENT TRENDS IN THE NORTHEAST CORRIDOR

Over 45 million people now live within the Northeast Corridor--more than one-fifth of the Nation's population on less than two percent of the Nation's land. By 1980, nine million persons will have been added to this total.* Table T2-1 summarizes changes in population anticipated for the period 1960 through 1980 for the Corridor by northern, central and southern subregions.

The most significant feature--for transportation development--of Corridor population growth as shown in Table T2-1 is the large difference between increases in urban and rural areas. Overall it is estimated that the Standard Metropolitan Statistical Areas (SMSA's) in the Corridor will attract almost four times as many people within their borders during the decade from 1960 to 1970 as will non-SMSA portions of the Corridor. Current projections beyond 1970 are based on the assumption that this trend will continue; over the next decade more than seven million new residents will be added to the metropolitan areas of the Corridor in contrast to fewer than two million in rural areas.

Also important for transportation requirements is that within metropolitan areas in the Corridor there have been sharp differences between growth of population in the suburbs as contrasted to growth in the center cities. In the five SMSA's listed in Table T2-2, suburban population increased by 44.6 percent between 1950 and 1960 while in core counties it decreased 5.9 percent. Employment showed much the same pattern of change; suburban counties had 41.6 percent more jobs in 1960 than in 1950, while the core counties dropped 5.3 percent over the same period.

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*These figures are extrapolations, based on U.S. Bureau of the Census estimates of growth rates 1960-1966 for the 165 counties and independent cities included in the Northeast Corridor Project region (see Table T2-2). The geographic limit of the NECTP region was determined on the basis of population density, economic interdependence and topography.

Figure T2-1. The Northeast Corridor Transportation Project Region

TABLE T2-1. CHANGES TO SMSA AND NON-SMSA POPULATIONS FOR THREE SUB-REGIONS IN THE NORTHEAST CORRIDOR (1960 COUNTS: 1970 & 1980 ESTIMATES)

Region**	Population, Thousand				
	1960	1970	Increase 1960-70	1980*	Increase 1970-80
Northern					
21 SMSA's ***	7,324	8,319	995	9,363	1,044
Non-SMSA	1,667	1,958	291	2,391	433
Central					
14 SMSA's	22,424	24,290	2,866	28,053	3,763
Non-SMSA	1,956	2,689	733	3,583	894
Southern					
6 SMSA's	5,554	7,139	1,585	9,750	2,611
Non-SMSA	879	1,054	175	1,565	511
Total					
41 SMSA's	34,302	39,748	5,446	47,166	7,418
Non-SMSA	4,502	5,701	1,199	7,539	1,838
GRAND TOTALS	38,804	45,449	5,745	54,705	9,256

*Estimate based on extrapolations of observed growth rates 1960-1966, U.S. Bureau of the Census "Population Estimates and Projections," Current Population Reports, Series P-25 No. 432, October 3, 1969.

**Northern region consists of Massachusetts, Rhode Island, Connecticut and portions of New Hampshire. Central region consists of New Jersey and portions of New York and Pennsylvania. Southern region consists of Delaware, the District of Columbia and portions of Maryland and Virginia.

***Areal extent of 1960, 1970 and 1980 SMSAs throughout the Corridor are assumed to be those existing in January 1968 as established by the Bureau of the Budget.

Sources: 1960 population figures, U.S. Bureau of the Census, City and County Data Book, 1968; U.S. Bureau of the Budget, Standard Metropolitan Statistical Areas, Executive Office of the President, 1967. Updated by errata sheet January 15, 1968.

Table T2-2. PERCENT CHANGES IN POPULATION AND EMPLOYMENT WITHIN FIVE NORTHEAST CORRIDOR SMSA'S, 1950-66

SMSA	Percent Change in Population				Percent Change in Employment	
	1950-1960		1960-1966		1950-1960	
	Core*	Suburban	Core*	Suburban	Core*	Suburban
Boston	-11.8	4.3	-9.8	5.7	-6.6	17.6
New York						
Richmond	-----	15.6	----	22.5	----	11.0
Brooklyn	-4.1	----	2.5	----	-3.7	----
Manhattan	-13.4	----	-9.3	----	-8.9	----
Bronx	-1.8	----	8.3	----	0.5	----
Queens	-----	40.2	----	8.4	----	21.4
Other	-----	75.0	----	18.0	----	66.7
Philadelphia	-3.3	46.3	1.9	14.0	-5.0	40.1
Baltimore	-1.2	123.5	1.6	20.2	7.0	105.1
Washington	-4.7	96.5	5.4	39.0	-7.6	81.5
Total	-5.9	44.6	0.2	16.3	-5.3	41.6

*Core area of each SMSA was taken to be as follows:
Boston, Suffolk County; New York, as listed in table; Philadelphia, Philadelphia County; Baltimore, Independent city of Baltimore; Washington, District of Columbia.

Sources: 1950 and 1960 populations and employment--County and City Data Book, 1953 and 1968; Standard Metropolitan Statistical Areas, Executive Office of the President/Bureau of the Budget, 1967; and 1966 population estimates-- "Population Estimates and Projections," Current Population Reports, Series P-25 No. 432, October 3, 1969.

The disparity between core and suburban growth rates for these five SMSA's has continued into the 1960's; between 1960 and 1966 suburban population increased 16.3 percent while the core counties had a 0.2 percent rise. In the Washington, D. C., SMSA between 1960 and 1966 over 450 thousand persons were added to the suburban counties in contrast to fewer than 42 thousand persons added to the central city. As a consequence, in the Washington SMSA, where population in 1960 was evenly divided between core and suburbs, by 1966 the suburban population had become 50 percent larger than the core.

The trends noted above in the growth of population and employment are of great significance for future transportation requirements in the Corridor in that:

1. They will result in sharply increasing levels of demand for transportation between metropolitan areas. Inasmuch as the major cities of the region, located as they are in linear fashion, imparts a strong axis to the Corridor transportation system - the concentration of traffic flows will tend to be accentuated.

2. The dispersion of population and employment to the suburbs will push actual points of origin and destination of intercity trips away from centrally located common carrier terminals.

3. The relative and, in some instances, absolute decline of population in rural areas will continue to undercut the economic viability of common carrier transportation services in these areas, with the result that sections such as western New England and the Delmarva Peninsula will tend to become increasingly isolated from the rest of the region.

TRENDS OF TRAVEL DEMAND IN THE NORTHEAST CORRIDOR

Demand for transportation in the Northeast Corridor increased at an average rate of about four percent per year from 1960 to 1968,* more than twice the rate of estimated population growth for the same period. The rise in patronage, however, has not been uniform among the several transportation modes, as shown in Table T2-3. Air travel increased the fastest, averaging 13 percent annually and ranging as high as 20 percent per year between some city pairs. In sharp contrast, rail travel decreased over the 1960-68 period, with the largest losses occurring for trips of 150 miles and longer. Auto travel (which accounts for most of the travel in the region and, therefore, dominates most statistical summaries of such travel) grew at a rate very close to the average for all trips. The total number of intercity bus trips increased slightly between 1960 and 1968, but the share of trips by bus in the total Corridor intercity travel market decreased over the period.

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*1968 Northeast Corridor Travel Survey

TABLE T2-3. CHANGES IN INTERCITY TRAVEL BY MODE, 1960-68 FOR 19 MAJOR CITY PAIRS IN THE NORTHEAST CORRIDOR

Year	Passenger-miles by mode, millions				Percent by mode			
	Auto	Rail	Air	Bus	Auto	Rail	Air	Bus
1960	2,994	999	492	411	61.2	20.4	10.0	8.4
1968	4,226	767	1,391	432	62.0	11.3	20.4	6.3
Change, 1960-68	1,232	-232	899	21	0.8	-9.1	10.4	-2.1

Source: Compiled from preliminary tabulations of the 1968 Northeast Corridor Travel Survey and other sources.

The growth of transportation demand in the Northeast Corridor over the past 10 years, and the distribution of the growth by modes and geographic areas are the results of the interplay of many social and economic factors. In addition to population growth, the most important of these factors have been (1) rising per capita income, and (2) improvements to the transportation system which have been made since the early 1950's.

Increasing Income

The demand for transportation, as is the case for most goods and services, tends to rise with increasing income. Between 1960 and 1967 (in 1967 dollars) median family income in northeastern United States increased from $6,859 to $8,492. Perhaps even more significant, the proportion of families with annual income under $5,000--those families least likely to make frequent intercity trips--dropped from 38.6 percent in 1960 to 20.3 percent in 1967; families in the $10,000 and over bracket--those families most likely to make frequent trips--increased from 23.4 percent in 1960 to 38.0 percent in 1967.*

Along with a rising demand for travel have come changes in the characteristics of the services sought. Not only is more transportation being demanded but better transportation as well. "Better transportation" most often can be translated into "faster transportation," but comfort and the convenience offered by frequent schedules are also increasingly in demand. Although a higher quality of service generally carries with it a higher price, a more affluent public in general, and business travelers in particular, tend to be willing to pay more for better service.**

Impact of Transportation Improvements

Also, we must recognize the effect which improvements in transportation themselves have upon trip-making. Transportation improvements tend to induce more travel. Although it is not always possible to distinguish clearly between traffic which is wholly new to the system and that which has been diverted from other modes, the persistent increases in both auto and air travel in the Corridor over the past ten years suggest very strongly the power of improved transportation facilities over a period of time to encourage new demand.

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*Analyses of travel, population and income data for the Northeast Corridor suggest that the number of families in the $10,000-and-over income bracket in a given travel market provides a better basis for forecasting demand than the population as a whole.

**Such data as are available on intercity travel in the Corridor reveal that for all travelers the elasticity of demand with respect to time is about twice that with respect to price; for business travelers time elasticity is several times higher than price elasticity.

TRANSPORTATION FACILITIES AND USAGE IN THE NORTHEAST CORRIDOR

Patterns of Usage

The Northeast Corridor is an old region in the United States and so, too, in many respects is its transportation system. The streets of its largest cities were laid out in Colonial times and, with the exception of the Interstate network, many of its major highways follow post roads and stage coach routes. Most of the Corridor's mainline railroads were laid out before 1875. The railroads still focus on the cities' early commercial centers, and between cities often follow the twisting routes which were dictated by terrain and the construction methods of the 19th Century. Even the region's airports, the product of a more modern age and technology, are now in many instances restricted by suburban development which has grown up around them.

The status of common carrier modes in the Corridor is particularly significant in view of the intensive use of these facilities relative to common carrier usage in the United States as a whole. As can be seen from the data in Table T2-4, the common carrier modes--air, rail, and bus--serve twice as large a percentage of intercity travel in the Corridor as is the case for the Nation. The non-highway modes--air and rail--carry nearly 24 percent of intercity trips in the Corridor in contrast to the nationwide average of ten percent.

Within the Northeast Corridor, the distribution of trips among the four modes is principally a function of trip length and the relative quality of service (time, fare, and departure frequency) offered. Total trips and the distribution of trips by mode between the four largest travel markets in the Corridor is shown in Table T2-5. Automobile transportation clearly dominates, particularly between the two large cities closest to each other--New York and Philadelphia--where this mode accounts for roughly three-quarters of the trips.

Air transportation now carries the major share of common carrier trips between the cities in Table T2-5 and vies effectively with auto for a share of all intercity travel in these markets, with the notable exception of the New York-Philadelphia pair. Bus transportation has accounted for a relatively small but fairly constant share of the travel between the cities shown. Rail, which in 1960 carried roughly 20 percent of all passenger trips between the four cities listed in Table T2-5, has lost patronage in both a relative and an absolute sense. The one exception is for trips between New York and Philadelphia, where rail still accounts for almost 75 percent of common carrier trips.

The flow of traffic on the principal intercity links between Boston and Washington is shown for each mode in Figure T2-2. The heavy volume of traffic in the center links reflects the overlap of origin-to-destination trips between major cities along the Corridor spine, and also the heavy dominance of New York City as a trip generating and terminating point.

TABLE T2-4. COMPARISON OF INTERCITY TRAVEL BY MODE, FOR NORTHEAST CORRIDOR AND UNITED STATES, 1968

Mode	Percent of total intercity passenger miles	
	Northeast Corridor	United States
Auto	67.6	87.7
Air	11.3	8.8
Bus	8.4	2.3
Rail	12.6	1.2

Source: Data compiled from preliminary tabulations, 1968 Northeast Corridor Travel Survey, and other sources.

TABLE T2-5. TRAVEL TRENDS BETWEEN FOUR MAJOR CITY PAIRS IN THE NORTHEAST CORRIDOR, 1960-68

City pair and year	Travel between city pairs				
	Total trips, thousands	Modal split, percent			
		Auto	Air	Bus	Rail
Boston - New York					
1960	3,425	48	25	8	19
1965	4,400	44	40	7	9
1968	5,700	41	47	7	5
Boston - Washington					
1960	530	57	31	2	10
1965	785	48	46	1	5
1968	990	43	53	1	3
New York - Phila.					
1960	11,000	71	1	8	20
1965	12,500	75	1	7	17
1968	14,360	74	1	6	19
New York - Washington					
1960	3,780	48	18	12	22
1965	4,735	46	29	11	14
1968	5,200	45	36	10	9

Source: Compiled from Federal, State, Regional and Toll Transportation Agencies and 1968 Northeast Corridor Travel Survey by Peat, Marwick, Mitchell and Company.

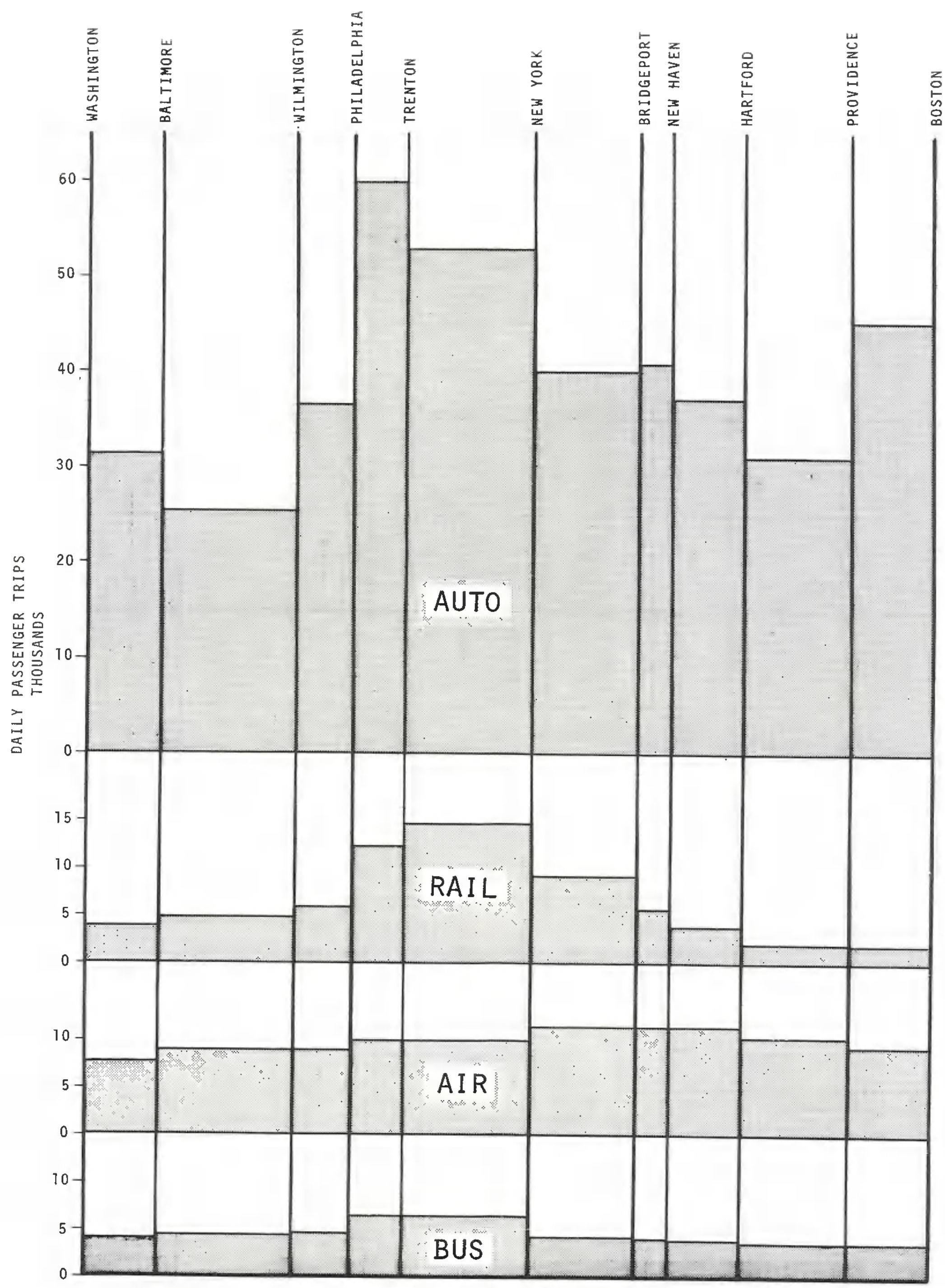

Figure T2-2 Trip densities on principal intercity links by mode--1968

Mode Characteristics

Air

The persistent increase in travel by air between the region's major cities has not been matched by a comparable increase in the capacity of airway and air terminal facilities. As a consequence, airspace in the vicinity of the Corridor's major airports is becoming increasingly congested. The Federal Aviation Administration estimates that total hours of air traffic delay at Kennedy, La Guardia and Newark airports will increase 100,000 hours in 1970 over the 33,000 hours reported for 1966, and will become much greater by 1975 unless the number of daily operations at these three airports is strictly controlled.

Currently, prospects for solving the problem of air traffic congestion include the introduction of jumbo jets capable of moving more people in fewer flights, the construction of new jet-ports, and the separation of general aviation from commercial aviation. The introduction of jumbo jets, while relieving air congestion for a-while would aggravate the serious problems of terminal congestion, inadequate parking and poor access which now characterize the major airports in the Corridor. New Jet-ports require about 10,000 acres of land, which frequently must be taken from other productive uses. This use often creates in the vicinity of the airport severe problems of access, noise and air pollution.

The amount of congestion evidenced throughout air facilities in the Corridor is to a significant extent a function of the proportion of trips and flights flowing through the terminal grounds which have one or both ends outside of the region. The impact of extra-regional travel is more pronounced for air than for any other mode of passenger transportation in the Northeast Corridor. Extra-Corridor traffic accounts for over two-thirds of all air passenger trips at the region's major air hubs, ranging from 81 percent at Philadelphia to 47 percent at Boston. The data presented in Table T2-6 suggest that provision of additional air terminal capacity in the Corridor should take into account the projected needs of extra-regional traffic originating or terminating at Corridor airports. These data also suggest that if some portion of the intra-Corridor air traffic were to be diverted to other modes, congestion in Corridor air terminals might be substantially reduced.

Highway

Since 1950, intercity highway travel in the Northeast Corridor has been greatly facilitated by the construction of key river crossings and freeway links. The impact which these improvements have had on driving times between Washington and New York City and Between New York City and Boston is shown in Table T2-7. Driving time between Washington and New York decreased by over three hours between 1950 and 1963. The major single reduction in driving time--about two hours--re-

TABLE T2-6. TOTAL DOMESTIC AND INTRA-CORRIDOR AIR PASSENGERS FOR SIX CITIES IN THE NORTHEAST CORRIDOR

	Total passengers exchanged with all U.S. cities	Intra - corridor passengers	Intra - corridor percent
Boston	6,291,530	3,313,390	53
Washington	7,326,390	2,765,370	38
Hartford	1,196,410	403,180	34
New York	20,820,910	5,117,640	25
Baltimore	1,753,370	409,120	23
Philadelphia	4,210,470	796,500	19
Totals	41,599,080	12,805,200	31

Source: Civil Aeronautics Board, "Domestic Origin-Destination Survey of Airline Passenger Traffic, "Calendar Year 1967.

TABLE T2-7. AUTO TRAVEL TIME TRENDS, WASHINGTON - NEW YORK - BOSTON

Year	Improvement	Trip time*
	Downtown Washington - Mid-town New York	
1950	(then current status)	7h 33m
1951	Delaware Memorial Bridge	7 03
1952	New Jersey Turnpike	5 14
1953	Baltimore-Washington Parkway	4 58
1957	Baltimore Harbor Tunnel	4 36
1963	Kennedy Expressway	4 16
	Mid-town New York - Downtown Boston	
1950	(then current status)	6h 02m
1957	Massachusetts Turnpike	5 18
1958	Connecticut Turnpike	4 56
1965	Massachusetts Turnpike Extension	4 50
1966	I-95, Through Providence	4 40
1966	I-91, New Haven to Hartford	4 28

*Average off-peak, includes stops: 30 minutes in earlier years for meal and fuel; 10 minutes in later years for fuel.

Source: Estimates prepared for NECTP by Peat, Marwick, Mitchell & Co.

sulted from the opening of the New Jersey Turnpike in 1952. Subsequent improvements have had a less dramatic impact. The average driving time between Washington and New York has remained essentially unchanged since 1963.

A similar situation applies to the effect of improvements made north of New York City. The opening of the Massachusetts Turnpike in 1957 reduced driving time between Boston and New York by almost a full hour. Improvements since then have resulted in additional savings totalling approximately 45 minutes.

As has been the case with air transportation, intercity highway travel in the Corridor has been adversely affected by deficiencies at critical points. Congestion at the interface between urban and intercity highways and within urban areas contrasts sharply with the smooth, high speed flow of auto and bus travel over most of the interstate and other limited access rural highways.

Eventual completion of the urban portions of the interstate system will alleviate many of the bottle-necks which now exist.* However, since local metropolitan area traffic constitutes well over 90 percent of all highway trips in the Corridor, congestion from this source will continue to impede intercity highway travel, particularly during peak periods. The degree to which intraurban traffic overlaps intercity flows is clearly evident in Figure T2-3.

New highway facilities would have to be accommodated into what is already the most intensively developed region in the country--14 percent of the nation's total road mileage is concentrated within the Corridor. The freeway network in the Corridor now occupies roughly 300 square miles--an area equivalent to one-quarter of the State of Rhode Island; the entire road and street network covers about 6,300 square miles--an area equal to all of Connecticut, Rhode Island, and the District of Columbia. The significance of such demands for space should be considered within the context of land values in the Northeast Corridor, which average approximately $4,000 per acre in rural areas of one person per acre to $1/2 million per acre for urban land at a density of 100 persons per acre.

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*The extent of improvements to the principal highway system in the Corridor which are planned between now and 1980 is shown in Figure T2-4. The bulk of these improvements are planned for the less intensively developed portion of the region and will, therefore, have a relatively minimal impact on travel within the large urban areas along the Corridor Spine.

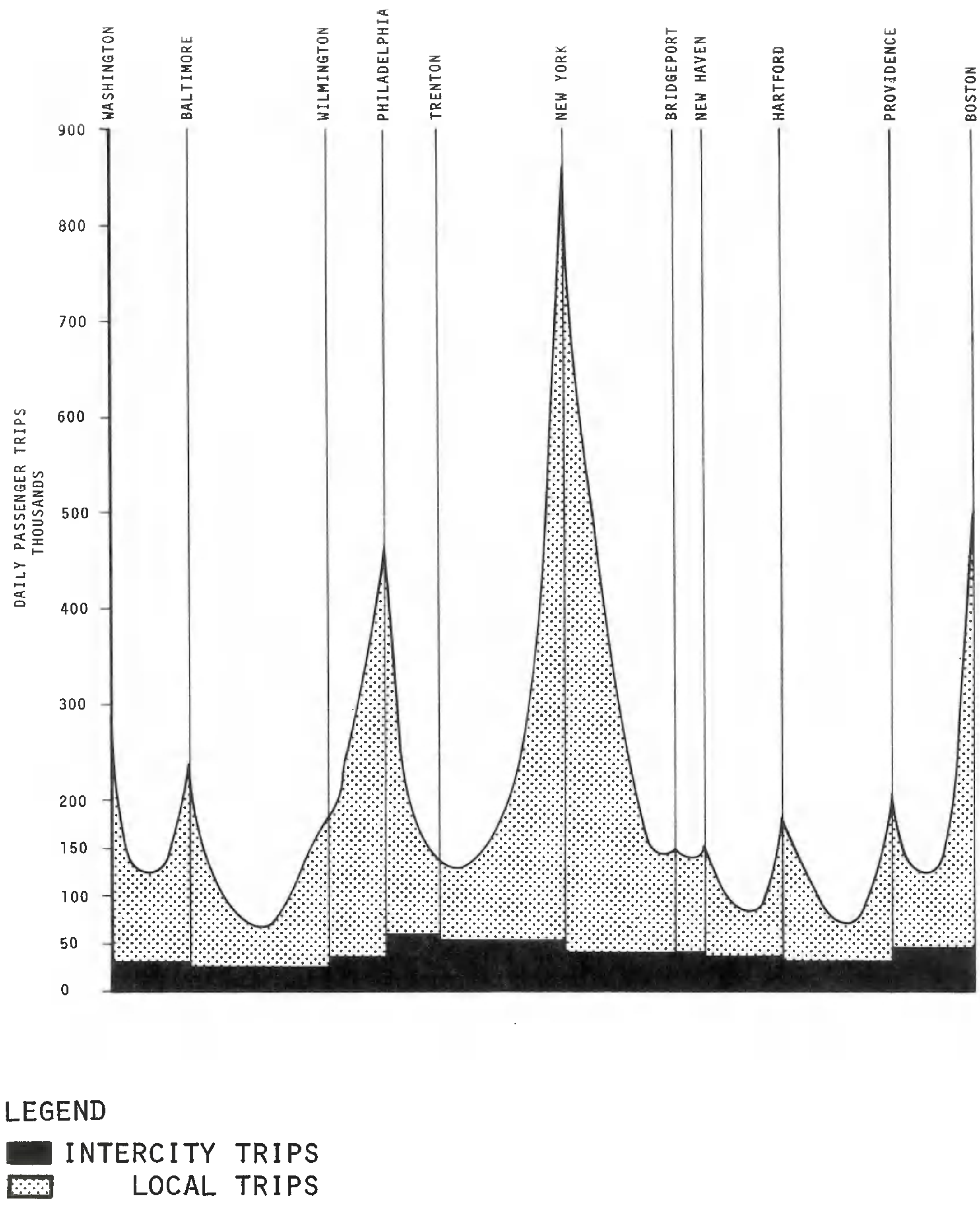


Figure T2-3. Intra-urban and interurban trip densities, Boston-Washington--1968

SOURCE: Compiled from Federal, State, Regional and Toll Transportation Agencies

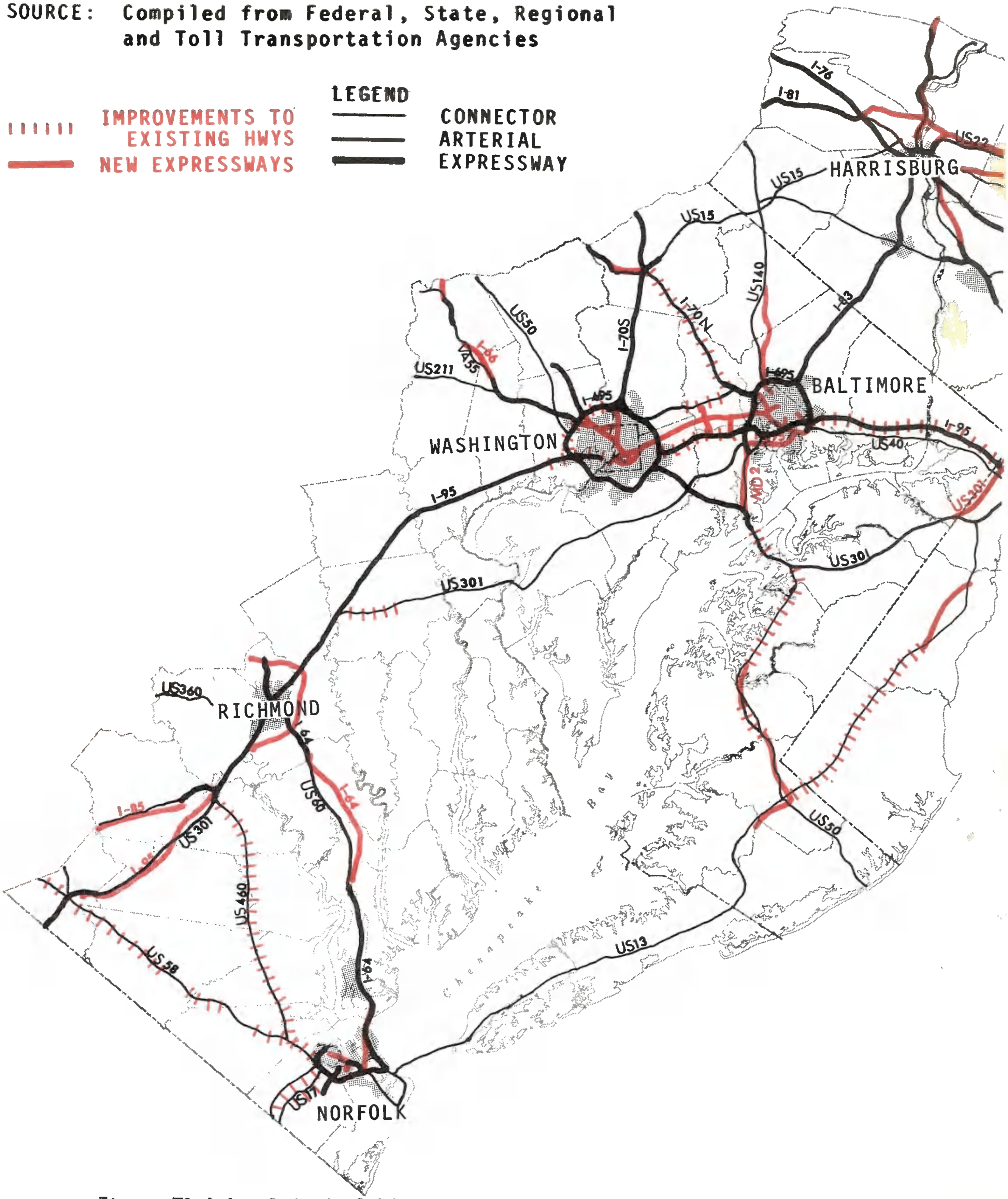
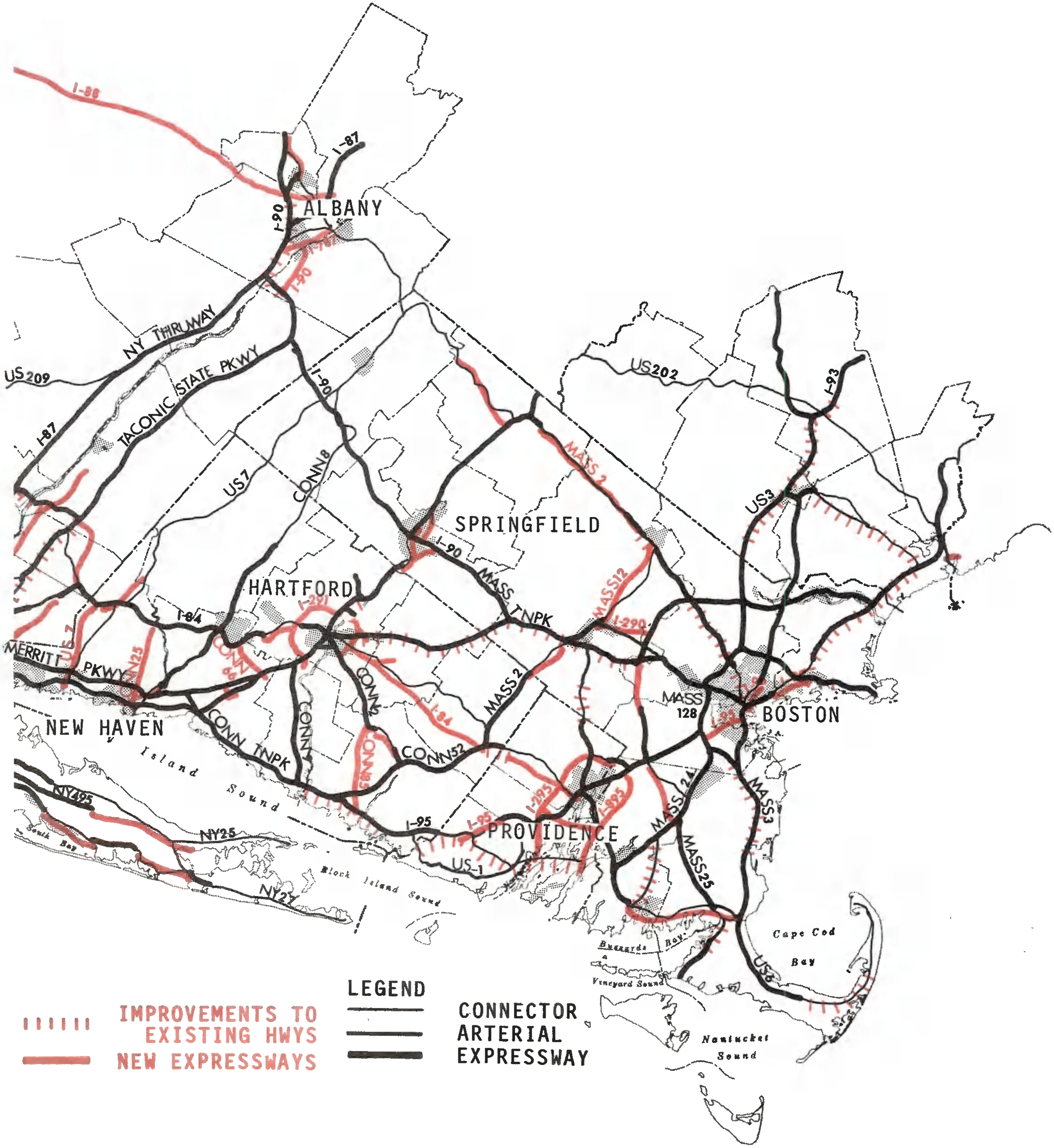


Figure T2-4-A. Principal highway improvements planned through 1980 in the Northeast Corridor -- Southern sub-region

Figure T2-4-B. Principal highway improvements planned through 1980 in the Northeast Corridor -- Central sub-region

SOURCE: **Compiled from Federal, State, Regional and Toll Transportation Agencies**

Figure T2-4-C. Principal highway improvements planned through 1980 in the Northeast Corridor -- Northern Sub-region



SOURCE: Compiled from Federal, State, Regional and Toll Transportation Agencies

Rail

In contrast to the steady increase in travel on the air and highway modes, rail passenger travel in the Corridor has declined sharply since the early 1950's. Between 1955 and 1968 the number of non-commuter passengers carried by railroads serving the Northeast Corridor dropped by 47 percent. Longer trips fell off more rapidly than shorter trips, with the result that the number of passenger-miles carried dropped by almost 70 percent and gross revenues (in constant dollars) were reduced by approximately 60 percent.*

The decline in rail patronage has been matched by a steady decline in the number of communities served by rail and in the level of service provided. Since 1955, rail passenger service has been discontinued on 2,380 miles, or 40 percent of the roadbed miles then in use in the Corridor. Discontinuances have been most widespread in New England, although other parts of the region have lost service as well. See Figure T2-5.

As a consequence of the steady shrinkage of service and patronage which has been taking place over the last 20 years, there now exists considerable excess capacity in almost every section of the Corridor rail system. Significantly greater numbers of passengers could be transported by rail without expansion of the fixed plant. The problem, however, lies not with the capacity of the Corridor rail system to carry passengers, but in the ability of this mode to attract patronage in the face of strong competition from air and highways.

There is some evidence that rail patronage can be increased through improved service. The number of passengers carried by the Penn Central Railroad between Washington and New York during the first two quarters of 1969 was eight percent higher than during the same period in 1968, with much of the addition carried by the Metroliners. Thus, as the popularity of this new equipment suggests, it may be possible through even modest expenditures and a modicum of technological advance to make more efficient use of selected portions of the existing Corridor rail system.

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*These figures include some data for trips outside of the Corridor on the Penn Central and Baltimore and Ohio railroads.

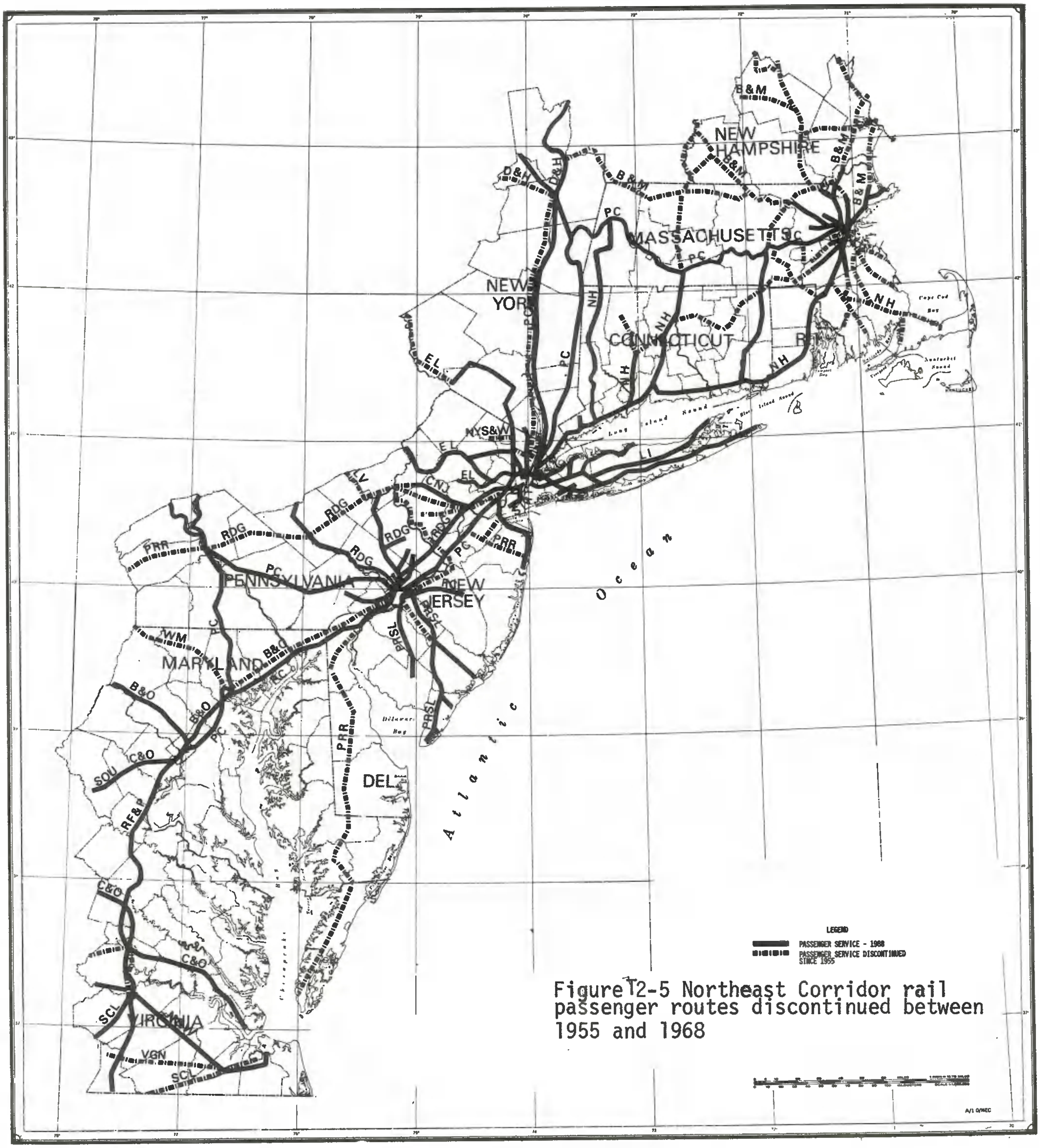

Figure T2-5 Northeast Corridor rail passenger routes discontinued between 1955 and 1968

The Problem of Access

Underlying many of the difficulties faced by travelers in the Northeast Corridor is the problem of access to intercity transportation facilities. This problem is most apparent in the case of intercity trips by bus, air and rail, but even the auto traveler must pass through the urban traffic gauntlet on his way to the open road.

Many passenger terminals are now poorly located with respect to the markets they serve. Shifting patterns of residential and business development have not been accompanied by corresponding shifts in terminal locations and design. Although downtown rail and bus terminals are often convenient to public transit routes and to central business districts, they have little or no parking nearby and are often not accessible to expressways .

Airports, by way of contrast, are removed from central urban areas and are almost totally dependent on public highways for access. Air travel is predominantly by businessmen, many of whom are destined for downtown. Inadequate rapid transit imposes heavy reliance on automobiles, buses and taxis, whose ability to move depends on hour-by-hour changes in the density of traffic flows.

As we shall see in subsequent parts of this report, slow acess/egress has for many passenger trips nullified substantial reductions in line-haul time.

TECHNICAL APPENDIX 3

METHODOLOGY

INTRODUCTION

The basic tool used by the Northeast Corridor Project to analyze transportation system alternatives is an interlocking set of analytical and simulation models which represents the transportation sector of the Northeast Corridor and its interaction with the economy of the region. The structure of the model system is designed to meet the commitment of the project to "general" rather than "partial" analyses. In the context of the NECTP, the term "general analysis" is intended to include:

1. Analyses of systems involving general transportation modes in which changes in the supply characteristics of one mode are reflected in the demand for and, in turn, the supply characteristics of competing modes.

2. Consideration of direct transportation system benefits and costs and also of the potential interaction of changes in transportation systems with regional economic development.

3. Provision for comparison of a broad range of alternative transportation systems incorporating new as well as existing technology.

In order to carry out such analyses, the NECTP has had to develop models and procedures which would permit the accomplishment of the following tasks:

1. Forecast socio-economic variables--forecasts of population and economic activity for each sub-area in the Corridor, including the impacts which transportation system changes would have on these characteristics.

2. Forecast transportation demands--forecasts of the numbers of travelers by mode, between each area of origin and destination as a function of (a) population distribution and the economic status of potential travelers, and (b) the service characteristics of the several modes which together constitute an alternative transportation system.

3. Generate alternative transportation systems--specification of the transportation service characteristics

of new modes and representation of the service characteristics of existing modes; selection of a set of alternative modal mixes responding to these specifications; representation of the network corresponding to each modal mix in a form suitable for analysis by means of computer simulation; and development of cost estimating relationships for each mode on its relevant network.

4. Balance transportation supply and demand--calculation of the level of transportation services and fares, by mode, which would balance supply and demand for a given modal mix.

A very simplified representation of the way in which these four activities interact is shown in Figure T3-1. The model system postulated in Figure T3-1 can be operated in 5-year steps to trace over time the consequences of a given transportation change or series of changes. The model system can also be used to analyze a transportation alternative or set of alternatives over a single year or other given period of time. The information produced by the first of these two types of analyses may be likened to a series of discrete images in a strip of motion picture film; the second type of analysis provides an image from a single frame of that film.

The exercise of the model system described in the remainder of this chapter was limited for the most part to one "frame," the year 1975, in the life cycles of the nine prospective transportation system alternatives. Thus, each alternative system was described in terms of its costs and benefits as they might occur in that year. The evaluation did not attempt to trace over time the stream of transportation system costs and benefits that might accrue from adoption of one or another alternative.

The way in which the model system was used in evaluating the nine alternatives is more fully described in Figure T3-2. Along the top row of the figure are shown the various inputs which feed the supply-demand simulation. These inputs include population and income projections for the sub-areas of the region (counties and aggregations of counties) and the cost and service characteristics of the particular mix of new and existing modes which comprise a given transportation alternative. The costs and times required to move between local origins and destinations and terminals on the intercity network are also considered in the analysis.

The supply-demand interaction simulation balances the supply of transportation services provided by a mix of modes and the demands for these services. The level of transportation demand between two areas is assumed to be a function of both the socio-economic

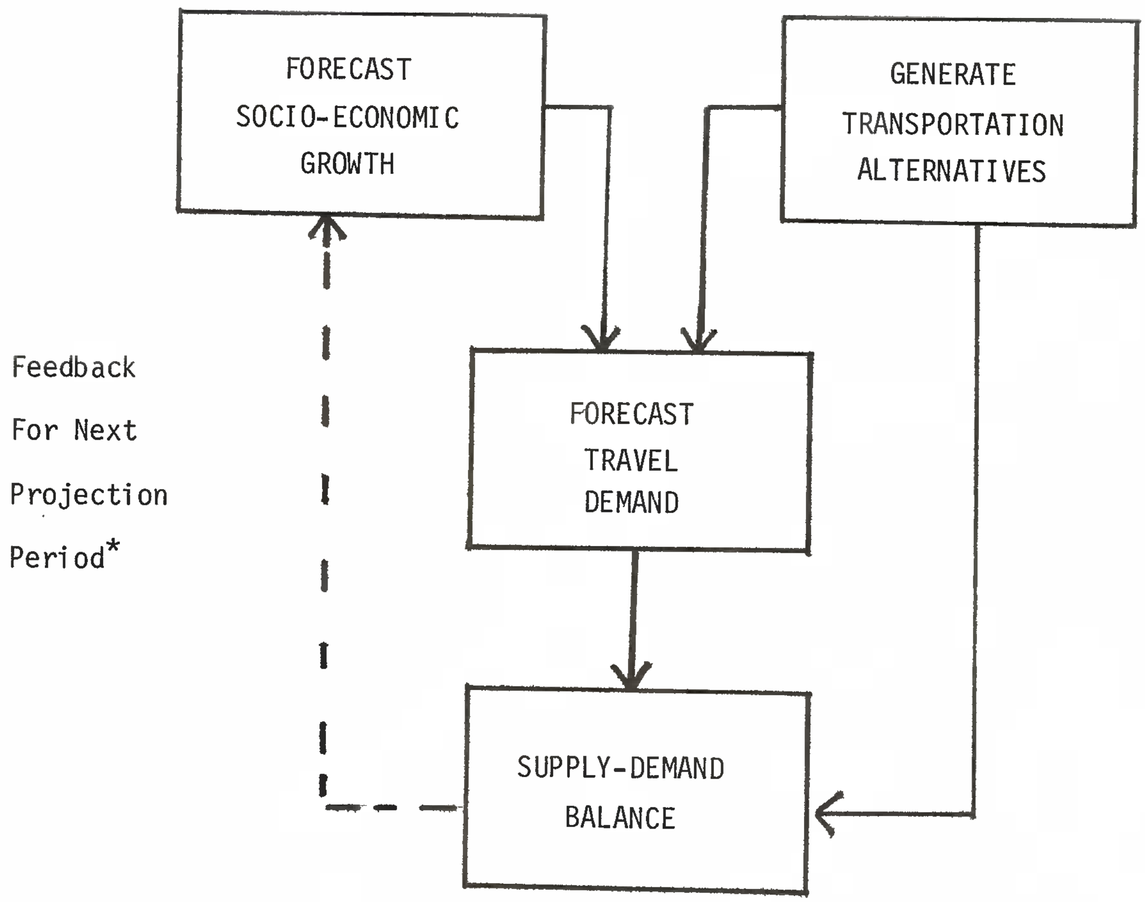

Figure T3-1. Simplified Representation of NECTP Analysis Framework

*The model system does not provide for continuous feedback. The economic impact of changes in transportation services are given effect in the model system every five years.

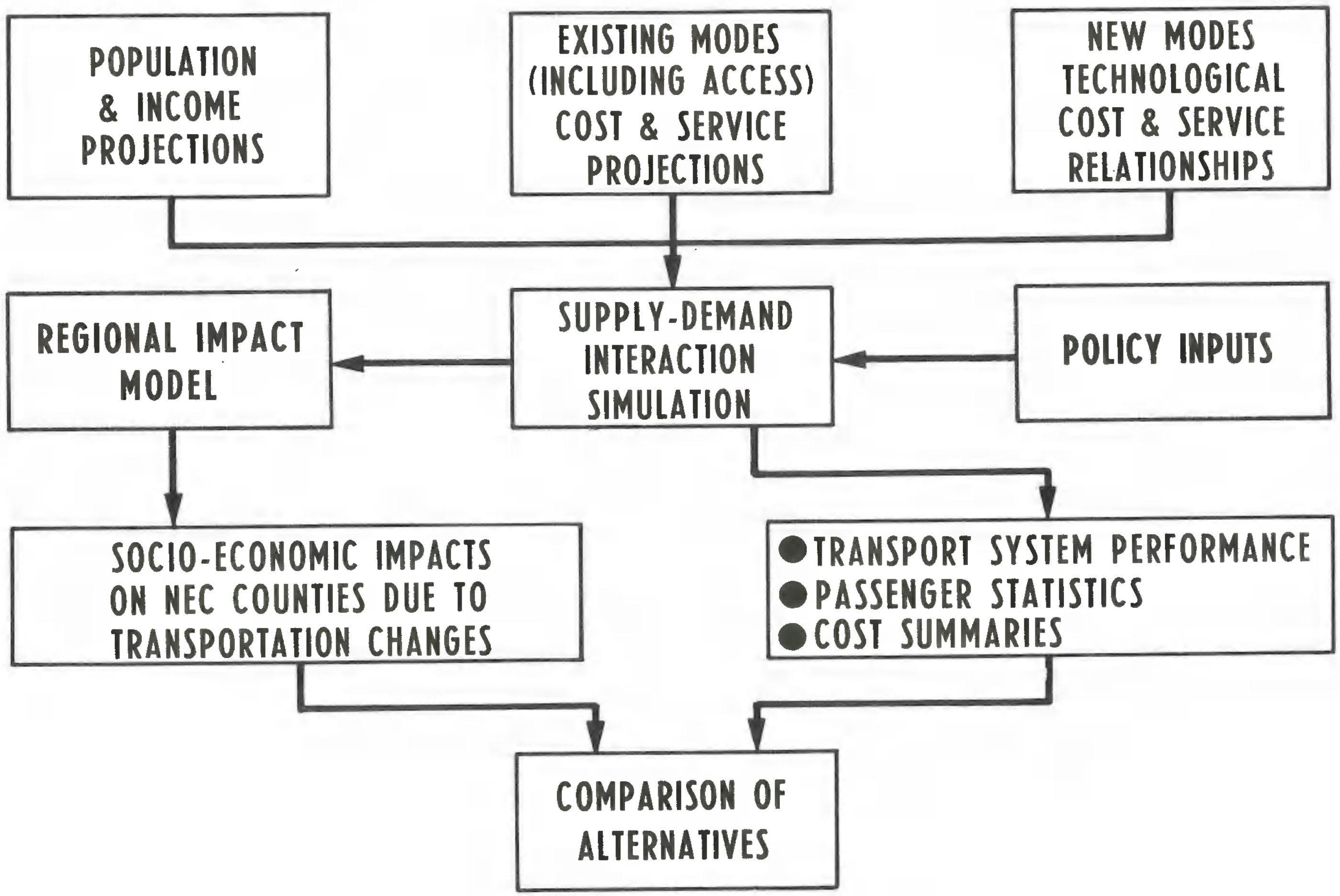

FIGURE T3-2
RELATIONSHIP BETWEEN ELEMENTS OF FIRST GENERATION MODEL SYSTEM

characteristics of the two areas and the price and service characteristics of the transportation connecting them. In the model system the proportion of this demand which moves over a given mode depends upon the quality and price of the service provided by that mode relative to the quality and price of the services provided by competing modes. The cost to provide a given level of service (i.e., schedules, fares, and trip time) is a function of both the level of demand to be met and the cost-service properties of the providing mode.

Based on functional relationships among costs, services and demand, an expenditure and output level for a single mode can be determined at which supply and demand are in equilibrium. A straightforward solution can also be found for a single mode in competition with one or more other modes, if the prices and levels of service provided by the other modes are not allowed to change with varying levels of demand. This was the procedure used in reaching equilibrium with the single new modes introduced in alternatives II through VI. In these alternatives, characteristics of the service to be provided by the conventional modes were pre-specified* and the output level of each new air or ground mode was established at the point where supply and demand for that mode would be in balance. Where equilibrium between new air and high-speed ground modes was sought (as in alternative VII, VIII and IX) a successive approximation technique was used, holding fares, schedules, etc., of first one and then the other competing mode fixed.

Referring again to Figure T3-2, the output of the supply-demand interaction simulation is a matrix of travel volumes between city pairs, by mode, for a "typical day." The simulation also produces both detailed and summary data on patronage,costs and other system output measures. These measures are used to compare the costs and benefits of alternative systems. Based on transportation service characteristics generated by the network simulation, the regional impact models forecast the effects which transportation investment would have upon regional growth patterns. Socio-economic forecasts are produced for each county in the Corridor. These forecasts provide a basis for comparing the differential impacts resulting from alternative transportation investments.

The modeling system described above in summary and in more detail in the sections which follow, is a limited, but useful tool for analyzing and evaluating transportation system alternatives. It has many shortcomings, but it also has one great advantage--it works now.

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*This prespecification of characteristics assumed infinite elasticity of supply by conventional modes.

The remainder of this chapter is devoted to a discussion of the individual parts of the model system shown in Figure T3-2. Emphasis is on providing an overview of each of the major activities; supporting documentation can be found in the cited references.

SUPPLY-DEMAND INTERACTION SIMULATION

This description of the model system begins at the central element of the model system--the supply-demand interaction simulation--and works outward from there. The principal segments of this simulation, with the demand model at the heart, are shown in Figure T3-3.

The Demand Model

Underlying much of the Corridor analysis is the assumption that reasonably accurate forecasts can be made of the demands for transportation which future transportation investments might generate. In the NECTP model system, demand forecasts are made by means of a demand model--a set of mathematical formulas which relate the numbers of trips by mode between a zone of origin and a zone of destination, to the population and income characteristics of the two, and to the service characteristics and fares of each of the modes connecting the two zones. In formulating the Corridor demand model, several criteria were established; namely, that the model must be able to:

--forecast the demand both for new transportation services and for those which are currently being provided.

--forecast the total transportation demand between areas of origin and destination for at least ten years into the future.

--allocate forecasted demand to modes on the basis of modal characteristics.

Given these requirements, it was clear that demand forecasts could not be based on simple extrapolations of observed trends. Rather, a forecasting procedure was needed which would relate changes in demand to variations in such factors as population, income, and level of transportation service; i.e., a predictive model was required. To be useful as a forecasting tool, the model would have to be based on socio-economic data which were both readily available and easily projectable, and on attributes of transportation systems which could be derived from engineering and operational design estimates.

In developing this model, the Corridor Project has been forced to rely heavily on transportation data collected over the past ten years in a wide variety of independent surveys and projects. These data have been carefully screened and adjusted to provide a representation

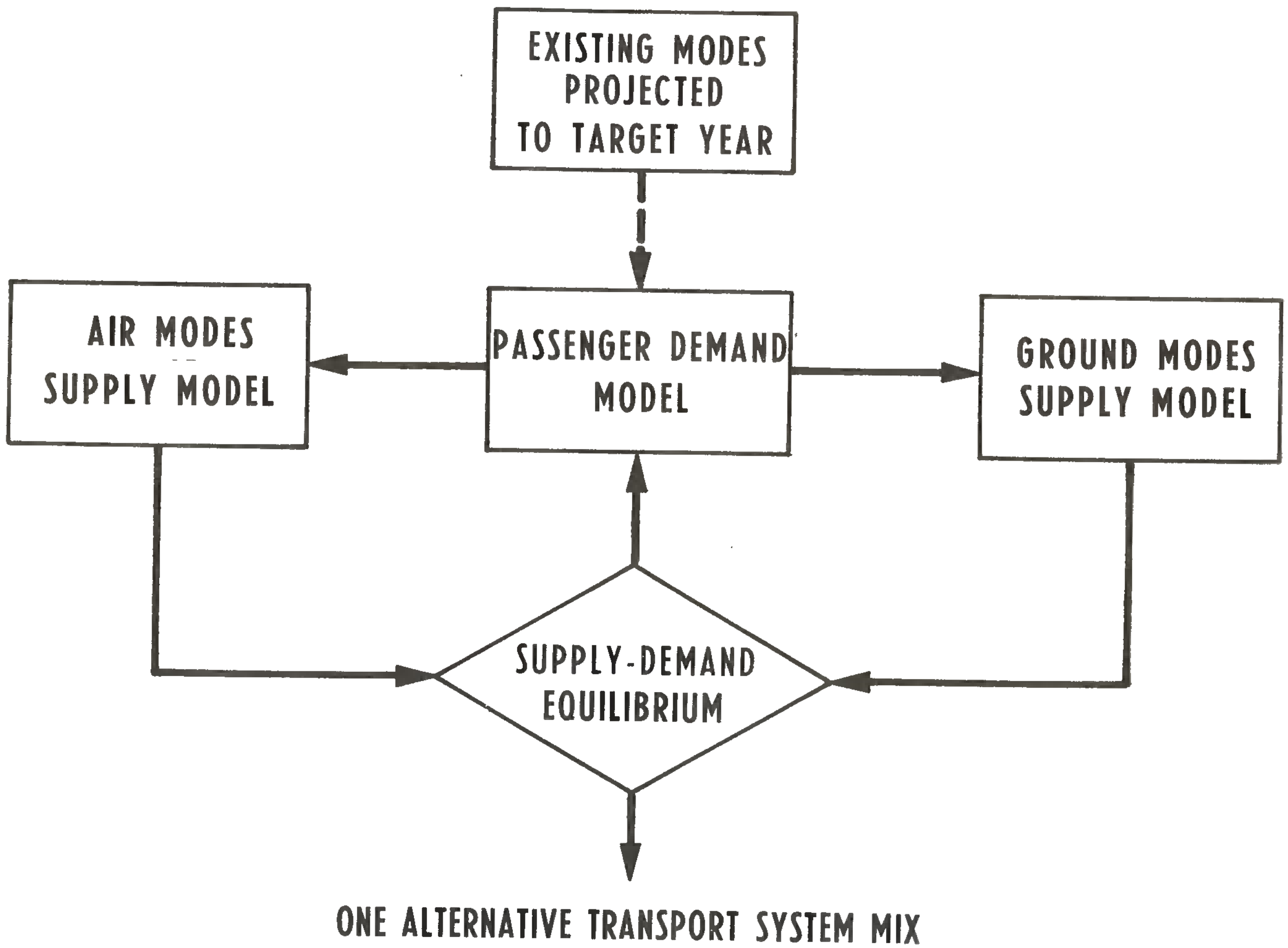

FIGURE T3-3
SUPPLY-DEMAND EQUILIBRIUM SIMULATION

of the volume of travel by each mode between major Corridor cities for the same year. The data base has gaps which ex post cannot be filled--most notably because of the lack of fine grain origin-destination data. Most intercity auto data are limited to screen-line volumes, and the few available passenger counts on common carriers provide terminal-to-terminal rather than door-to-door figures.*

As with all models, the NECTP demand model is an approximation of reality. The real-life demand process involves a very large number of complex and changing patterns of subjective relationships. In contrast, the model employs very simple relationships shown empirically to be most significant.

The present demand model,** in forecasting travel between zone pairs, uses only zonal population and income as travel-generating and attracting measures, and trip time, trip cost and trip convenience (as measured by frequency of service) as attributes of the transportation service. The current form of the estimating equation for total

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*Most of these data have been pieced together from many sources including metropolitan area transportation studies, highway and toll facility traffic counts, CAB quarterly survey records, the Census of Transportation, and the rail demonstration projects of the Office of High Speed Ground Transportation. Some of the problems created by the lack of good data will be ameliorated when the survey covering all intercity passenger modes in the Corridor, recently initiated by OHSGT, is completed.

**The development of demand models by the Corridor project is continuing and is covered at length in supporting volumes to this report. Rather than attempt here a full mathematical description and justification of the particular formulation used, this document presents only the principal characteristics of the model and its development is given in Tab 3-1. For a more complete discussion of the demand model used for analyses in this report see Section IV, NECTP-213. For a further discussion of demand models see also NECTP-230.

demand being used by the Corridor project is given by:

$$T_{ij} = B_1 (P_i P_j)^{B_2} (\sum_k \omega_{ijk})^{B_3}$$

where

T_{ij} = Average number of daily intercity passenger trips between area i and area j via all modes.

P_i ,P_j = Total number of families with income greater than $10,000 in areas i and j, respectively.

ω_{ijk} = The level of transportation service provided by mode k between area i and area j.

B_1, B_2, B_3 = Coefficients estimated by statistical calibration.

The allocation of total demand to individual modes is given by:

$$T_{ijk} = \frac{\omega_{ijk}}{\sum_{\text{all modes}} \omega_{ijk}}$$

where T_{ijk} = Average number of daily intercity passenger trips between area i and area j via mode k.

$\omega_{ijk} = \alpha_1 (t_{ijk})^{\alpha_2} \quad (c_{ijk})^{\alpha_3} (F_{ijk})^{\alpha_4}$

t_{ijk} = Perceived trip time, including local access and egress, between area i and area j by mode k.

c_{ijk} = Perceived trip cost, including local access and egress, between area i and area j by mode k.

F_{ijk} = Convenience measure based on daily departure frequency for mode k.

$\alpha_1, \alpha_2, \alpha_3, \alpha_4$ = Coefficients estimated by statistical calibration.

The explicit use of only three factors to characterize a transportation mode assumes that other factors influencing travel decisions such as safety, comfort, and reliability are more or less the same for new modes as well as for the old modes for which data have been derived.

A number of properties of the NECTP demand model are deserving of special note:

Induced and Diverted Demand

Normally, the total volume of traffic between two points will increase following the improvement of service between them. Assume, for the sake of illustration, that this improvement of service is offered by one of several modes connecting the two points. The increased traffic on this mode will be composed in part by traffic diverted from competing modes, in part by traffic diverted from other origins and destinations, and in part by wholly new traffic. The present Corridor demand model is capable of forecasting diversions from one mode to another, but it is not designed to forecast changes in origins and destinations which may result from transportation improvements.* Hence the model treats all traffic not diverted from other modes as induced traffic. Based on the 1965 calibration data, such induced demand makes up approximately 85 percent of the increase in volume resulting from improvements in service.

Price Elasticity

Based on the data used to calibrate the demand model, the elasticity of demand with respect to price is approximately -0.95. Hence, a one percent increase in price would result in a 0.95 percent decrease in the number of trips demanded. It should be understood, however, that this price elasticity was derived from data covering a narrow range of prices. Great caution should, therefore, be exercised in assuming that this value for elasticity would necessarily apply very much beyond the range of fares in effect today.

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*This can be seen from the foregoing set of equations in which the number of trips between area i and area j (T_{ij}) is a function only of the characteristics of areas i and j and of the transportation conductances between the two areas. Since T_{ij} is a function of the sum of the transportation services provided by all modes ($\sum_k \omega_{ijk}$), the total demand between area i and area j is increased by either improving one or more of the existing modes or by adding a new mode to the original mix. Also, since T_{ijk}/T_{ij} is a function of $1/\sum_k \omega_{ijk}$, the proportion of total demand enjoyed by any one mode is reduced by improving the other modes or by adding a new mode.

Time Elasticity

The model as calibrated indicates that the elasticity of demand with respect to trip time is approximately -2.0; i.e., a one percent decrease in trip time would yield a two percent increase in number of trips taken. (Note that the same caveats about extending the figure for elasticity beyond a narrow range apply here, too.) Since time elasticity is twice the fare elasticity, changes in travel time presumably have a much greater effect on the volume of demand than do changes in fares.*

Schedule Frequency

The demand model is so calibrated that an increase in the frequency of service results in an increase in the volume of demand. However, the effect of added frequency diminishes as the number of trips per day becomes large, falling from an elasticity of about +0.3 for the first few scheduled trips per day to near zero at a frequency of 30 departures per day. Thus, additional daily departures above 30 will increase capacity, but will have only a negligible effect on traffic.

Area Structure and Network Analysis

Area Structure

The basic geographic unit of analysis used in the NECTP model system is the "district," equivalent to a county in most cases. The 131 districts into which the Corridor was divided are shown in Figure T3-4. While counties are well suited as data-base units, it was convenient to deal with a small number of units for many of the

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*Analyses of data now being collected in the rail passenger demonstrations tend to support the demand model calibrations based on historical data in terms of the relative importance which NEC travelers place on price and time. Tabs 3-2 and 3-3 present a synopsis of this continuing utilization of the new information generated in the NECTP.

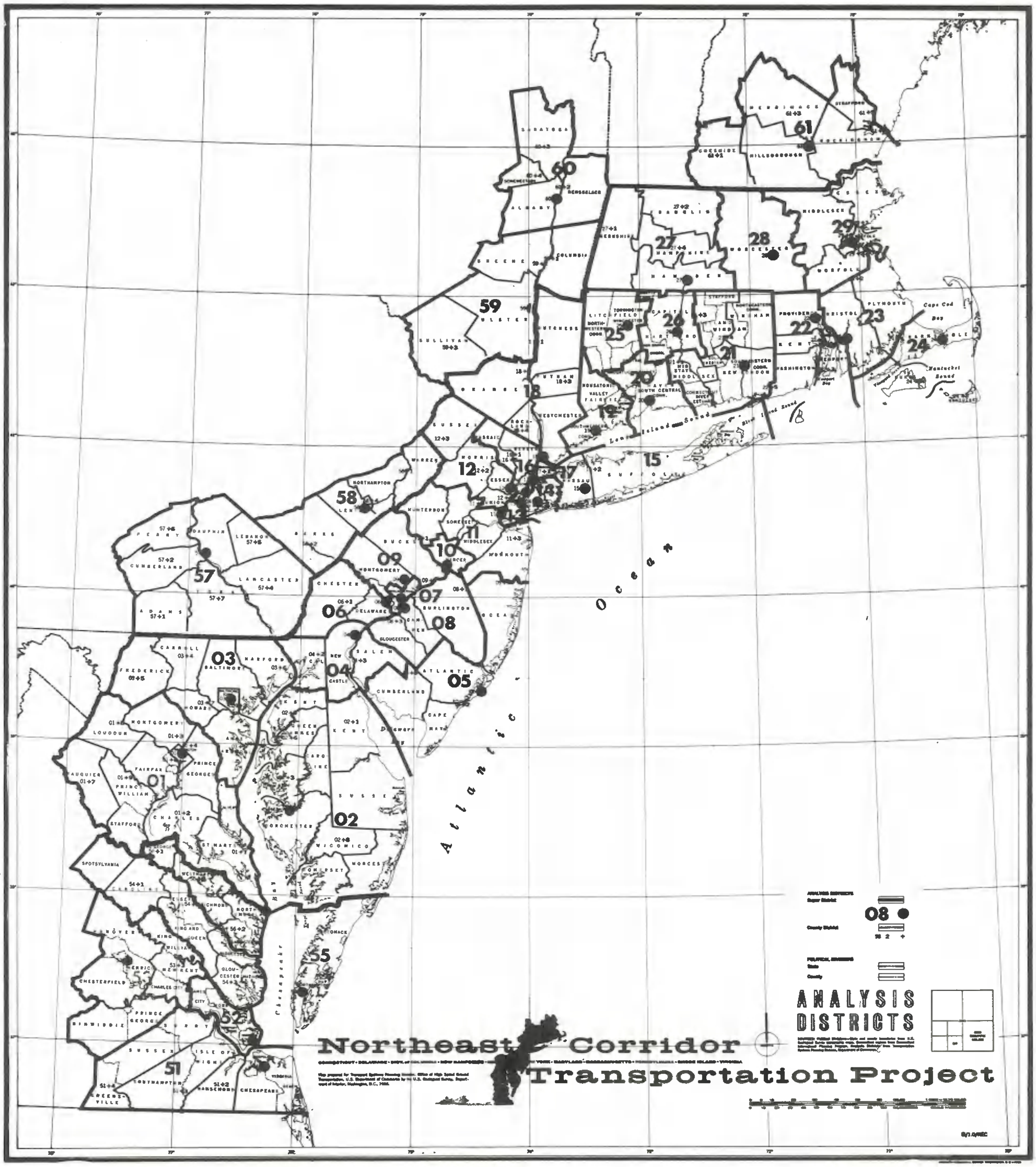

FIGURE T3-4
NORTHEAST CORRIDOR DISTRICT DIVISIONS

model runs. Thus the 131 districts were grouped as shown in Figure T3-4 into 29 larger units, termed "superdistricts."* These 29 superdistricts were used for the bulk of the transportation network analyses. A third areal unit, the "market area," was used in the analysis of the ground modes and for reporting of results. The market area represents approximately the combination of superdistricts from which traffic through a particular terminal is expected to be drawn. For the presentation of results, market areas were aggregated about the rail terminals as shown in Figure T3-5.

Network Analysis

The set of routes associated with each of the nine transportation alternatives are represented in the NECTP model system by geometric abstractions termed "networks." Each link in a network is characterized by the time required to traverse that link, by the fare or cost and, in the case of common carrier links, by schedule frequency. Additional travel time is assigned, where appropriate, to represent the delays occasioned by transfers between intercity and urban portions of a network or between different common carrier schedules.

The parts of trips from local origin to intercity terminal and from terminal to local destination account for significant proportions of the cost and. particularly, the time spent in intercity travel within the Corridor. Access-egress times and costs must, therefore, be added to the line-haul portions of each trip in order to obtain an accurate representation of door-to-door travel. The access and egress portions of intercity trips are determined for the relevant terminals in each superdistrict on the basis of the distribution of local origins and destinations of trips within the superdistrict. By weighting according to population access and egress times and costs for small sub-areas within the zone tributary to an intercity terminal, single values of access-egress times and costs are computed for each superdistrict, by mode, in the Corridor.

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*The choice of zone size represents a compromise between the locational precision of a large number of small zones and computational ease of dealing with a small number of large zones. Practical limiting factors on zone size are the lack of fine grain NECTP origin/destination demand data and the comparative rarity of intercity trips reflected in the data gathered in home interview surveys. The small zone size usually associated with urban transportation studies yields a significant number of daily urban trips but very few daily interurban trips. To avoid computational difficulties in dealing statistically with these small trip numbers, the NECTP models operate with larger zones and use a weighted average time and cost for the access or egress trip segments from origins in the zone to the terminal used for that zone.

FIGURE T3-5
NECTP MARKET AREAS

Access-egress times and costs include getting to and from the terminal, and, terminal time and parking cost appropriate to the mode. The latter cost is based on private auto at one end and rental car or taxi (whichever is cheaper) at the other. The central business district population is given extra weight to allow for its greater trip-making propensity. Access-egress time and cost values are calculated separately for each mode and terminal location.

Terminal sites have, in all cases, been selected with regard for both access-egress characteristics and compatibility with neighboring land uses. For example, VTOL and STOL terminal sites were screened for good (preferably over water) approaches and for distance from noise-sensitive residential areas.

The Air Modes Supply Model*

The air modes supply model operates within the supply-demand equilibrium simulation to balance supply and demand for each of the new modes. The equipment type and operating characteristics of STOL and VTOL are pre-specified for each of the transportation system alternatives in which they are used. Routes, schedules, fleet size and fares, however, are permitted to vary with volume and distribution of traffic.

The air modes supply model incorporates a cost-estimating sub-model which, when linked to the NECTP supply-demand simulation model, simulates all three supply adjustments by means of a route-setting program, a scheduling and fleet size estimation program, and a fare-setting program. The new air modes are assumed to accept all business so long as total costs, including return on capital investment, are covered by total revenues.** The route-setting procedure begins with all possible trip pairs served by direct, non-stop links, and in the simulation process re-routes trips on links showing insufficient patronage. The criterion for the indirect re-routing path is minimization of additional trip time for passengers. The scheduling program sets up connections to provide easy passage through the network rather than to minimize fleet requirements.

*Reference NECTP-215.

**This is not strictly in accord with the economic theory of the firm. It does, however, to some extent represent the situation in regulated industries.

The sequence of steps by which equilibrium is reached in the air mode supply model is shown in Figure T3-6. A set of schedules and fares is first established based on the maximum estimate of demand for air service between the 29 Corridor superdistricts. A more realistic estimate of demands for air service is next computed between all O-D pairs, based on this initial set of schedules and fares, and taking into account the effect on air demand of services provided by competing modes. The frequency of service on each link in the air network is then determined by reference to this new estimate of O-D demands, and to vehicle capacity and desired load factors. Demands which are too small to justify direct service are re-routed over more heavily traveled links. Schedules are then constructed and the required fleet size is estimated on the basis of peak loadings during the day.

System costs are calculated on the basis of required fixed investments, fleet size and operating schedules. Fares are set for each O-D service consistent with cost and a pre-specified return on investment; the product of these fares and the initial estimate of demand produces the "Expected Revenue" shown in Figure T3-6. The demand model is then re-entered with the adjusted times, fares and service frequencies. Since these service parameters will tend to differ from the service levels on which the previous estimates of demand were based, the revised demand forecast will also tend to differ from the previous estimates. The resulting demands, when multiplied by the adjusted fares, yield the "realized revenues." Since the previous estimate of demand will tend to be high, the realized revenues will tend to be lower than the expected revenues, and one or more additional cycles will be necessary to balance the system. The economic system represented by the transportation supply and demand models is stable and deterministic, and the iterations converge rapidly to an equilibrium point. Figure T3-7 illustrates the results of a series of converging iterations for a STOL mode case.

The air modes supply model is not inherently limited to air modes but is also applicable to other modes with dispersed-route networks. With an appropriate cost model, the bus mode could be treated in the same way as STOL and VTOL. As presently implemented, the air mode supply model will handle two modes, STOL and VTOL, simultaneously. More modes could be handled by expanding the iterative process.

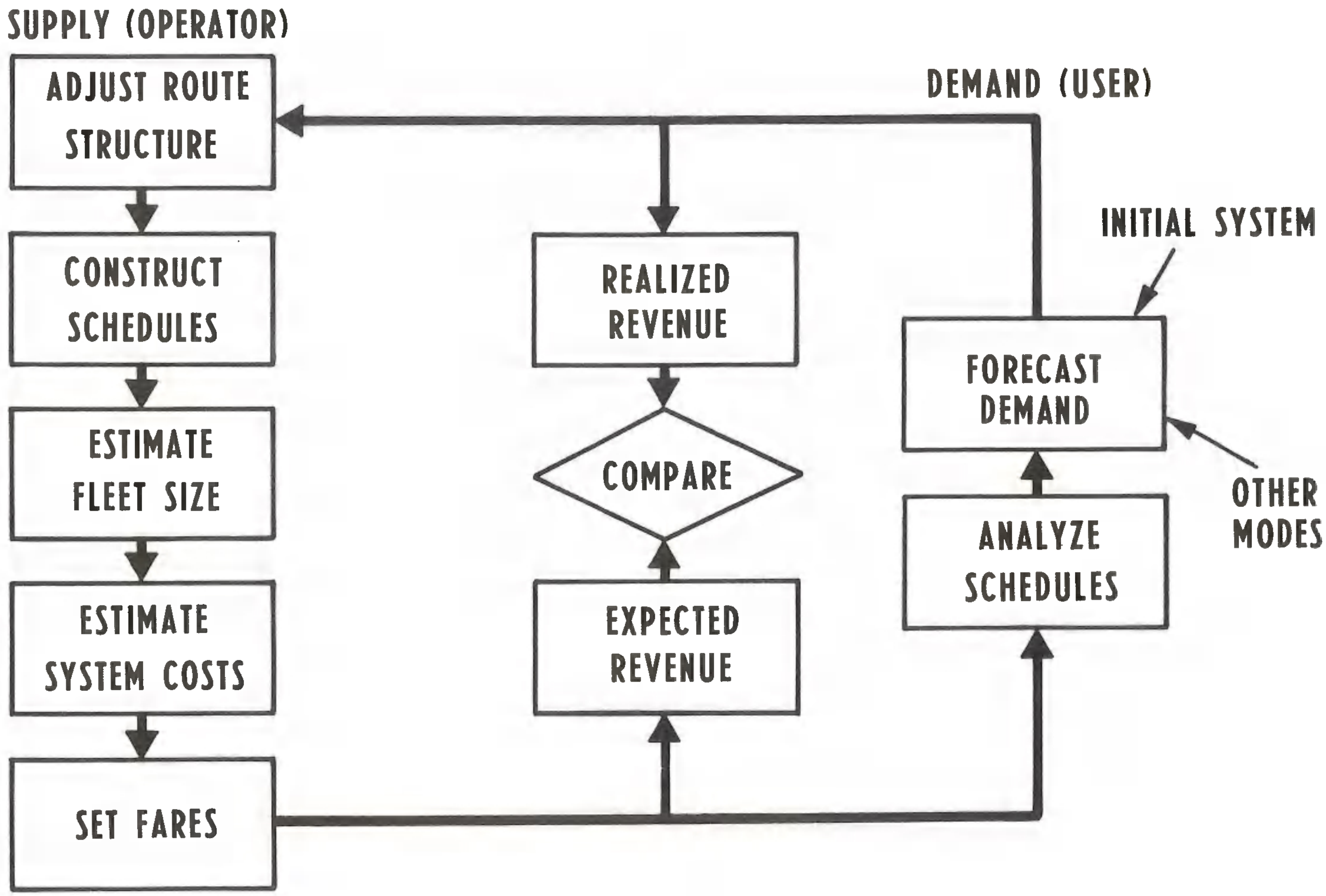

FIGURE T3-6
ITERATION SEQUENCE
(AIR MODES SUPPLY MODEL)

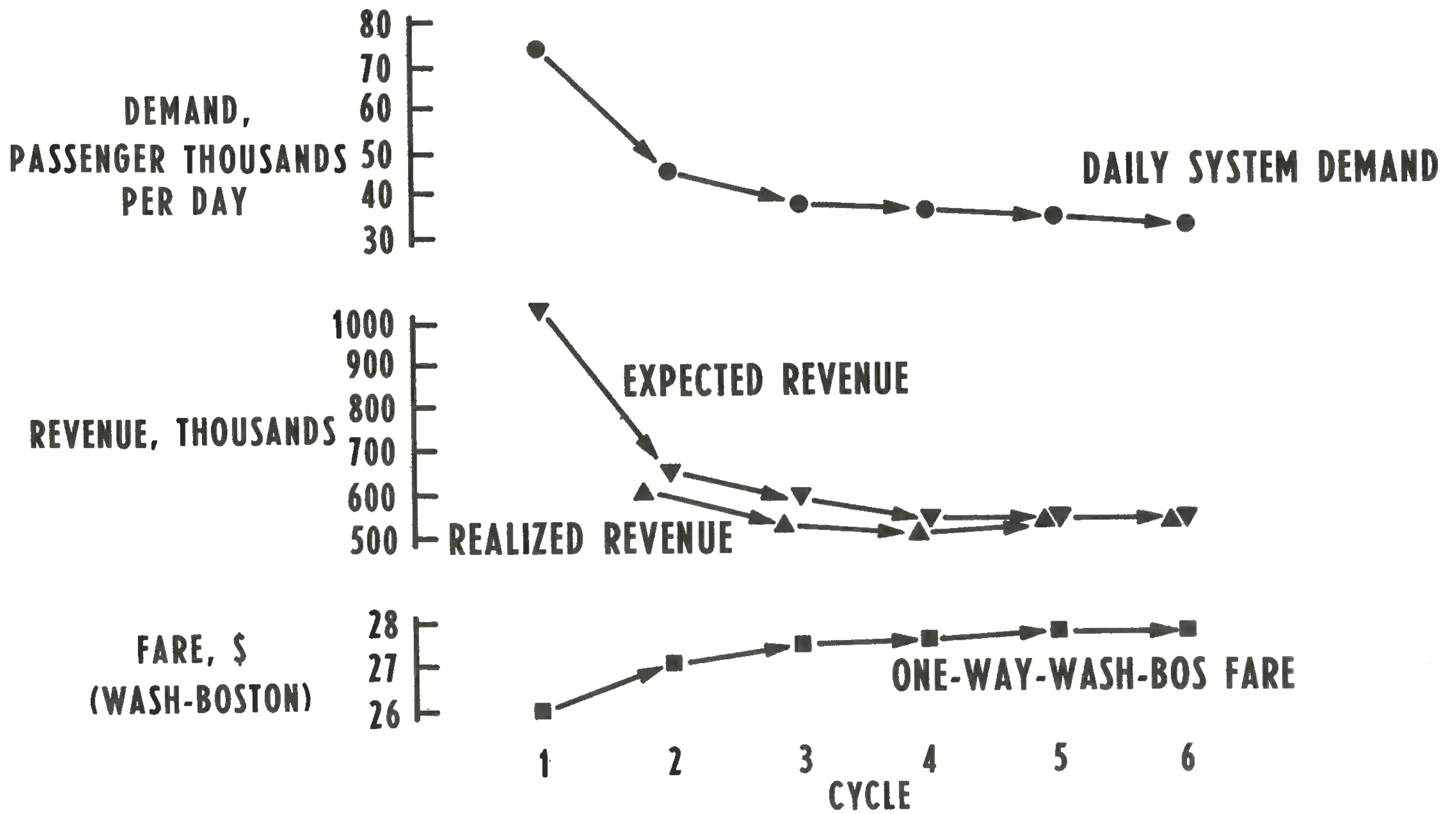

FIGURE T3-7
STOL CONVERGENCE ITERATIONS

The High-Speed Ground Modes Supply Model*

The principal difference between the "air" and the "ground" models results from the geometry of the networks assumed for each. The ground model is designed for a spinal network with pre-specified station stops and, therefore, requires no route-setting section. Scheduling for ground modes does, however, involve a trade-off between number of trains (frequency) and number of cars on each train. The basic ground mode supply model includes both cost and fare-setting sections, and can have as its objective either the maximization of patronage or net revenues, or the minimization of costs. The ground model is implemented for a smaller network than the air model--nine terminals for high-speed rail and TACV in contrast to 29 possible terminal areas for VTOL--and uses more rigorous optimization techniques. The end result, with either the ground or air mode supply model, however, is the same--a supply-demand equilibrium between the transportation mode and the users of the mode.

The high-speed ground modes analyzed in the various alternatives require a very large fixed investment and, consequently, a high yearly return on investment for break-even operation. If demand is insufficient, the model net revenue maximization logic tends to drive the service in the direction of very high fares in an attempt to take advantage of the price inelasticity of demand. The model might in this way eventually reach equilibrium, but at a fare completely beyond the range for which the demand model was calibrated. To avoid this situation fares were set externally for the ground modes supply model, thus allowing a deficit between costs and revenues to occur. The fare-setting option was not used, leaving only train size and frequency as variables for optimization.

The Existing Modes**

The supply and cost characteristics and the services offered by the existing modes--auto, bus and conventional air--were held constant within each alternative. Bus schedules, routes, speeds, and fares were projected on the basis of trends over the past ten years and on expected highway improvements. Conventional airline (CTOL) speed and costs were projected assuming introduction of new aircraft equipment now on order. Routes for CTOL were arbitrarily set to be complementary to the STOL service postulated in each alternative.

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*Reference NECTP-216

**Reference NECTP-211

Bus and CTOL could, in principle, be represented by an equilibrium-seeking supply-demand model, as was done in the case of the STOL, VTOL and high-speed ground modes. Because both bus and CTOL have extensive operations and services outside the Corridor, their costs do not reflect only Corridor operations. Hence, a supply model for these modes did not seem useful for this exercise.

Supply-Demand Equilibrium

The operation of the supply-demand simulation alternates between the ground and air supply models until a sufficiently small change in demand over a cycle indicates that a practical equilibrium has been reached.* The output from the supply-demand simulation is thus a complete set of services and travel volumes for all the modes at equilibrium.

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*Any iterative process requires an external decision rule to recognize when the imbalance has become sufficiently small to be insignificant. All the NECTP alternatives tested have converged smoothly and have not required sophisticated equilibrium tests. A residual low level of imbalance always exists, since the schedules must deal with integer numbers of whole trains or aircraft.

RELATED INPUTS AND OUTPUTS

Population and Income Projections

In the first generation model system, population and income projections were made exogenously, based on extrapolations of observed trends. 1960 population, 1966 population estimates, and compounded annual growth rates for the intervening period were available from the Census Bureau for each county in the Northeast Corridor.* The 1960 and 1966 estimates of county populations were aggregated into superdistrict populations, and a compound annual superdistrict growth rate was computed. This rate was applied to the 1966 superdistrict value to obtain a 1975 estimate. County and SMSA income data were taken from the 1960 censuses,** and from the Office of Business Economics (OBE) estimates for 1959 and 1966.*** The 1966 census income estimates were obtained by using the ratios of 1959 to 1966 OBE estimates of income, and applying them to the 1960 census values. The 1966 estimates were extended to 1975 by using the annual growth rate from the OBE sources for the period 1929 to 1966.

These population and income projections, along with measures of transportation service, form the basis for forecasting travel demand within the Corridor. The demand model, as presently formulated, uses a single socio-economic measure--the number of families in each superdistrict with incomes over $10,000--to capture the effect of population and income changes. Although forecasts based on available data are made for travel by the total Corridor population, the $10,000 and over measure appears to provide a more stable relationship to total travel for the 1975 to 1980 time period than either total population or median income, alone or together.

Regional Impact Model

The socio-economic effects of changes in the passenger transportation system serving the Northeast Corridor are measured through the use of an impact model, called INTRA-1.**** The specific objective of this model is to predict, by five-year increments, changes in the geographic distribution of employment and population among the various districts within the Corridor. The predicted changes are attributable, in part, to changing transportation impedances associated with changes in the transportation system itself. The mathematical structure of

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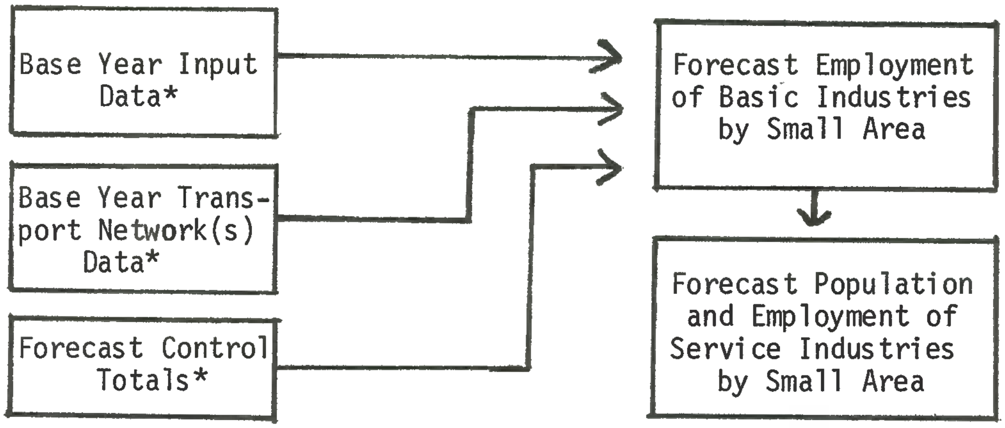
*U.S. Bureau of the Census, Current Population Reports, "Population Estimates," Series P-25, Nos. 401-404, 409.

**U.S. Bureau of the Census, County and City Data Book, 1967.

***Survey of Current Business, "Metropolitan Area Incomes 1929-1966," August 1968, Vol. 48, No. 8, pp. 25-48. These data are collected on a "where earned" basis, while the census income estimates are collected on a "where reside" basis.

****Reference NECTP-218.

the model system will not be described here; however, its major operational features are depicted in Figure T3-8



*Exogenously determined fixed inputs to the model.

Figure T3-8 The Structure of the INTRA-1 Model

The impact model was supplied with exogenously determined projections of the total levels of employment and population for the entire Corridor. These control totals were then allocated by the model among the various districts of the Corridor. Thus, changes in the Corridor's passenger transportation system were reflected only as changes or redistribution within the Corridor itself, but they did not affect the position of the Corridor as a unit with respect to the rest of the Nation. Totals of population and employment for the Corridor as a whole were assumed not to be affected by changes in the Northeast Corridor transportation system.

The control totals of employment and population for the Corridor are shown in Table T3-1 below for the years 1965 through 1990.

These control totals are the input numbers which were then allocated by the impact model to each of the Corridor sub-areas in each of the five-year increment periods.

TABLE T3-1

CONTROL TOTALS FOR THE NEC IMPACT MODEL

Year	Employment (x 1,000)	Population (x 1,000)
1965	14,536	42,099
1970	15,681	45,370
1975	17,004	49,309
1980	18,117	42,509
1985	19,021	55,134
1990	19,971	57,891

Source: U. S. Department of Transportation, OHSGT, September 1969.

Technological Cost and Service Relationships

Systems Engineering

A decision was made early in the Northeast Corridor project to make extensive use of systems engineering techniques in determining possible alternative transportation modes for the Corridor. (A major part of OHSGT's efforts in high-speed ground transportation has been directed toward this end). The objective of the systems engineering was to screen from the large number of possible alternatives the most promising modes for more precise descriptions and definitions. The elements of each of these modes was then subjected to an optimizing process which assured that the mode as a whole, within parametric bounds, approached an optimum. The results of this process became inputs to the rest of the Corridor model system.

Given the long history of extensive Federally-supported R&D programs in air and highway transportation, the prospects of development of technologically new elements in these modes could be forecast with some confidence. For example, complete descriptions, performance predictions, and cost estimates for VTOL were available from testimony provided by air frame manufacturers in the CAB, Northeast Corridor VTOL Investigation (Docket #19078).

In contrast, at the beginning of the Corridor project little R&D was under way in rail transportation and none on new high-speed ground modes. Hence, the systems engineering included an extended screening and engineering evaluation phase along the lines shown in Table T3-2. In this phase, high-speed ground mode classes which could be implemented by 1975-80 were identified--steel rail based modes and tracked air cushion vehicles.

After the initial selection of modal classes, studies were undertaken to determine the parameters which would govern the specification of engineering components. Thus each mode was defined in terms of performance (e.g., speed, block time, and capacity) and the costs of development, acquisition, operation, and maintenance.

Each candidate mode was hypothesized with alternative sets of components, each set having its own performance and cost relationships. The modes were also tested over a wide spectrum of operational policies. Given the large number of hardware and policy alternatives which had to be considered simultaneously with the interactions of all components in a given mode, an efficient mathematical optimizing procedure was required. Therefore, a computerized procedure was developed for determining the combination of characteristics which would result in an efficient hardware mix for each policy options. A number of systems questions could be conveniently answered through

TABLE T3-2 -- POSSIBLE HIGH-SPEED GROUND TRANSPORTATION ALTERNATIVES

	CLASS	CHARACTERISTICS	SPEED RANGE (mph)	GUIDEWAY	SUSPENSION	PROPULSION	POTENTIAL ADVANTAGES	DISADVANTAGES
STATION-TO-STATION	TRACKED AIR-CUSHION SYSTEMS	Vehicle guided along track and supported by air cushions	150–300	Flat concrete horizontal surface for support and vertical surface for guidance. Inverted T, box and U	Air cushions pressurized by centrifugal or axial compressors	Linear electric motor with reaction rail in guideway; propeller driven by gas-turbine or rotary electric motor	Guideway may be cheaper to build and maintain; smoother ride at high speeds than rail system; no wheel hop or traction limitations	Power to support weight of vehicle is high. Air-cushion equipment may be noisy. Switching is difficult
STATION-TO-STATION	ROLLING-SUPPORT SYSTEMS	Vehicle guided and supported by either conventional surface rails or monorail	150–300	Conventional or improved rail roadbeds or elevated structures modified to be straighter and more level	Steel wheels on welded steel rail; rubber tires	Rotary electric motor; gas-turbine engine (both with drivethrough wheels); linear electric motor	Since wheels support vehicle, no energy is required for support. Power is required only for propulsion. Extends conventional technology to a higher speed range	Wheels start to slip at high speeds. Guideway maintenance cost may be high. Monorail poses switching problems
STATION-TO-STATION	TUBE-VEHICLE SYSTEMS: Ambient Atmospheric Pressure	Vehicle guided and supported by enclosed guideway or subterranean tube	150–300	Concrete or steel tubes. Can be located aboveground, on surface or underground	Wheels, rails or air cushions	Electricity preferable to combustion engines	Can minimize disturbance to environment or corridor community. All-weather operation. The one system offering complete aerodynamic control. More chance of straight-line paths	Tunneling costs are high at present. Existing power-pickup devices are unsuitable for high speeds. At present, tube-vehicle technology is not as advanced as that of some other classes. Evacuated system poses special safety and maintenance problems.
STATION-TO-STATION	TUBE-VEHICLE SYSTEMS: Evacuated	Evacuated guideway reduces aero drag. More expensive to construct, but potentially more economical to operate	200–400	Same as above, and pumping systems and airlocks also required	Primary wheels on rails	Linear electric motor. Pneumatics and gravity-assisted acceleration and braking	High speeds because of reduced aero drag, in addition to above advantages	
STATION-TO-STATION	TUBE-VEHICLE SYSTEMS: Electromagnetic Suspension	Vehicle guided and supported electromagnetically in tube	200–500	Passive aluminum loops or structure buried in guideway	Electromagnetic forces generated by superconducting magnets on vehicle	Same as above	Presently the only suspension candidate for systems running in evacuated tubes at speeds unsafe for metallic wheels	Intense magnetic fields may affect passengers and subsystems. Vehicles may require heavy shielding
DOOR-TO-DOOR	MULTIMODAL SYSTEMS	Vehicle uses both conventional surface routes and new automated guideways for intercity portion of trip. Optimum configuration depends on urban system interface: bimodal or ferry pallet	80–150	Suspended and overrunning	Steel wheels or rubber tires; magnetic; air cushions	Linear electric motor; rotary electric motor; internal-combustion engine	May offer shorter door-to-door travel time. Retains advantages both of private auto and high-speed mass transit. Possibly compatible with urban systems	Vehicle unit costs/passenger are higher than for conventional auto or mass transit; maintenance of privately owned vehicles may require verification before use on public guideway
DOOR-TO-DOOR	AUTO-TRAIN SYSTEMS	Conventional autos, along with drivers and passengers, are loaded on a carrier vehicle and transported over the high-speed link	100–150	Standard gage for lengthwise loading and ≈ 17 ft for crosswise loading of autos	Steel wheels on welded steel rail	Rotary electric motor; gas-turbine engine; diesel-electric locomotive	Offers door-to-door service. No parking problem at terminal	Flexibility of loading for different destinations is poor for lengthwise loading
DOOR-TO-DOOR	AUTOMATED-HIGHWAY SYSTEMS	Conventional autos and highways are modified to provide automatic control of traffic flow on the high-speed link of intercity trips	Higher than present auto speeds	Conventional concrete highway, special-purpose or modified to accommodate appropriate control system	Auto wheels with conventional suspension	Internal- or external-combustion engine or electric motor	Offers increased safety and density over existing highways. Driver becomes backup controller. Door-to-door service. No terminal interface required	Vehicle maintenance may be beyond control of system operator and therefore inadequate; merging for entry, exit and lane changing requires complex central control system
*	CONTINUOUS-CAPACITY SYSTEMS	Transportation is available continuously. Employs variation of endless-belt principle	15–25	Enclosed belts, elevated or subsurface	Rollers; wheels; air	Rotary and linear electric motors; air pressure	Offers uninterrupted, continuously available service to many passengers	Passenger acceptance is not widespread. Slow. Not suited for growth or intercity speeds

*This class offers continuous service between terminals, unlike the sequential, scheduled service of the other six classes.

* At the time this chart was developed the term "system" was used to denote mode. In this report the term system is used to refer to an alternative mix of modes.

the use of this procedure, including the iterative calculation of minimum costs or optimum configuration of power plant capacity, fleet size, train length, etc., to achieve minimum total cost.

Throughout this process a strong feedback existed between the rest of the model system and the systems engineering. Analyses of modes in competitive environments frequently occasioned changes in modal configurations. As an example, early indications of high capital costs for the ground modes caused extensive rethinking and redesign of routeways, tunnel sizes, etc., which resulted in lower cost configurations. Similarly, as is discussed later in this report, inadequate STOL vehicle utilization in preliminary model runs caused the selection of a smaller STOL vehicle for subsequent analyses.

Cost Methodology

The computation of direct operator costs required the development of cost estimating relationships for each of the transportation modes included in the NECTP analyses. The estimating relationships developed for the high-speed rail modes and for TACV formed the cost sub-models of the ground mode supply model; the cost functions for STOL and VTOL were inputs to the air mode supply model. Cost equations were also developed for the CTOL and bus modes, which were treated as nonreactive (i.e., fares and schedules were not subsequently adjusted for CTOL and bus when their shares of total demand were calculated from each model run). The CTOL and bus cost equations were used to compute the investment and operating costs required for each of these modes to meet model-generated demand levels. For the automobile mode, cost functions were used to estimate "perceived costs," i.e., those costs considered by an automobile traveler as the actual costs of making a trip by automobile. These perceived costs were used in the demand model as the automobile equivalent to common carrier fares.

Theoretical and Practical Problems: The description of NECTP cost methodology should be prefaced by recognition of some of the difficulties of cost/benefit analyses. These difficulties include unresolved theoretical issues; gaps between theoretical concepts and capabilities for practical application; and problems in applied cost analysis, including data deficiencies and methods of quantification. (See NECTP-225.)* Because of these and other problems of cost determination, completely accurate evaluation of alternative

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*Research concerning both the theoretical bases for cost/benefit analysis and the compromises required in application has been funded as part of the Northeast Corridor Transportation Project over the past several years.

transport modes is nearly impossible. The effort discussed in this report, however, does provide considerable insight into the relative costs of alternative modes, major problem areas, and requirements for new costing concepts and methodology.

General Assumptions: Emphasis was placed on achieving as great a degree of consistency as possible in developing cost estimating relationships for each of the modes. Some of the general assumptions underlying the cost analyses are discussed in the following paragraphs:

1. Single management of each mode.--Each mode, for costing purposes, is treated as a single enterprise operating solely within the boundaries of the Northeast Corridor; no intramodal competition is considered.

2. Service provided.--Each operator's entire service is assumed to be devoted to scheduled intercity passenger transportation.*

3. Rate of return on investment.--The rate of return on investment in vehicles and fixed facilities was set at 10 percent for the new modes, and the interest rate on investment in land was fixed at eight percent.

4. Economic life.--Economic life of fixed facilities for high-speed rail, TACV and VTOL modes was set at 35 years, economic life of rail and TACV vehicles was 14 years, and life of CTOL, STOL, and VTOL aircraft, 12 years. Land was not amortized.

5. Definition of operator costs.--As far as possible, all costs applicable to the new modes were included as operator costs. Terminal costs for high-speed ground modes and for VTOL, and terminal approach air traffic control costs for VTOL, were charged to the operators; it was not assumed that these facilities would be provided by Federal or local government agencies.** It also was assumed that, for all new systems, revenues from concessions would not offset any portion of terminal costs. However, parking facilities were assumed to be self-supporting, and were not included in terminal costs. Opportunity costs for inherited or existing assets were not charged to the systems. Corporate taxes, which are not a function of costs, but of cost-revenue results, were not included as cost inputs.

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*Exceptions are DEMO and HSRA, the high-speed rail modes which would operate on existing Penn Central right-of-way. For these modes, some costs were allocated between passenger and freight traffic.

**For the high-speed rail and TACV modes, in cases where revenues do not cover operator costs, the model system indicates the amount of the deficit. Terminal costs for STOL were included in the form of landing fees and short-term rental costs.

6. Constant dollars.--All costs (and fares) for the 1975-1980 time period are expressed in terms of 1970 dollars. In cases where more specific price indexes were not available, an extrapolated estimate of the Bureau of Labor Statistics Consumer Price Index was used to convert cost estimates to 1970 dollars.

Cost Methodology for Specific Modes

High-Speed Ground Modes: The high-speed ground modes cover a relatively wide range in the technological spectrum, extending from equipment currently available to that still in early development stages. Differences in quality of information available for the ground modes required that the cost methodology embrace a variety of cost estimating procedures. However, since the emphasis was on development of estimates that are consistent and comparable, generalized estimating equations were developed wherever possible. In some cases sufficient data were available to permit derivation of statistically significant regression equations, e.g., land acquisition costs for HSRC and TACV, and some equipment items. More commonly, however, the sample size was too small to justify regression analysis and estimating relationships were obtained by visually fitting a line through a scatter of several points. In other cases, estimates were based on engineering analogues. The foregoing techniques were applied only in cases where system components, such as those still in development, could not be priced directly. For equipment in use today, (e.g., vehicle furnishings), manufacturers' list prices were used. Table T3-3 indicates, in highly summarized form, the types of estimating techniques used for each cost element for three of the high-speed ground modes.* Detailed documentation is presented in NECTP-222.

Air Modes: Like the high-speed ground modes, the air modes represent a range in the technological spectrum including a projection of today's conventional take-off and landing (CTOL) mode, a short take-off and landing (STOL) mode, and a vertical take-off and landing (VTOL) mode. As in the case of ground modes, different cost analysis techniques were applicable for the conventional as opposed to the innovative modes. A substantial volume of historical cost data is available on CTOL operations, while STOL and VTOL costs had to be developed without benefit of previous production or operating experience. Table T3-4 summarizes the estimating techniques and sources used. Detailed documentation is presented in NECTP-223.

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*In addition to the three high-speed ground modes shown in the table, a rail mode (DEMO) was also defined for 1975, at a level of capability between the Metroliners now operating and HSRA. The cost estimating relationships used for the DEMO are based on those developed for HSRA.

TABLE T3-3 HIGH SPEED GROUND MODES--COST METHODOLOGY

COST ELEMENT	HSRA	HSRC	TACV
RDT&E	Statistical estimate of engineering development; unit costs and analogues for test and evaluation	Same techniques as for HSRA, plus costs of research program, related to engineering man hours	Same techniques for HSRA, plus costs of research program, related to engineering man hour requirements.
Investment Land Acquisition	Identification and appraisal of specific land parcels	Statistical estimates based on land use and population density	Statistical estimates based on land use and population density
Routeway Preparation & Guideway Constr.	Detailed engineering assessments and pricing of required improvements	Civil engineering unit costs for roadbed, bridges, tunnels, track structure	Same techniques as for HSRC with changes for TACV guideway, switches
Guideway Electrification	Identification and pricing of improvements required, using standard cost factors	Unit cost factors, based on recent construction contracts and electrification studies	Extrapolation based on engineering analogues
Command, Control & Communication	Engineering estimates of costs for semi-automatic train operation	Automatic train operation unit costs, based on recent analogous installations	Unit costs from utility and telephone companies, equipment manufacturers, cost manuals
Terminals	Statistical estimates relating platform cost to maximum train length, and other terminal costs to peak passengers per hour	Same estimating technique as for HSRA	Same estimating technique as for HSRA
Yards & Shops	Shop addition, based on historical cost experience	Fixed costs plus unit cost per car for storage capacity plus land at cost per acre by location	Same costs as HSRC plus increment for switches at each storage yard.

TABLE T3-3 CONTINUED

Vehicles	Based on Metroliner experience	Manufacturers' estimates and railcar construction experience	Manufacturers' estimates; equations based on engineering analogues
Operating Costs Energy	KWH requirements computed by link; equation relating cost/KWH to energy consumption	Same methodology as for HSRA	Same methodology as for HSRA
Crew	Existing union rules and Turbotrain experience	New work agreement assumed; 2-man crew	2-man crew assumed; based on adjusted rail crew pay
Vehicle Maintenance	Penn Central Silverliner experience	Penn Central Silverliner experience	Statistical estimate based on rail and aircraft experience
Guideway Maintenance	Penn Central and AAR Data; allocation between freight and passenger	Statistical equation based on AAR Data	Statistical equation based on engineering analogues
Power & Control Maintenance	Cost factor: percentage of investment cost	Cost factor: percentage of investment cost	Cost factor: Percentage of investment cost
Maintenance Burden	Cost factor: Percent of direct maintenance	Cost factor: Percent of direct maintenance	Cost factor: Percent of direct maintenance
Indirect Operating Cost	Equations based on historical rail and air data	Equations related to block speed and load factor	Equations related to block speed and load factor

TABLE T3-4. AIR MODES--COST METHODOLOGY

Cost Element	VTOL	STOL	CTOL
Investment			
Vehicles	Estimate from Sikorsky Aircraft*	Estimate from McDonnell-Douglas*	Costs of typical aircraft in Corridor Use
Terminals and Other Ground Facilities	Estimates for terminals, maintenance facility, management information system, and terminal air traffic control based on studies by MIT Flight Transportation Laboratory and Sikorsky Aircraft.	Terminal expenses included as landing fees and rents; operator investment estimated by use of ratio of total system investment to aircraft investment based on CAB data from domestic trunk air carriers.	Terminal costs included as landing fees; operator investment estimated by use of ratio of total system investment to aircraft investment, based on CAB data from domestic trunk air carriers.
Direct Operating Costs	Based primarily on data from Sikorsky Aircraft, equations were developed relating DOC elements per flight hour to stage length; crew costs per flight hour from Sikorsky estimates, were invariant with stage length.	Based on McDonnel-Douglas estimate of direct operating costs as a function of stage length.	Cost estimating relationships developed from data reported to CAB by commercial airlines. The data were adjusted to reflect the types of aircraft operating in the Corridor, higher than average NEC traffic delays, and NEC shuttle operations.
Indirect Operating Costs	Personnel and overhead costs based on current commercial airline salaries, wage rates, and overhead ratios. Numbers and types of personnel reflect relatively austere service levels.	Based on indirect operating cost data for commercial airline trips between twelve Northeast Corridor city pairs. Regression analysis was performed to obtain an equation relating indirect operating cost to stage length.	Cost estimating relationships developed from CAB data, as described above for direct operating costs.

*The civilian share of research and development costs for these aircraft is assumed to be included in the manufacturers' vehicle price estimates.

Highway Modes: Costs for intercity bus operations were based on data from reports of two bus companies operating in the Northeast Corridor--Eastern Greyhound and Safeway Trails--to the Interstate Commerce Commission. The data were used to compute average bus load factors, annual miles per vehicle, average operating cost per vehicle, and the ratio of total investment to vehicle investment. These averages were then used to calculate investment and operating costs for intercity bus operations sized to meet model-generated demand levels.

In the case of the automobile mode an attempt was made to determine "perceived costs," i.e., those costs considered by an automobile traveler as the actual costs of making a trip by automobile. These costs include certain vehicle operating costs and projected 1975 highway toll charges; they were computed by use of a model which incorporated a Northeast Corridor highway network; average speeds for each link in the network; toll charges by link; an average vehicle occupancy factor; and an equation relating marginal vehicle operating costs to speed. The model selected minimum time paths for Northeast Corridor automobile trips, and computed operating costs plus toll charges, per vehicle and per passenger, for trips between city pairs in the Corridor.

Output Operations

As illustrated in Figure T3-2, the output of the supply-demand simulation follows two paths. The socio-economic impacts are the subject of a section in Chapter 1 and are not discussed here. The second output line shows three separate activities--transport system performance, passenger statistics and cost summaries. These three sets of summary measures are prepared for each alternative by means of extensive computer post processors which extract, aggregate, and organize into convenient summary tables the raw output of the supply-demand simulation for further analysis, interpretation, and presentation.

TAB 3-1 DEMAND MODEL

The demand model which was used for the analyses for this report was the one most acceptable to the project staff at the point in time at which the analyses began. Much research was performed on demand models under the project's auspices before that time, and research has continued since then.

The project has found it extremely difficult to forecast patronage for many modes of transportation simultaneously and consistently. Many models developed for this project and by other investigations have predicted demand for one or two particular modes acceptably well but have failed to handle the competition between several modes in a reasonable and consistent manner. It has taken much research to finally find one acceptable formulation.

The particular formulation which was focused upon separates the estimation of total demand for a city pair from the estimation of the modal split or market share of a particular mode. The total demand model is a function of socio-economic characteristics of the cities and of the total transportation service provided. The modal split model is a ratio of a term representing the attributes of one mode to the sum of similar terms for each mode.

Two separate models were initially developed having this general formulation. However, the two formulations differed in the way they represented many components of the model. These approaches were merged and the combined model was tested. Further improvements were made on this merged model and the result became the model used for this report.

Further development of demand models has occurred since the analyses of alternative transportation systems reported on in the report were completed. No new formulations have been developed, but the one that has been used has been modified in two important ways. These are:

1. Demand can now be stratified into business and non-business trips.

2. A new parameter has been inserted into the demand model to control induced demand. Without time series data to estimate this parameter, the fraction of a new mode's patronage which is induced must be determined from analyses of information from other situations.

The project has recently derived usable demand data stratified by business and non-business purpose categories. These data are not definitive, and represent the forceful merging of data obtained from disparate sources. Still, they have proven usable. New elasticities of demand for each strata have been calculated. More stratification analyses will continue as better data are acquired.

For business trips, a price elasticity of -0.33 and a time elasticity of -3.44 have been calculated. These values agree with many observers' estimates. For non-business trips, the price elasticity is -1.18 and the time elasticity -1.00. Analyses of surveys show that non-business trips include two types: trips of short duration, such as visits and personal business trips, where travel time is important, and trips of long duration, such as vacations and prolonged visits, where price is more important than travel time. Probably the non-business trips should be further stratified, if data become available, to give more reasonable elasticity estimates.

The Census of Transportation of 1967 has shown that each of the existing modes has a different mix of business and non-business trips. Hence, the average elasticities for each mode based on these mixes and on business and non-business elasticities can be calculated. For airlines a time elasticity of -2.8 and a price elasticity of -0.55 is obtained in this way. This last number differs from the value of -1.3 which the CAB has measured for the price elasticity for airlines, but is in line with what most carriers believe. Rail elasticities for time and for cost are -1.9 and -0.86, respectively. Bus elasticities are for time, -1.3, and for cost, -1.1. Auto elasticities are for time -1.5, and for cost, -1.0.

Estimates of trip time and fare elasticities of patronage for rail coach passengers in the New York-Washington Corridor were calculated.* All calculations are based on measurements of patronage as determined by the data tag counts. The average fare data for 1968 was calculated from the on-board survey. (Data tag counts and on-board survey data are compiled by the Demonstrations Division, OHSGT).

All elasticities reported below are exponents in multiplicative models (equations) fitted by multivariate regression analysis. More than one estimate has been obtained of fare and trip time elasticities. Different estimates correspond to different time periods, different kinds of rail passenger service and different groupings of variables.

Estimated Fare Elasticities

Fare elasticity of patronage has been estimated for non-Metroliner service during 1968 alone, for non-Metroliner service during the period October 1966 through September 1969, and for Metroliner service during the first nine months of 1969. The estimated elasticities and the 80 percent confidence intervals around these estimates are as follows:

	Estimated Fare Elasticity	80 Percent Confidence Interval
Non-Metroliner Traffic (1968)	-.56	-.56 ± .31
Non-Metroliner Traffic (1967-1969)	-.61	-.61 ± .52
Metroliner Traffic (1969)	-.59	-.59 ± .68

The Non-Metroliner Traffic (1968) estimate of fare elasticity is derived by regressing average daily passengers by train (ADPT) upon a number of variables including average fare and day of the week for Northeast Corridor trains operated in the calendar year 1968. No fare changes were made by the Penn Central in 1968. However, variation existed in average fare by train and day-of-week, due to the varying makeup of patrons by type of ticket. The estimated fare elasticity is based upon this variation in average fare.

The Non-Metroliner Traffic (1967-1969) estimate uses monthly passengers from New York to Washington as the dependent variable; the independent variables include trend, the individual months, and certain irregular factors as well as a fare index. Fares were increased on March 1, 1969. Monthly New York to Washington Metroliner patronate and a fare index reflecting the fare increase of September 5th underlie the Metroliner Traffic (1969) estimate

*The estimates of trip time and fare elasticities were calculated by Economic Sciences, Inc. of Washington, D. C.

of fare elasticity. The observations begin with January 1969, the month in which Metroliner operations commenced.

Estimated Trip Time Elasticity

Two estimates of trip time elasticity of non-Metroliner patronage have been made. The estimate of -2.41 (shown below) resulted from the model described above which uses the 1968 average of daily passengers by train as the dependent variable. The estimate of -1.60 is based on monthly weekday (Monday through Friday) patronage from April through October 1969 of one pair of trains in each direction between New York and Washington. It is appropriate to note that estimates of non-Metroliner trip time elasticities may be affected by the fact that trip time is correlated with departure time; slower trains very often leave later in the day.

	Estimated Trip Time Elasticity	80% Confidence Interval
Non-Metroliner (1968)	-2.41	-2.41 ± .28
Non-Metroliner (1969)	-1.60	-1.60 ± 1.95
Non-Metroliner vs. Regular Metroliner (1969)	-2.03	-2.03 ± .32
Regular vs. Non-Stop Metroliner (1969)	-4.09	-4.09 ± .87

The comparison of non-Metroliners with regular Metroliners is based on a model which uses monthly passengers as the dependent variable and has a data base which includes paired non-Metroliner and regular Metroliner trains northward and southward for the period April 2, 1969 through August 31, 1969. This comparison is affected by other differences between conventional trains and the Metroliners. Metroliner coach fares and higher, and all Metroliners have added comfort. The resulting elasticity -2.03 is, therefore, a combined effect expressed in terms of trip time.

The trip time elasticity of Metroliner patronage was estimated by pairing the non-stop Metroliner in each direction with the regular Metroliner closest in departure time between New York and Washington during the period of April 2 through October 25, 1969. In this comparison the comfort and fare factors are the same for all trains. The Metroliner estimate (-4.09) was obtained in this manner with "monthly weekday passengers" as the dependent variable since non-stop Metroliners do not run on weekends. Departure times of the paired trains are different as are arrival times. These differences and the convenience they imply may affect the estimate shown.

TAB 3-3 NECTP DATA COLLECTION AND ANALYSIS

The collected data base provides support to three operations of the model system:

- calibration data for the demand model
- socio-economic data for population and income projections and calibration of input model.
- modal service data for projection of existing modes.

The data collection activity is continuing, particularly in conjunction with the present Northeast Corridor intercity passenger survey. The data collection methodology and a brief description of the separate data collection and analysis projects follow.

Historical Transportation Data

Historical information on the demograhic and economic characteristics of the region, time series data on person movements over all modes of intercity transportation and descriptions of the transportation systems and services in the Northeast Corridor have been assembled from a variety of sources throughout the Northeast Corridor Region. Major sources have been the publications of the Bureau of the Census, the Civil Aeronautics Board, the Interstate Commerce Commission, local and state planning agencies, highway departments, the various transportation and planning associations and the published schedules of the common carrier companies. Unpublished information has been obtained by special request from state highway departments, state and local planning agencies, the Bureau of the Census, the Office of Business Economics and many other sources.

The major limitations of the historical data are (1) the lack of uniformity with respect to the time periods to which the data apply, (2) the inconsistent definition of variables, (3) the varying levels of reliability, (4) the type detail and (5) the geographic area of coverage. No exhaustive study or consistent collection of data was made for the entire Corridor area prior to the NECTP. Most data collection efforts have been local in character, and even the largest, around New York and Philadelphia, cover only a portion of the Corridor area as now defined.

In an attempt to overcome some of the major deficiencies and inconsistencies in existing movement data, the Office of High Speed Ground Transportation has funded data collection for continuous passenger counts on the Penn Central Railroad, a survey in December 1966, of users at the three Washington and Baltimore Airports, a specialized household survey of travel by the Bureau of the Census in 1967, 1968 and 1969, and a survey of auto, air, bus and rail travelers moving between the major Corridor cities in 1969. This latter effort is still underway and the resulting data will be available in early 1970.

Following is a brief description of these collection efforts:

Continuous Railroad Passenger Counts and Questionnaire Survey.

As a part of the high speed rail demonstration project the Demonstrations Division of the Office of High Speed Ground Transportation is sponsoring two data-collection programs: (1) an origin and destination count of Penn Central intercity passengers between Washington and Boston, and (2) an on-train survey.

The origin/destination count, with minor exceptions includes all passengers on through trains between New York, Philadelphia, and Washington and between Boston and New York. Excluded from the count are commuter (non-through) trains and passengers who are traveling from or to points south of Washington.

The origin/destination count is the source of passenger volume information on the New York-Washington and New York-Boston routes. OHSGT devised machine-readable tags serving both as conventional passenger seat checks for the railroad and as means of obtaining adequate counts of passengers identified by stations of origin and destination, and by individual trains. The system has been in full-scale operation on a continuous basis since 1966 in order to develop base period information, and will continue during the demonstration.

The on-train questionnaire survey was inaugurated by OHSGT on the New York-Washington route to provide more comprehensive qualitative information to be used in evaluating public response to the improved service. This questionnaire survey is being administered on-board the trains on a continuing basis to a sample of passengers. It obtains information of the passengers' socio-economic characteristics, purpose of travel, frequency of travel and attitudes toward the service. These pre-demonstration data are still being collected. Comparisons with the information to be collected for both conventional and Metroliner passenger service will enable some determination of the effect of the new service and reaction to factors such as higher speeds, more frequent service, new equipment and improved comfort and convenience. An on-train survey of a similar nature was started on October 19, 1969, for the New York-Boston route.

Bureau of the Census Travel Survey

As a part of its 1967 National Travel Survey, the Bureau of the Census under an agreement with the Demonstrations Division of the Office of High Speed Ground Transportation, began collecting statistics quarterly on trips made by a sample panel of Northeast Corridor residents. The sampled households were asked to report trips 100 miles or longer, or overnight for any distance, made by family members during the previous three months. The sample of approximately 7,500 households was drawn from the Standard Metropolitan Statistical Areas (SMSA's) in the Northeast Corridor. In 1968 and 1969 the Census Bureau conducted the Northeast Corridor Household Survey again. Present plans envision the continuation of the survey into 1970. For the 1968 and subsequent surveys, the trip definition was changed to include trips 50 miles or longer.

Washington-Baltimore Airport Access Survey*

This survey was conducted jointly by OHSGT and FAA to collect information on the origins and destinations of users of National, Dulles and Friendship Airports during a week in December 1966. The purpose of the survey was to examine the patterns of access and egress to determine if high speed ground transportation could improve door-to-door service for intercity air trips. This study is being continued by the Washington Metropolitan Area Council of Governments under the sponsorship of the Urban Mass Transportation Administration and the Bureau of Public Roads.

Transportation Network Data

The transportation networks in the Corridor have been characterized by measures of travel distance, travel time, travel cost and service frequencies between all Northeast Corridor Districts. These attributes have been compiled and tabulated for 1955, 1960, 1965 and they have also been projected into future years in order to compare various proposed candidate systems. This information was obtained from schedules, tariffs and maps of the various transportation networks. For the common carrier modes, estimates of access and egress travel times and costs (to and from terminals) were developed as a single average value for each District, Superdistrict and Metrodistrict. A description of the assumptions, methodology, and areas employed is contained in a report number NECTP-217.

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*Washington-Baltimore Airport Access Survey, Volume 1, 2, 3, and 4. PB 176573, -4, -5, -6.

Northeast Corridor Intercity Travel Survey

The principal objective of this survey conducted by OHSGT is to develop statistical estimates of the total annual volume of intercity passengers traveling by air, automobile, bus and rail between the major cities of the Northeast Corridor. In addition to the estimates of annual trip volume by mode and by origin-destination, the following information is also being obtained:

a. Trip purpose

b. Access and egress modes (to and from public transportation terminals)

c. Access and egress travel time and costs (for public transportation users)

d. Fare and common carrier modes

e. Frequency of travel (for same O-D)

f. Annual family income of traveler

g. Place of residence

h. Actual origin and destination

i. Preferred schedule time (for p ˈic transportation users)

The air, bus and rail traveler surveys consist of self-administered questionnaires distributed and collected on-board the vehicles. The auto traveler survey consists of direct personal interviews on the major intercity routes and a self-administered mail-back questionnaire for the minor intercity roads. The auto sample is selected from traffic flows on highways intercepted by two screenlines; one along the Susquehanna River and the Chesapeake Bay and one located along the Housatonic River in western Connecticut.

Survey of the Dynamics of Mode Choice Decisions

The mode choice decision survey conducted by OHSGT has been designed to determine the bases for individual travel decisions, i.e., how and why alternative modes of transportation are selected. The needs, preferences, values, attitudes and criteria of the intercity traveler (and the effect of these factors on mode choice decisions) will be determined. The findings will be used in evaluating the demonstrations and predicting the effect of changes in transportation system alternatives on the decisions of the travelers. The data will also provide insights that will be useful in the improvement and development of demand and modal choice models.

New York-Washington Air Survey

A survey by OHSGT of the major air carriers serving Washington and New York was conducted for a six month period during 1969 to determine; (1) the overall mode loyalty of the air and rail travel passengers, (2) the source of business (i.e., the mode of transportation previously used) and (3) the socio-economic and travel pattern characteristics of Metroliner passengers, regular train passengers and air passengers.

TECHNICAL APPENDIX 4

DESCRIPTION OF ALTERNATIVE SYSTEMS

This chapter contains the pro forma descriptions of the alternative systems which were postulated for study. Each is based primarily on the system already existing in the Corridor. Each alternative beyond the first adds one or more modes to the Corridor transportation system. In this chapter, and throughout the report, "transportation system" refers to the combination of modes brought together to form a single alternative system for the Corridor; "mode" refers to the transportation service provided by a given technology; e.g., rail or auto.

NEW MODES ADDED

Five new modes were selected as possible additions to the Northeast Corridor transportation system during the 1975-1980 time period. The new modes are:

High-speed rail on existing right-of-way	HSRA
High-speed rail on new right-of-way	HSRC
Tracked air cushion vehicle	TACV
Short take-off and landing aircraft	STOL
Vertical take-off and landing aircraft	VTOL

Specific performance values, such as vehicle speed and capacity, were selected from the continuum of values which might have been chosen in the design of a new transportation mode. In some instances, the performance specifications have been the subject of engineering optimization studies. In others, the specification determination was arbitrary, but illustrative of anticipated capabilities. The speed for each new mode is set near the upper limit expected for the vehicle type and particular operating regime. The 150-mph HSRA vehicles, for example, would require the best conceivable maintenance and control on an upgraded Penn Central right-of-way. A 200-mph HSRC design pushes wheel-on-rail technology toward its upper limit. The TACV starts to lose effectiveness due to increased aerodynamic drag at speeds above 300 mph. STOL and VTOL represent some of the manufacturers' best designs for the period. Details of the characteristics of each mode are given where the mode is first used.

Criteria for the Specification of Alternatives

Assembly of the existing modes and selected new modes into nine combinations as NEC transportation alternatives was guided by the following criteria:

1. All the technology, whether to improve existing modes or for new modes, should be capable of application in the time period 1975-1980.

2. The series of alternatives should present a wide range of characteristics for consideration by decision makers. Alternatives were defined whose characteristics differed sharply with respect to the following:

   a. Degree of technological innovation
   b. Emphasis on suburban or central city service
   c. Magnitude of capital cost
   d. Performance capability
   e. Private and public investment requirements
   f. Need for institutional change
   g. Impact on metropolitan development

3. The alternatives should be evaluated to determine (for economic feasibility) those which take advantage of the high sensitivity of travel demand to reductions in total trip time.

4. Undesirable environmental impacts of the designs, such as noise and pollution, should be kept to a minimum.

ALTERNATIVE I

This alternative constitutes the base case for the 1975-1980 time period. It describes the system which might exist if present plans and policies are continued. The existing modes will have undergone certain improvements. The rail mode presumed in this alternative is an outgrowth of the current demonstration rail service (DEMO), with additional Metroliners and Turbotrains running on the present roadbed. The level of DEMO service was not only determined on its own characteristics, but also in competition with the other modes. The rail trip from Washington to New York is set at three hours (which is already bettered by the Metroliners) and the New York to Boston portion, set at three and one-half hours. The conventional air service (CTOL) in this alternative is an extension of existing commercial jet service, using the same aircraft. The auto and bus services take advantage of the new highway completions expected by 1975.

The individual modes comprising this first alternative are described in the following sub-sections.

Demonstration Rail Service (DEMO)

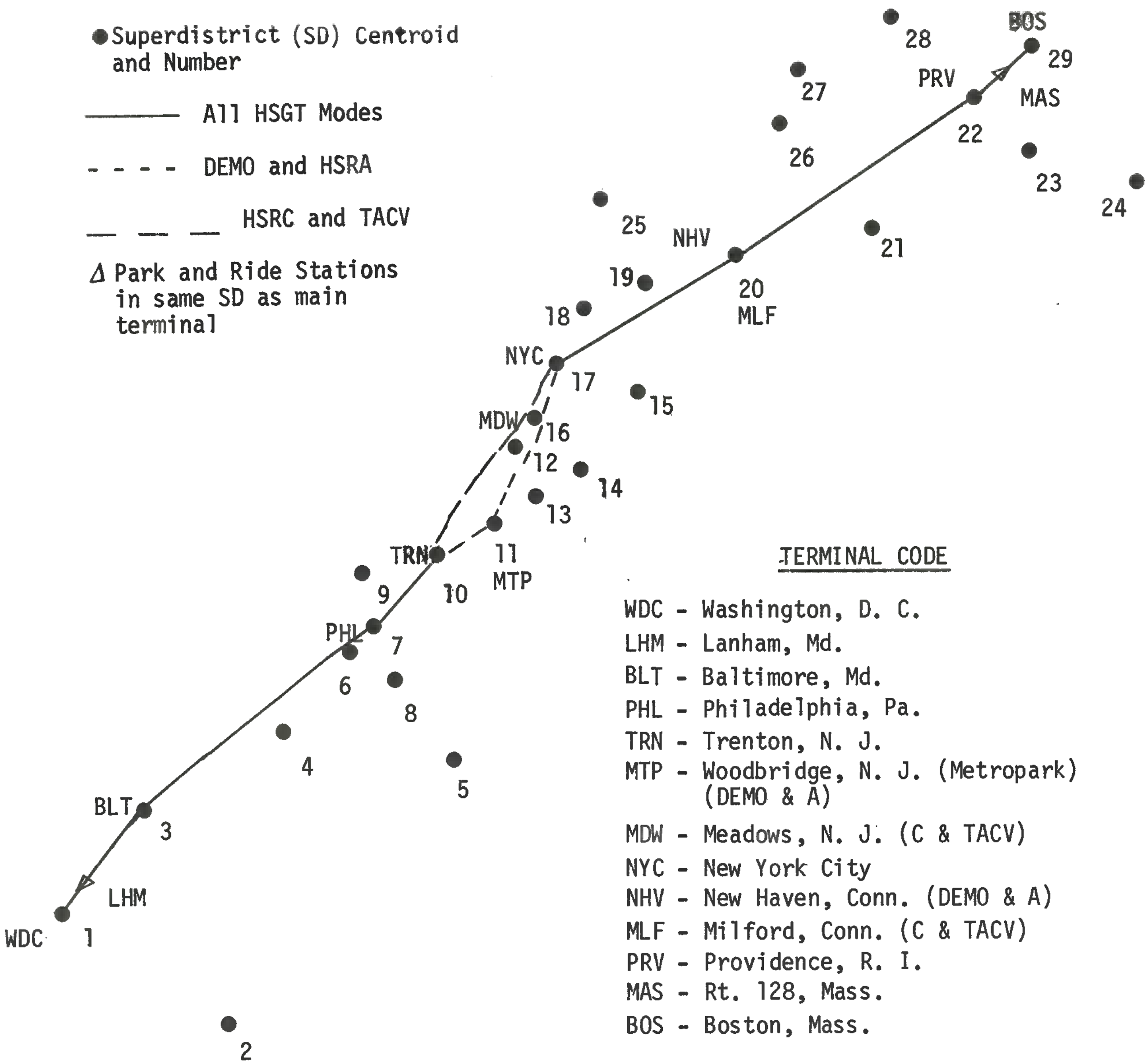
The DEMO service is assumed to be an extension of the high speed service on the Penn Central right-of-way. The northern and southern divisions would operate different vehicles. The schedules in this analysis match Metroliner and Turbotrain arrivals and departures at New Haven for "cross platform" continuation of service. Some Metroliner trains would run only between Philadelphia and New Haven for "inner loop" service and would not be met by Turbotrains at New Haven. Otherwise all trains would make all stops. See Figure T4-1.

Fixed Facilities

The suburban stations at Lanham, Maryland (Capital Beltway Station), and Woodbridge, New Jersey (Garden State Parkway Station, also popularly referred to as "Metropark"), would be complete and in use.

Vehicles

The vehicle and train sets will be the same as the present Metroliner and Turbotrain equipment, with normal retrofits or modifications. Cruise speeds up to 125 mph would be permitted on the better track sections.



TERMINAL CODE

WDC - Washington, D. C.
LHM - Lanham, Md.
BLT - Baltimore, Md.
PHL - Philadelphia, Pa.
TRN - Trenton, N. J.
MTP - Woodbridge, N. J. (Metropark) (DEMO & A)
MDW - Meadows, N. J. (C & TACV)
NYC - New York City
NHV - New Haven, Conn. (DEMO & A)
MLF - Milford, Conn. (C & TACV)
PRV - Providence, R. I.
MAS - Rt. 128, Mass.
BOS - Boston, Mass.

Note: Ground mode terminals for all alternatives are shown in this figure for comparative purposes.

FIGURE T4-1. Northeast Corridor Superdistrict Map for Fixed Guideway Modes

Service

An hourly schedule during the working day was assumed for the DEMO service between Boston and Washington, with additional trains operating (interleaved) between Philadelphia and New Haven. Chapter 5 lists the specific times.

Costs

Direct and indirect costs for the entire DEMO service were calculated in the model system on the basis of patronage and other physical transportation characteristics. Small annual, incremental capital expenditure charges were also included. Fares were extrapolated to 1975 from early 1969 DEMO rail fares. See Chapter 5 for projected fares.

Conventional Air (CTOL)

The air mode assumed to be operating in alternative I for 1975 is based largely on the current NEC configuration. No significant breakthroughs are expected to relieve congestion affecting aircraft movements at the major terminals. The industry will, however, be able to handle a relatively large increase in passengers by utilizing new "jumbo-jet" aircraft. The economies of bigger vehicles are expected to counter the rising costs of delays and inflation, resulting in an apparent fare stability for CTOL as compared to rising passenger costs on the other modes.

Fixed Facilities

The CTOL operation as modeled does not utilize any new airfields within the NEC. CTOL operations are continued only at the major terminals shown in Table T4-1.

Vehicles

Specific aircraft types were not identified for purposes of modeling and were not necessary since only the scheduled block times directly affect the demand model. The flights were all presumed to be made by subsonic jet aircraft, operating at or over 600 mph. To allow for possible greater demand, it was assumed that "jumbo-jet" aircraft could be inserted in the CTOL schedule without changes in block time.

Service

The 1975 operating schedules between conventional airports were adapted from the 1969 Official Airline Guide. The assumptions were made that no new construction would be completed to relieve airport congestion by 1975 and that the hourly frequency limitations applied by the FAA at major airports would continue.

TABLE T4-1. CTOL, STOL AND VTOL TERMINAL LOCATIONS WITHIN SUPERDISTRICTS FOR THE NINE ALTERNATIVES

SUPERDISTRICT	NAME	CTOL	"MERGED AIR" CTOL	"MERGED AIR" STOL	VTOL
1	Washington, D. C.	1*	1*	2	4**
2	Cambridge, Md.				
3	Baltimore, Md.	1	1	1	1**
4	Wilmington, Del.	1		1	1
5	Atlantic City, N.J.				
6	Upper Darby, Pa.			1	1
7	Philadelphia, Pa.	1	1	1	1**
8	Camden, N. J.			1	1
9	Abington, N. J.			1	1
10	Trenton, N. J.	1		1	1
11	Woodbridge, N. J.				1
12	Newark, N. J.	1	1	1	1
13	Staten Island, N.Y.				
14	Brooklyn, N. Y.	1*	1*	1	1
15	Levittown, N. Y.			1	1
16	Jersey City, N. J.			1	1
17	Manhattan, N. Y.			1**	1**
18	Yonkers, N. Y.			1	1
19	Norwalk, Conn.			1	1
20	New Haven, Conn.			1	1
21	Norwich, Conn.				1
22	Providence, R. I.	1	1	1	1
23	Fall River, Mass.				1
24	Hyannis, Mass.				
25	Torrington, Conn.				
26	Hartford, Conn.	1	1	1	1
27	Springfield, Mass.			1	1
28	Worcester, Mass.			1	1
29	Boston, Mass.	1	1	2	3**
	Total Airports	10	8	23	29
	Superdistricts	10	8	21	24

*The number of NEC intercity travelers is very small for JFK and Dulles airports and they were not included in the air network.

**Includes one downtown multistory port building.

Costs

The cost characteristics of the air modes considered in the study are shown in NECTP Report No. 223 and are summarized in Table T4-2. For costing purposes the 1975 commercial fleet serving the Corridor was presumed to consist of a variable mix of two aircraft sizes (with their consequent investment and operating costs). The smaller approximates the DC-9 type with 150 passengers, and the larger resembles the Lockheed 1011 with 320 passengers.

Automobile/Highways

The automobile mode in the Northeast Corridor has been modeled in a level of detail consistent with that used for other modes. A network of links and nodes has been traced and coded which represents the primary road system. It includes provisions for connections into or out of each of the NEC superdistricts. The existing highways were traced and geographically coded for 1965 and previous years. The network was updated to 1975 by anticipating the completion of new major facilities, including the Interstate highway links (See NECTP Report No. 211 for detailed descriptions of the expected improvements.).

No significant change was assumed in the performance of drivers or vehicles over the planning period.

Fixed Facilities

In order to represent the NEC automobile/highway mode for computer modeling, it was necessary to prepare a description of actual and planned facilities in a form which could be handled by the computer logic. The highway network used in this study included:

1. All freeways and Interstate routes except those within the central city analysis district of a Standard Metropolitan Statistical Area (SMSA);

2. All limited-access toll highways except those within the central city of an SMSA; and

3. Those segments of other highways over which Federal Aid Interstate (FAI) traffic is routed, pending completion of the Interstate routed except those within the central-city district of an SMSA.

All other highways were treated as access links.

TABLE T4-2 UNIT COSTS AND COST-ESTIMATING RELATIONSHIPS, CTOL and STOL*

INVESTMENT	CTOL
Air craft & spare parts	$3.9 M/aircraft
Ground equipment and Misc.	19.2% of aircraft investment
OPERATING COST**	
Passenger-Related	(2.26 + .0079D)$/pass.
Flight-Related	(.368 + .98D)$/flight

INVESTMENT	STOL
Aircraft & spare parts	$5.0 M/aircraft
Ground equipment and Misc.	19.2% of aircraft investment
OPERATING COST**	
Direct Operating Cost	(174.85+1.351D)$/flight+(2.39+.0185D)$/pass.
Indirect Operating Cost	(378.44+1.023D)$/flight

* For documentation of CTOL and STOL cost inputs, See NECTP Report No. 223.

** Operating costs include depreciation and return on investment.

D= Stage length in miles.

M= Millions

Vehicle Movement

Estimates of average speed characteristics were made for each of the segments of existing or proposed highways included as links in the various direct-coded highway networks. To estimate the link-speed characteristics for rural areas, only one average speed was used for both peak and off-peak hours. Speed limits supplied by state highway departments, the Rand McNally Atlas, and turnpike and toll road authorities were used as the upper bounds. Link speeds for the model were generally taken to be about five miles per hour less than the official speed limit. Travel speeds were further reduced below stated limits for roads that are mountainous, winding, flanked by commercial development, pass through numerous small towns, or have other speed-reducing characteristics.

To estimate the link speed characteristic for urban areas, three average travel speeds were used for each direction: one for off-peak hour flows, one for a.m. peak hour flows, and one for p.m. peak hour flows. In all cases, however, the a.m. and p.m. average travel speeds were reversed, depending upon direction of traffic (i.e., the a.m. inbound speed is the same as the p.m. outbound speed, and vice-versa).

This system of determining the three average travel speeds was used in the six major metropolitan areas (Boston, Providence, New York, Philadelphia, Baltimore, and Washington).

Service

The automobile provides the equivalent of infinite frequency. The demand model of the model system treats auto separately to allow for this characteristic.

Costs

The cost characteristics of the intercity highway system used in the study were developed as described in NECTP Report No. 223. Expenses for highway travel were based on the costs perceived by each user, whether an automobile driver or passenger. These costs did not include depreciation of the vehicle and were allocated to individuals on the assumption that the average vehicle occupancy in intercity driving was two and one-half persons.

Bus (Intercity Motor Carriers)

The common-carrier bus mode occupies the same pathway as the auto mode. With only a few restrictions, largely regulatory rather than physical, the bus can operate on the same roadway with the auto and, for this reason, it was decided not to develop a separate bus network. The same highway network used in the model system for auto travel was used for bus for the years 1965 and 1975.

Fixed Facilities

Bus terminal locations were included in each of the 29 super-district areas in the study. Access times for the bus mode were developed which simulate the existence of multiple bus terminals in the more dense areas by a reduction in the average access time.

No new construction of terminals was postulated for this investigation, since costs and fares were derived by a general method of trend analysis for the industry, rather than by costing specific facilities.

Vehicles

No specific assumptions regarding vehicle configurations were made. Travel times used for the bus mode in the models were derived from published bus schedules for 1965. For 1975, these travel times were reduced by 10 percent to represent the average decrease in trip time expected on the highway network over the 1965-1975 interval.

Passenger capacity of the buses was not a factor, because no changes of scheduling or routing routine were performed for the bus mode during this study.

Service

The 1975 daily operating schedules used for the intercity bus mode were derived from published schedules for 1965 with a few modifications to allow for routings over new highway links appearing in 1975. Frequency was increased by 40 percent to conform with industry expansion trends in the 1955-1965 period.

Motor Bus Fares and System Costs

Costs characteristics of the bus mode are shown in NECTP Report No. 223. Run results and bus system costs are reported in Chapter 5. Unit bus costs and estimating relationships are shown in Table 4-3.

TABLE T4-3 UNIT COSTS AND COST-ESTIMATING RELATIONSHIPS, INTERCITY BUS*

INVESTMENT COST	
Vehicle	$ .058 M/vehicle
Other	$ .015 M/vehicle
OPERATING COST**	
Total Operating Cost	$ .775 per vehicle mile

*For documentation of cost inputs, See NECTP Report No. 223
**Operating cost includes depreciation and return on investment.

M = Millions

ALTERNATIVE II

Alternative II represents the expectation that STOL aircraft will be in wide-spread use by 1975 on intercity routes. It also includes the projected 1975 demonstration rail service (DEMO). In this alternative, the STOL mode was sized by an iterative solution to operate in competition with the four other modes. The STOL and CTOL modes were treated as a single air mode, with the CTOL routes and service reduced from that of the previous case on the assumption that many CTOL short-haul flights in the NEC would be replaced by STOL flights by 1975. This "merged air" situation is carried into all subsequent alternatives, with competitive response (fares, schedules) taking place in the STOL mode but not in the CTOL mode. The auto and bus modes are unchanged in their physical descriptions. The new STOL mode considered in alternative II is described below, and the necessary modifications to CTOL are noted.

Short Take-Off and Landing Mode (STOL)

For this study, the short take-off and landing mode (STOL) was treated as an outgrowth of the present conventional air (CTOL) mode. In laying out tentative routes, STOL was excluded from operating over stage lengths in excess of 250 miles while CTOL was restricted from operating over stage lengths less than 150 miles. Below 150-mile stages, STOL and CTOL could not compete; in the 150-to-250 mile range, the two could be in direct competition; above 250 miles, a multi-leg STOL trip could compete with a non-stop CTOL.

Facilities

STOL was assumed to be a dispersed mode and to fly from peripheral small airports. Wherever possible, existing small airports listed for upgrading in the FAA airport plans* were taken as STOL ports. In a few cases, sites were chosen at locations where no airports existed but where the FAA plan called for them to be developed. The metropolitan areas having STOL sites are listed in Table 4-1, along with the corresponding set of CTOL ports.

Vehicle

The characteristics of the vehicle used for the STOL mode were based on the McDonnell-Douglas 210G. The selection of a particular aircraft is significant mainly for the effect it has on block times and fares presented to the demand model. Passenger capacity of the vehicle is used in scheduling and fleet size determination.** The

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*FAA National Airport Plan, 1969

**Sensitivity runs made with a smaller vehicle are discussed in Chapter 5.

aircraft speed is converted to block time between any two particular terminals by calculating the flight time over the linear distance, and adding a delay time for the flight to represent ground and air traffic maneuvers. The fares are derived through costing of the system and application of a fare policy to cover these costs.

The 210G aircraft* is one of several passenger designs derived by the U.S. from the French-developed Breguet 941 STOL vehicle. It is a fixed-wing aircraft, with the wing surface totally immersed in the slipstream of four turbo-prop engines. Large flap surfaces, with large angles of deflection in the slipstream provide the high lift coefficients to enable STOL operation. The 210G version has the following characteristics of interest:

Gross weight	84,000 lbs.
Cruise Speed	368 mph (320 knots)
Range	463 nautical miles
Passenger Seats	122 (maximum)

Service

Daily schedules of STOL operations are determined in the model to maintain as nearly as possible present load factors and utilization averages. STOL would not be restricted from flying between the several STOL ports within a metropolitan area, but passengers would not be able to buy tickets on these local flights and high fare settings would be inserted to prevent a STOL demand from rising on very short intra-urban legs.

STOL Costs

Most of the costs for the new modes were calculated within the computer models and are variable, depending on the passenger loadings calculated for different points in the network. (See the "Cost Methodology" discussion of Chapter 3.) The costs for land acquisition, construction, and installations at 22 STOL terminals are summarized in Chapter 5. Since STOL encountered different levels of competition in each alternative system, the capital costs to establish the mode in each (static) situation are different. This is also true of the other new modes. One element which was used consistently in total cost calculations was the flyaway cost of a single 122 passenger aircraft at $4.5 million. NECTP Report Number 223 gives the detailed breakdown of the unit costs used. (Also see Table 4-2)

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* The use of data for the 210G aircraft does not imply endorsement. The data was considered as representative for purposes of analysis.

Modifications to CTOL

With the availability of adequate STOL equipment and airport facilities, it is expected that CTOL aircraft would be shifted from the marginal short-haul routes in the Corridor to more profitable long-haul routes elsewhere.

The 1975 operating schedules of CTOL were, therefore, curtailed to a significant degree to account for the competition of STOL over the same routes with an essentially identical service. Service on CTOL when merged with STOL was restricted to the following pairs:

Washington - New York (LaGuardia and Newark)
Washington - Providence
Washington - Hartford
Washington - Boston
Baltimore - New York (LaGuardia and Newark)
Baltimore - Hartford
Baltimore - Boston
Philadelphia - Providence
Philadelphia - Hartford
Philadelphia - Boston
New York (LaGuardia and Newark) - Providence
New York (LaGuardia and Newark) - Boston

ALTERNATIVE III

For the third alternative system, a 150 mph rail mode (HSRA) was substituted for the DEMO rail mode. The STOL and HSRA modes were each subjected to iterative solutions by the model. These solutions modified the service characteristics of the two modes to meet the competition of one with the other and with the three conventional modes. The STOL physical description was unchanged from that given for alternative II. The new HSRA description is given below.

High Speed Rail A (HSRA)

The high speed rail A mode was defined to be the existing Penn Central route from Washington to Boston, upgraded to permit passenger trains to run at a sustained top speed of 150 mph over substantial portions of the track.

Fixed Facilities

The present track, catenary, and signal systems all require substantial work to permit the high-speed operation. Specific projects deserving special attention are: the replacement of bridges across the Susquehanna, Bush and Hackensack rivers; construction of bypasses at Bridgeport, New Haven, Old Saybrook, and New London; rebuilding of the Midland Branch into Boston; and construction of a new tunnel and station at Baltimore. The closing or grade separation of all crossings was considered mandatory for the safe operation of this mode.

The HSRA description presumes that bolted rail will be replaced entirely by continuous welded rail and maintained to very close tolerances. The existing catenary and the electrical system between New York and New Haven would be replaced. The electrification which presently terminates at New Haven would be extended on to Boston to eliminate a locomotive change or a cross-platform transfer. Automatic train controls and/or cab signals would also be required to permit higher speeds (now limited to 79 mph) between New York and New Haven.

Existing stations, or new stations placed at present locations, will be used at Washington, Philadelphia, Trenton, New York, New Haven, Providence, Route 128, and Boston. Two new suburban stations with parking facilities are currently under construction as part of the Metroliner demonstration project at Lanham, Maryland (on the Washington Beltway), and at a site called "Metropark" near Woodbridge, New Jersey (at the intersection of the Penn Central Line and the Garden State Parkway). See Figure T4-1.

Vehicle

The vehicles envisioned for this mode would be quite similar to the present Metroliners and would be self-propelled, multiple-unit electric cars. Maximum width which is limited by existing railroad clearances to 10' 6" would permit spacious 2 and 2 seating in the coaches.

Rather than providing a cab in each unit as at present, intermediate cars without cabs would be built. An A-unit would have streamlined nose and control cab, would seat 64 coach passengers, would be lighter in weight, and would have improved suspensions. Trains would vary in size from a maximum of ten to a minimum of two cars, with each train having A-units as the leading and trailing cars.

Service

The average speed over the entire route would be 109 miles per hour. The elapsed time from Washington to New York would be about 2 hours, and from New York to Boston about 2-1/4 hours. This represents a one-hour saving over present Metroliner time in the south and a 1-1/2-hour saving over present Turbo train time on the northern segment. Peak traffic periods would have service as frequently as every 15 minutes.

The portion of the line from Washington to New York presently carries a substantial amount of freight and, in the vicinities of Philadelphia and New York, there is also heavy commuter traffic. Therefore, the region from Washington to New Haven must be analyzed to determine the effects of freight and commuters on the high-speed intercity service, and vice-versa. Some rescheduling of freight operations may prove desirable. Additional tracks and interconnections may have to be provided at certain locations. Where this is not possible, the speed of the new trains would have to be restricted to insure a meshing of operations. The upper limits of capacity for mixed operations of high-speed trains, slower freight trains, and locals must be established. This information regarding the ultimate capacity of the existing rail line, when considered in conjunction with expectations of future demand, will permit better judgments regarding the extent of improvements required.

HSRA Costs

Some of the primary unit costs assumed for the HSRA mode are listed in Table T4-4. These costs or cost-estimating relationships were used in the model runs to develop component and total costs under different conditions of passenger demands in each of the transportation mixes utilizing the HSRA mode. A detailed discussion of costs is contained in NECTP Report No. 222.

TABLE T4-4 UNIT COSTS AND COST-ESTIMATING RELATIONSHIPS, HIGH SPEED GROUND MODES*

	HSRA	HSRC	TACV
RDT&E	$30.0M	$68.0M	$210.0M
INVESTMENT COST			
Right-of-way Acquisition	$213.8M	$463.8M	$463.8M
Guideway Construction, Electrification and control and Communication	$1197.5M	$1794.9M	$2276.2M
Terminals	$72.5M + adjustment for peak passenger throughput	$113.0M + adjustment for peak passenger throughput	$113.0M + adjustment for peak passenger throughput
Yards and Shops	$2.0M	$72.7M	$80.7M
Vehicles, per unit	Type A $.48M Type B $.43M	Type A $.58M Type B $.54M	$4.3 for first vehicle, with learning curve adjustment
OPERATING COST			
Vehicle movement, including energy, crew, vehicle and guideway maintenance	$.52 per vehicle-mile	$.51 per vehicle-mile plus additional guideway maintenance at $2000 per track mile	$1.01 per vehicle-mile plus additional guideway maintenance at $8000 per guideway mile
Power & Control Maintenance	$1.88M per year, plus burden**	$4.6M per year, plus burden**	$8.1M per year, plus burden**
Indirect Cost	$.017 per passenger mile	$.015 per passenger mile	$.013 per passenger mile

*For documentation of cost inputs for high speed ground modes, see NECTP Report No. 222

**Maintenance burden rate estimated as 66 percent.
M=millions

ALTERNATIVE IV

Alternative IV would introduce a new 200-mph railroad in place of high speed rail A. The size and service characteristics of STOL and HSRC would then be determined in the model iteration.

High Speed Rail C (HSRC)

The high-speed rail C mode would be a completely new, 200-mph passenger railroad, serving the centers of the seven largest NEC cities and four suburban park-and-ride terminals located near major highways. The concept is similar to the Japanese New Tokaido Line, but calls for a higher level of performance in the equipment. There is sufficient confidence in the capabilities of the steel-wheel concept at sustained speeds up to 200 mph to contemplate such operations in 1975. At speeds above 200 mph, power collection, aerodynamic drag and adhesion problems would require significant changes in basic design.

Fixed Facilities

The new HSRC mode would make use of existing terminals at Washington, New York, and Boston; but, at all other points to be served, the right-of-way and stations would be entirely new. Underground stations would be built at Baltimore and Philadelphia, and new surface stations would be constructed at the Washington Beltway, Trenton, Meadows (in the Jersey meadows near Secaucus), Milford (serving Bridgeport and New Haven), Providence, and Route 128. From Washington to New York the route would not deviate far from the existing route. North of New York, however, the route would run farther inland through rougher terrain than it does at present. As a result, tunneling would be required to avoid the excessive curvature of the present route. Even though the existing Penn Station in New York would be used, new tunnels under the Hudson and East Rivers would be required for the improved service.

The HSRC railroad would be completely electrified, using overhead catenary wires. The standard-gauge track would be laid on a rigid structure, designed to hold the rails within the tolerances required for 200-mile-per-hour operation without an excessive amount of maintenance.

Vehicles

The HSRC mode would require a higher-powered vehicle than HSRA and, also, improved suspension. The vehicles would be self-propelled by alternating current motors on the axles. The cars would be manufactured with two exterior configurations: A-units with a streamlined nose and a control cab, and B-units to serve as intermediate cars. The A-units would seat 64 passengers and the B-units, 70 passengers. A ten-car train of 2 A-units and 8 B-units would be the maximum-size train.

Service

Trains could operate as often as every five minutes during peak hours on the new mode. The trains would average 159 miles per hour, with a trip from Washington to New York taking 1 1/2 hours. The New York-Boston trip would taken another 1 1/2 hours. The operating schedules assumed for the model include 1 or 2 minute stops at each station. Two basic train runs are utilized, one from Washington to Boston and return; the other cycling between Philadelphia and Milford. The two services combined result in daily frequencies at the center of the Corridor which are double those available toward the ends of the route.

HSRC Costs

The primary units costs and estimating relationships used in modeling the HSR system are contained in NECTP Report No. 222 and summarized in Table T4-4.

ALTERNATIVE V

Alternative V assumes that the 200 mph passenger rail mode is replaced with TACV (300 mph).

Tracked Air Cushioned Vehicles (TACV)

The TACV used for these studies is an innovative ground mode which would operate over the same route and use the same terminal locations as the HSRC mode described above. The TACV, inherently more suitable for higher speeds than rail cars, is designed for a 300-mph cruise speed. (See NECTP Report No. 219).

In TACV, air cushions eliminate mechanical contact by forcing air between the vehicle and the guideway with sufficient pressure to support the vehicle. Air cushions also act against vertical surfaces to constrain the vehicle to the guideway--a function normally provided in ground transportation by the flanged steel wheel or the lateral resistance of a rubber tire. The air-cushion principle is already employed in the marine transportation field--Hovercraft are operating in passenger and auto-ferry service across the English Channel and have been demonstrated in passenger service in the San Francisco Bay area. Experimental and prototype TACV's have been operated successfully in France. Experimental TACV components currently are under construction in England. In this country, TACV development has been limited to system engineering studies, linear electric motor development, and research vehicle design. The TACV concepts used in this analysis were derived from system engineering studies sponsored by OHSGT.

Fixed Facilities

The right-of-way and terminal locations for the TACV are the same as those used for the HSRC. The TACV guideway was presumed to have a "U" shaped cross-section which would enclose the lower portion of the vehicle. The guideway would be twelve feet wide with sides four feet high. This design has the advantage of minimizing cross-wind effects and provides a very stiff beam to reduce deflection under vehicle loading. Prestressed reinforced concrete construction, when used in the elevated structures, would permit seventy-foot spans between supporting piers. Reaction rails for the linear electric motors would be imbedded in the guideway.

The low foot-print pressure and the smoothing effect of long air cushions should help to minimize guideway maintenance requirements. Considerable attention to guideway smoothness and the interior dimensions will be necessary, however, to retain the proper clearance for the air cushions and the linear motor.

Vehicles

TACV would have a capacity of 150 passengers. A width of 10 feet, 6 inches would allow comfortable 2 and 2 seating. To minimize the frontal area of the vehicle, a modular concept would be utilized, with the passenger compartment adjoined at either end by equipment modules containing the propulsion and air cushion equipment. The vehicles could operate singly or in trains.

The propulsion of the TACV to be provided by linear electric induction motors has been under development by OHSGT. This means of propulsion is ideally suited to TACV because it functions with no mechanical contact between the vehicle and guideway. The electricity would be supplied to the vehicle by trackside contact with a "stiff rail" power distribution system. The power would be converted to the proper voltages and frequencies for the electrical equipment by power conditioning equipment on-board the vehicle. Passenger loading would be restricted to the side away from the power pickups. The planned station-platform lengths would limit trains to five vehicles alongside at one time. No turnouts at stations would be used.

The vehicle configuration assumed for this study differs from slower speed TACV's presently being tested by Britain and France, but is similar to the research design being considered in the U.S. for test by OHSGT. The mounting of equipment for propulsion, cushion support and power conditioning on board the vehicle involves a considerable weight penalty. As in aircraft, each pound added requires more power to maintain lift and to achieve the desired acceleration and cruise speed. Direct operating costs, therefore, are expected to be higher than for wheel-supported vehicles. One point for evaluation will be the trade-off between the revenue gained by higher speed and the added costs. The engineering of such vehicles is still in an early stage and considerable economies in guideway structures and vehicle design may be yet possible.

Some future trade-off's may be made to reduce the power and air supply equipment carried on board. Reductions in tunnel diameters with consequent lower tunnel speeds may permit further cost savings without significant increase in trip time and resulting loss of patronage. Several other optimization possibilities may be investigated in a later model run series.

Service

The same type of service would be provided with the TACV as with the HSRC mode. The long-haul (Washington - Boston) schedules would include stops at all stations and the shorter schedules would stop at all terminals between Philadelphia and Milford. The short and long-haul runs are interleaved, providing higher frequency service at the center than at the ends. The frequencies of daily service and required fleet sizes are derived in the model system by passenger demand and cost/revenue balancing.

TACV Costs

The primary unit costs and cost-estimating relationships used in modeling the TACV system are given in NECTP Report No. 222 and are summarized in Table T4-4.

ALTERNATIVE VI

A dispersed VTOL mode (with 29 terminals) was introduced as a new competitive mode, in an environment which included the DEMO rail and the merged STOL/CTOL. The VTOL and STOL services reacted to each other in the model system until a passenger demand and cost/revenue balancing solution was reached.

Vertical Take-Off and Landing Mode (VTOL)

The VTOL mode postulated for this run series represents only one of the many configurations possible with the vehicle type. VTOL and STOL modes were assumed to be coexistent. VTOL has a unique capability to operate from small landing areas and was configured to operate from the sites shown in Table 4-1. VTOL was assumed to operate in the same manner as busses; i.e., with no checked baggage or in-flight food service. Stage lengths were limited to 250 miles or less, but schedules were designed for high connectivity among routes and for rapid transfer of passengers. VTOL would not, however, be connective with STOL/CTOL.

Fixed Facilities

Regardless of location, the basic land area for VTOL terminal facilities would be small, in general, only of the dimensions necessary for vertical take-off and landings and aircraft parking. In-city terminals would be multiple-story structures on more expensive land. The landing surface would be on the roof with ticketing offices, parking, and other services below. Suburban ports would have small, low-budget terminal buildings. Terminal sizes and construction costs at each location would be dependent upon the passenger throughput calculated for each port by the model. Terminals would be selected from one of four predetermined designs. Land costs varied with location. The evaluation was based on a set of 29 VTOL terminals at the locations listed in Table 4-1. Specific terminal locations were selected in and around cities to minimize air traffic and noise problems, but these locations could be modified without affecting the assumptions on local access times.

Vehicle

The VTOL vehicle was assumed to be a compound-helicopter--a probable outgrowth of rotary-wing development by 1975. The Sikorsky S-65 was taken as representative of the compound helicopter class. Cost and performance data on the S-65 were taken from the manufacturer's filing in the Civil Aeronautics Board Northeast Corridor VTOL investigation in 1969. The use of data for the S-65 vehicle does not imply endorsement. The cost and performance of other manufacturer's compound-helicopter designs included in the CAB filings are similar enough so that any of them could have been used in this study without significant change in results.

The aircraft utilizes a large five-bladed rotor for vertical phases of flight and transfers lifting forces to a small fixed wing at higher forward speeds. The main rotor is partially unloaded at cruise speeds but rotates to provide controlling moments. Three turbine engines are cross-shafted to provide redundancy in rotor flight, and two of the engines provide forward thrust in cruise. Primary aircraft characteristics are:

Gross Weight	63,600 lbs.
Cruise Speed	265 mph (230 Knots)
Range	315 miles
Passenger Seats	86

Service

Schedules were determined within the model in response to demand at each terminal location. Direct flights would be possible, as would be indirect flights with one or two intermediate stops. The basic rules for the VTOL network layout would be:

1. Each node (terminal) would be connected to its two nearest neighbors.

2. Direct VTOL flights would not exceed over 250 miles in range.

3. Service would not be provided when passenger demand fell below the minimum load factor threshold.

4. Flights would be possible between nearby ports in the same metropolitan area, but passenger demand would be discouraged arbitrarily by setting high fares for those connections.

5. Delay times for transfer or layovers at intermediate stops would be added to the trip times of through passengers.

VTOL Costs

The fly-away cost for each 86-passenger aircraft was set at $3.5 million. As mentioned above, terminal sizes were variable during the model runs, with each class of terminal having a given cost. A description of the cost breakdown for VTOL is contained in NECTP Report Number 223, and summarized in Table T4-5.

TABLE T4-5 UNIT COSTS AND COST-ESTIMATING RELATIONSHIPS. VTOL*

		VTOL
INVESTMENT		
Aircraft & Spare parts		$4.276 M/Aircraft
Terminals: Land, Structive & Furnishings		
Minor Terminals:	Up to 2000 daily pass.	$ .950 M/terminal
	2000-6000 " "	$ 1.600 M/terminal
	6000 - 10,000 " "	$ 2.900 M/terminal
Major Terminals:	10,000-20,000 " "	$3,200 M/terminal
Other Investment:		
Management information system		$14.6-49.400 M**
Office building		$ .390 M/M Annual pass.
Electronics		$ .300 M/terminal
Maintenance facility		$ .117 M/aircraft
DIRECT OPERATING COST		
Flight crew		$66.75 per flight hr.
Fuel & Oil		($\$40.69D^{.10564}$) per flight
Insurance		($\$ .022+\$.0000285D)^{-1}$ per flight
Direct Maintenance		($\$945\ D^{-.389}$) per flight
Maintenance Burden		($\$569\ D^{-.390}$) per flight
INDIRECT OPERATING COST		
Terminal Personnel, Overhead & Maintenance		
Minor Terminals:	Up to 2000 daily pass.	$ .170 M/terminal
	2000 - 6000 " "	$ .345 M/terminal
	6000-10,000 " "	$ .689 M/terminal
Major Terminals:	10,000-20,000 " "	$2.269 M/terminal
Reservations staff		$ .050 M/M Annual pass.
Sales commissions and communications		$ .350 per pass.
Advertising, general & administrative, pass. insurance & miscellaneous		$ .006 per. revenue pass. mile

*For documentation of VTOL Costs, See NECTP Reports Nos. 215 and 223.

**Related to annual patronage; beyond 40 million annual passengers, cost extrapolated using approximately $1.2 million per million annual passengers.

D = Average stage length in miles.
M = Millions

ALTERNATIVES VII, VIII, AND IX

The last three alternatives combine the CTOL/STOL and VTOL modes with each of the new high-speed ground modes, as well as the conventional air and bus modes. In alternative VII, the HSRA mode was sized to meet the same competition it faced in alternative III augmented by the VTOL service. In alternative VIII, the HSRC mode takes the place of any other rail system and the economic equilibrium solution of service levels (on HSRC, VTOL, and STOL) was repeated in the NECTP model. Finally, in alternative IX the TACV mode replaced HSRC and was modeled in the same environment.

In addition to the prior nine alternatives, an analysis was made of 10 levels of rail improvement which could be added to plant and equipment, starting from alternative II and ending with alternative III. The descriptions of the interim rail improvements are presented in Technical Appendix 5.

TECHNICAL APPENDIX 5

EXPLORATORY STUDIES & SENSITIVITY TESTS

The results of the record runs for nine alternatives were presented in Chapter 1. In addition to providing insight into the possibilities for new transportation systems, the record runs quite properly raise a variety of questions. The modal configurations in the alternatives were intended to be good representatives of the technologies, but they are not necessarily best. Their design required many arbitrary decisions which are subject to reconsideration. The record runs thus served as starting points for a continuing set of exploratory studies, concerning both the sensitivity of the record runs to the arbitrary decisions made, and potential improvements in the initial configurations.

In this Appendix, the results of several such studies are presented. Not all the explorations used the full model system; in several cases only the individual ground or air supply models were exercised as required for the particular problem. And, as with the record runs, the explorations raised still more questions. The exercise of a model system is a continuing process, increasing in usefulness as the questions become more specific.

SECOND-ORDER ALTERNATIVES STUDY

The focus of this report has been on describing nine alternative transportation systems which could be adopted for Northeast Corridor operation in the 1975-80 period. However, because the future of inter-city rail passenger transportation in the Northeast Corridor poses major policy questions today, the Project staff decided to increase and refine the number of alternatives which rely on the existing Corridor rail facilities. Starting with system alternative II, which includes the demonstration level of rail passenger service, we have added 10 second-order alternative levels of improvement of rail plant and equipment. These 10 second-order alternatives are intended to be representative of perceptibly different levels of service, each of which could be adopted independently of the others although each succeeding alternative builds on the preceeding one. The last improvement would bring the rail mode up to the level of HSRA in alternative III. Each second-order alternative is evaluated in terms of user benefits, as measured by additional operator revenues, and in terms of operator costs, as measured by the additional costs of providing additional services.

The capital expenditures included in this analysis are for a fleet of Metroliner-type trains and for improvements to the track and roadway. Costs do not include payments to the Penn Central Railroad for any land or facilities that are already used for railroad operations.

The operating costs apply only to the intercity passenger service in the Corridor. They include all crew, energy, servicing, and maintenance expenses associated with the operation of these trains as well as passenger-handling costs such as ticketing, baggage-handling, food service, etc.

The revenues discussed here represent only the revenues from the operation of intercity passenger trains. Revenues received by the railroad from commuter and freight services were not included in the analysis.

Although much information has been obtained from the Penn Central Railroad, the design of the alternatives discussed here and their potential revenues and costs have not been reviewed with Penn Central officials.

Methodology

The second-order alternatives were delineated by starting with the existing rail system between Washington and Boston and then defining what the system would look like if it received maximum feasible improvement. This produced the HSRA mode of alternative III with sustained top speed of 150 mph and a 4 1/4 hour running time.

The second step was to determine the work to be done on the existing Penn Central line to attain the HSRA system. This entailed examining in some detail the present layout to locate where new tracks and interlockings would be required; where curves would have to be realigned; where grade crossings would need to be eliminated; etc. The cost of each individual work project was calculated, as well as the running-time reduction, if any, that might be attributable to that project. To reduce the projects to a workable number, all projects of a similar nature within each of the eight links between Washington and Boston (see Table T5-1) were aggregated and treated as a single project. This resulted in 26 separate improvement projects whose running time savings are independent of the time savings on any other project; i.e., the projects are not interdependent.

The third stop in the analysis was to rank the projects according to passenger-minutes saved per dollar of expenditure. Passenger-minutes saved were calculated by multiplying the running-time saving of each project by the number of passengers traveling over the link in which the project was located. Link passenger loadings for 1975 were estimated by the NEC assignment model, on the basis of alternative II results for DEMO service. These loadings are shown in Table T5-1.

TABLE T5-1 DAILY TWO-WAY PASSENGER LOADINGS BEFORE IMPROVEMENTS

Link No.		LINK LOADINGS
1	Washington-Baltimore	8,036
2	Baltimore-Philadelphia	8,455
3	Philadelphia-Trenton	14,485
4	Trenton-Metropark	17,101
5	Metropark-New York	13,082
6	New York-New Haven	6,200
7	New Haven-Providence	2,816
8	Providence-Boston	2,805

Table T5-2 shows the ranking of the 26 projects in descending order by passenger-minutes per dollar. This table was the basis for the selection of projects to be considered in a given level of improvement. In the fourth step of the analysis, nine intermediate levels of improvement between full demonstration (DEMO) and HSRA were arbitrarily selected for purposes of comparison and evaluation. Table T5-3 shows the improvement levels and the projects involved in each. Also shown are the associated running-time savings, and cost for construction and land.

TABLE T5-2 IMPROVEMENT PROJECTS: WASHINGTON-BOSTON

Project No.	Link	Project	Cost (million dollars)	Time savings (minutes)	Passenger-minutes saved daily (thousands)	Passenger-minutes per day per thousand dollars
1	4	General roadway improvements*	16.0	9.9	169.3	10.58
2	3	General roadway improvements	17.3	7.9	114.4	6.73
3	2	Grade crossings & general roadway improvements	45.4	10.7	90.3	2.01
4	5	Curves	15.8	2.2	28.8	1.80
5	8	Grade crossings & general roadway improvements	13.8	7.1	19.9	1.42
6	8	Curves	7.2	3.3	9.3	1.32
7	6	General roadway improvements	73.2	11.7	72.5	0.99
8	5	Hackensack River Bridge	14.9	1.0	13.1	0.87
9	3	Curves	52.0	3.1	44.9	0.86
10	2	Bush & Susquehanna River bridges	36.8	3.0	25.4	0.69
11	1	Curves	36.0	3.0	24.1	0.67
12	5	General roadway improvements	16.1	0.8	10.5	0.65
13	7	Grade crossings & general roadway improvements	68.4	16.0	45.1	0.65
14	1	Grade crossings & general roadway improvements	31.2	2.5	20.1	0.65
15	1 & 2	Baltimore Tunnel	102.6	7.0	57.7	0.56

(continued)

TABLE T5-2 (continued)

Project No.	Link	Project	Cost (million dollars	Time savings (minutes)	Passenger-minutes saved daily (thousands)	Passenger-minutes per day per thousand dollars
16	8	Providence Tunnel	7.5	1.5	4.2	0.53
17	4	Curves	37.0	1.1	18.8	0.51
18	2	Curves	100.5	5.8	49.0	0.45
19	7 & 8	Electrification	25.0	4.0	11.2	0.45
20	7	Curves	121.4	13.4	37.7	0.31
21	6	Bridgeport by-pass	60.0	2.5	15.5	0.26
22	6	Curves	298.2	11.8	73.2	0.25
23	7	New London by-pass	90.0	7.1	20.0	0.22
24	7	New Haven by-pass	46.8	3.5	9.9	0.21
25	8	Midland Branch rehabilitation	50.8	2.6	7.3	0.14
26	7	Old Saybrook by-pass	27.5	0.5	1.4	0.05

*"General roadway improvements" includes laying of welded rail and general track work; revisions to signal, catenary, and electric power systems; new communication equipment; fences; etc.

TABLE 5-3 SECOND-ORDER IMPROVEMENT LEVELS

Improvement Level	Last Project Included*	Minutes Saved	Construction Costs (including stations) $ Millions	Land Cost $ Millions
II	-	0	0.0	0.0
II-1	4	31	104.5	3.8
II-2	7	53	180.3	29.4
II-3	9	57	225.2	56.8
II-4	12	64	316.1	62.4
II-5	14	82	424.6	62.4
II-6	17	92	576.7	69.0
II-7	19	102	689.2	92.0
II-8	21	118	874.2	101.8
II-9	22	129	1083.4	213.8
III	26	143	1314.6	213.8

* Each improvement level includes all projects shown in Table T5-2 up to and including the project shown in this column.

In addition to the cost of improvements in Table T5-2, Table T5-3 includes additional capital costs to which no time savings could be directly attributed, but which would be necessary expenditures for improved service. These costs were allocated to each improvement level on a proportional basis. A summary of these costs is shown in Table T5-4.

TABLE T5-4 COSTS TO WHICH NO TIME SAVINGS WERE ATTRIBUTED

	$Millions
Research & Development	30.0
Stations	
Washington	*
Lanham (Washington Beltway)	5.0
Baltimore	19.0
Philadelphia	2.0
Trenton	9.7
Metropark	10.7
New York	5.0
New Haven	10.0
Providence	9.1
Route 128	5.4
Boston	9.1
Yards and Shops	2.0

*Washington Union Terminal is being converted into the National Capital Visitors' Center, and rehabilitation is being funded by the Federal Government.

Vehicle unit costs were assumed to be constant and independent of fleet size. An A-car with rounded nose and control cab was estimated to cost $480,000; an intermediate B-car, $430,000. Electrification of the line from New Haven to Boston (project 19) would occur only in improvement levels II-7 and above. For levels below II-7, passengers would change trains at New Haven. It was assumed that a separate set of turbine-powered vehicles, whose cost per seat would be approximately the same as for electric-powered vehicles, would be required for the region north of New Haven; and that it would take four minutes for passengers to change trains in New Haven.

Unit operating costs for the service offered at all levels of improvement are the same as those determined for the HSRA system, and are summarized in Table T5-5.

TABLE T5-5 UNIT OPERATING COSTS

Energy	4¢ /car mile
Crew	90¢ /train mile
Track Maintenance (allocated)	4¢ /car mile
Vehicle Maintenance	33¢ /car mile
Power and Control Systems Maintenance	$3.15 million per year
Indirect Operating Cost	1.7¢ /passenger mile

The fifth step of the analysis was to run the Northeast Corridor model system for each of the improvement levels. The objective function selected for this series of runs was maximization of net additional revenue. Fleet size, train size, and train frequency were permitted to vary according to the traffic generated by the demand model. The link running times associated with each improvement level, as well as the demonstration level in alternative II, are shown in Table T5-6.

TABLE T5-6 LINK BLOCK TIMES IN MINUTES

	IMPROVEMENT LEVELS										
LINK	II	II-1	II-2	II-3	II-4	II-5	II-6	II-7	II-8	II-9	III
1*	32	32	32	32	29	27	23	23	23	23	23
2	65	54	54	54	51	51	48	42	42	42	42
3	29	21	21	18	18	18	18	18	18	18	18
4	27	17	17	17	17	17	16	16	16	16	16
5	21	19	19	18	17	17	17	17	17	17	17
6	71	71	59	59	59	59	59	59	57	45	45
7	96	96	96	96	96	80	80	78	64	64	53
8*	43	43	33	33	33	33	31	30	30	30	27
	384	353	331	327	320	302	292	283	267	255	241

* Times for Links 1 and 8 include station stops at Capital Beltway and Route 128, respectively.

Results

The evaluation revealed that net revenues would be greatest with a fleet made up entirely of Metroliner-type equipment and a relatively small amount of right-of-way improvements. The revenues resulting from additional roadway improvements were offset by increased operating costs. Annual capital costs also increased; therefore, net revenues fell as more money was spent on improvements. The break-even point occurred at the $1.3 billion level. Losses appeared and increased as further improvements were made.

The results of the model runs are summarized in Table T5-7 which shows vehicle costs, total cost of improvements, annual operating costs, annual gross revenues, and annual surplus or deficit. The total cost of improvements includes the construction and land costs from Table T5-3 plus vehicle costs. All annual costs are for 1975.

Figure T5-1 shows that for the most part there is a linear relationship between costs of improvements and net revenues (or deficits). Each succeeding improvement is accompanied by a decrease in net revenues amounting to approximately 10 percent of the costs of the improvement. Gross revenues offset direct and indirect operating costs at higher levels of improvement. At the same time, the capital charge continues to grow at a rate of 10 percent of the total cost of improvement, resulting in the nearly constant slope of the net revenue line in Figure T5-1.

Because the first few projects, representing moderate expenditures, result in rather substantial time savings and increased demand, net revenue actually increased for the initial roadbed improvements. However, the time savings per investment dollar are much lower after the first several projects; as a result, increases in operating costs tend to counter additional revenue resulting from increased demand that occurs at the higher levels of improvement.

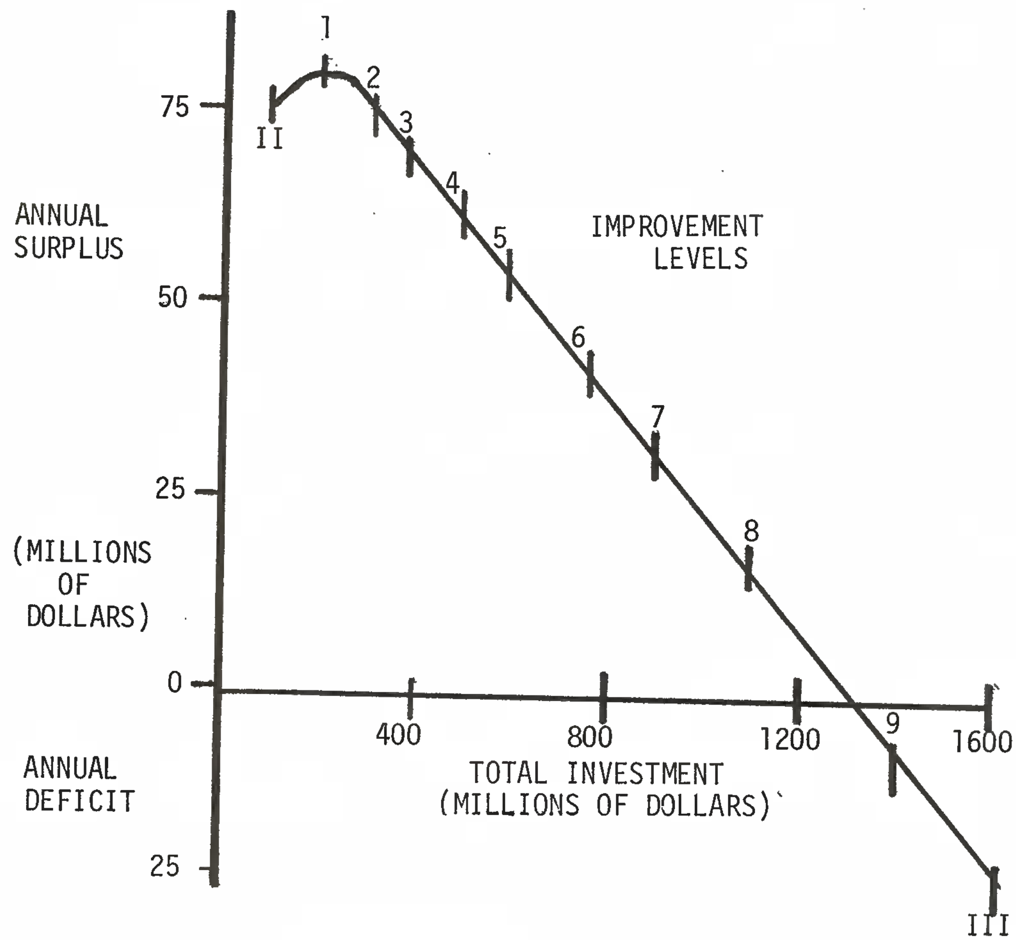
On Figure T5-1, the crossover point from surplus to deficit occurs near improvement level II-9, representing a total investment of about $1.3 billion. All work south of New York has been included at this level resulting in a quality of service equivalent to that of HSRA over the New York-Washington part of the line. Level II-9, does not include some of the more expensive curve realignments or by-passes north of New York. The highest benefits per dollar invested tended to occur south of New York because of the higher patronage levels on that portion of the route.

TABLE T5-7 COSTS AND REVENUES AT VARIOUS LEVELS OF IMPROVEMENT

Improvement Level	Vehicle Cost $Millions	Total Cost of Improvements $Millions	Total Annual Costs $Millions	Annual Gross Revenues $Millions	Annual Surplus (deficit) $Millions
II	70.0	70.0	61.7	136.5	74.9
II-1	78.2	186.5	80.0	160.4	80.4
II-2	78.2	287.9	91.8	166.8	75.0
II-3	78.2	360.2	99.9	171.0	71.7
II-4	88.1	466.6	115.2	176.2	61.0
II-5	84.4	571.4	127.4	181.3	53.9
II-6	84.4	730.1	145.7	187.8	42.1
II-7	80.4	861.6	160.7	194.4	33.7
II-8	76.1	1052.2	180.1	198.9	18.8
II-9	72.5	1369.7	211.4	205.7	-5.7
III	76.1	1604.5	238.4	211.6	-26.8

FIGURE T5-1

NET REVENUE RESULTS OF RAIL IMPROVEMENTS



The initial levels of improvement brought about large percentage increases in patronage which required larger fleets. As running times continued to fall due to improvements, equipment utilization rose; fleet requirements also increased initially, but then declined over the range of improvements.

Improvement level II-1, which yields the largest surplus, represents a total expenditure of $186 million ($104 million for fixed plant, $4 million for land, and $78 million for vehicles) and provides a running time of approximately 6 1/2 hours from Washington to Boston (3 hours Washington-New York and 3 1/2 hours New York-Boston). Annual gross revenues amount to $160 million, and total costs including interest on investment are $80 million.

At improvement level II-6, which represents about half of the total possible investment, revenues exceed costs by $42.1 million. This level represents a total investment of $730 million ($577 million for fixed plant, $69 million for land, and $84 million for vehicles) and provides a running time of approximately 4 3/4 hours between Washington and Boston (2 hours Washington-New York and 2 3/4 hours New York-Boston).

Finally, the HSRA mode, in alternative III, generates $212 million in annual gross revenues while its total annual costs amount to $238 million, resulting in an annual deficit in 1975 of $26 million. Total investment required would be $1.6 billion ($1.3 billion for fixed plant, $214 million for land, and $76 million for vehicles), and would provide a 4 1/4 hour running time between Washington and Boston (2 hours Washington-New York and 2 1/4 hours New York-Boston).

Limitations of the Evaluation

The base year for this evaluation has been 1975. Calculations of annual revenue and annual costs for the second-order alternatives have been estimated for that year in order to make the evaluation comparable to the evaluation of the major alternatives.

Using a constant fare for all levels of service is, to some extent, a shortcoming of this analysis. If additional analyses were to be performed, it would be desirable to examine the effect of increasing fares with improvements in service. Under those circumstances the surplus in the lower levels of improvement would be somewhat higher and deficits in II-9 and III would be somewhat less.

Because the direct and indirect cost equations were developed for the full HSRA level, and, as a result, are linear by passenger-mile or train-mile, there is an artificial linearity in the results. Improved cost-estimating relationships should be developed.

HSGT FARE POLICY SENSITIVITY

Revenues for all HSGT modes were calculated assuming a fare policy with a fixed element of $1.50 in each fare and $.075 per mile for each link-mile. Additional experimentation was performed with variations in the fixed and variable elements of the fare. These experiments were carried out for alternatives VII, VIII and IX. The results of the variations in fare policy are summarized in Tables T5-8 to T5-10 for HSRA, HSRC, and TACV, respectively.

The pricing variations were 0, $1.50, $3.00, and $5.00 for the fixed element and $.05, $.075, $.10 and $.12 for the variable element. (The demand model can probably handle this relatively narrow range of variation without change in the equations.) Generally, it can be observed from these data that, as the overall average fare increased, total revenue increased (demand inelasticity with respect to price), but, except for the lowest and highest prices considered, total revenue tended to change by small increments. Also, patronage decreased with increasing fare so that cost per passenger mile increased. This had the effect of increasing net revenues, but also resulted in less economic efficiency as unit costs rose. All in all, variations in fare policy might redistribute traffic; the explorations indicate, however, that no realistic fare policy would substantially affect the viability of the ground modes.

TABLE T5-8 HSRA Fare Policy Variation for Alternative VII

Ticket Policy: Fixed Portion ($)	Ticket Policy: Mileage Related (¢)	Annual Revenue (Millions of dollars)	Revenue Per Pass. Mile (¢)	Cost Per Passenger Mile (¢)	Ratio: Revenue To Cost (%)
0	5.0	120.6	5.0	9.99	50.0
0	7.5	133.2	7.5	12.43	60.3
0	10.0	141.3	10.0	14.69	68.1
0	12.0	146.6	12.0	16.78	71.5
1.50	5.0	128.2	6.24	11.15	56.0
1.50	7.5	138.9	8.77	13.50	65.0
1.50	10.0	145.9	11.30	15.97	70.8
1.50	12.0	149.6	13.31	17.77	74.9
3.00	5.0	135.2	7.40	12.05	61.4
3.00	7.5	142.9	9.98	14.63	68.2
3.00	10.0	148.9	12.53	17.18	72.9
5.00	5.0	141.5	8.89	13.35	66.6
5.00	7.5	147.8	11.51	16.04	71.8

TABLE T5-9 HSRC Fare Policy Variation for Alternative VIII

Ticket Policy: Fixed Portion ($)	Ticket Policy: Mileage Related (¢)	Annual Revenue (millions of dollars)	Revenue Per Pass. Mile (¢)	Cost Per Passenger Mile (¢)	Ratio Revenue to Cost (%)
0	5.0	171.9	5.0	10.54	47.4
0	7.5	171.9	7.5	10.54	71.2
0	10.0	202.3	10.0	16.05	62.3
0	12.0	190.6	12.0	13.34	90.0
1.50	5.0	183.9	6.16	11.71	52.6
1.50	7.5	198.2	8.69	14.43	60.2
1.50	10.0	207.4	11.22	17.11	65.6
1.50	12.0	213.0	13.23	19.49	67.9
3.00	5.0	192.3	7.26	12.85	56.5
3.00	7.5	203.8	9.83	15.68	62.7
3.00	10.0	211.5	12.37	18.35	67.4
5.00	5.0	200.5	8.67	14.37	60.3
5.00	7.5	209.6	11.29	17.30	65.3

TABLE T5-10 TACV Fare Policy Variations for Alternative IX

Ticket Policy Fixed Portion	Ticket Policy Mileage Related	Annual Revenue (millions of dollars)	Revenue Per Pass. Mile (¢)	Cost Per Passenger Mile (¢)	Ratio: Revenue to Cost (%)
0	5.0	208.1	5.0	11.04	45.3
0	7.5	230.9	7.5	14.08	53.3
0	10.0	245.0	10.0	17.01	58.8
0	12.0	253.0	12.0	19.55	61.4
1.50	5.0	222.3	6.12	12.41	49.3
1.50	7.5	239.8	8.65	15.61	55.4
1.50	10.0	251.1	11.17	18.46	60.5
1.50	12.0	257.6	13.19	20.72	63.7
3.00	5.0	232.3	7.18	13.45	53.4
3.00	7.5	246.4	9.75	16.52	59.0
3.00	10.0	255.8	12.29	19.54	62.9
5.00	5.0	242.3	8.54	15.21	56.1
5.00	7.5	253.1	11.15	18.23	61.2

INTEREST RATE SENSITIVITY

The costs of capital, particularly in the case of the fixed plant investment, significantly influence annual system costs and, therefore, the level of profitability that can be achieved by any of the modes. The sensitivity of profit levels for HSGT modes to variations in interest rates was examined. The analyses varied the rate of return on investments in the three general categories--fixed plant, land, and vehicles. The results, shown in Table T5-11, indicate that, if means could be devised to lower the cost of capital to a rate of approximately six percent, all of the high speed ground modes would move into profit situations.

TABLE T5-11 PROFIT (OR DEFICIT) OF GROUND MODES RESULTING FROM CHANGES IN REQUIRED RATE OF RETURN (IN MILLIONS OF DOLLARS)

Interest Rate Plant-Land-Vehicles	Alternative III	Alternative IV	Alternative V
10-8-10	(27)	(68)	(103)
9-8-9	(16.0)	(48)	(73)
8-8-8	(5.0)	(29)	(43)
7-7-7	+8	(10)	(13)
6-6-6	+20	+9	+17
5-5-5	+32	+28	+47

ACCESS/EGRESS TIME VARIATIONS

Door-to-door trip time is the most important single transportation service characteristic affecting both total demand and modal split. The preceeding analyses have shown that access/egress is a major factor of door-to-door time. For example, the TACV terminal-to-terminal time for a trip between Washington and Baltimore is 16 minutes while the average access/egress time for those two superdistricts is 56 minutes. Washington-Baltimore is an extreme case, but it is generally true that relatively small percentage changes in access/egress times can have disproportionately large effects on door-to-door trip times and hence on patronage. The elasticity of demand with respect to time is such that a one percent decrease in time could yield a two percent increase in patronage.

Of particular interest is the possible impact of access/egress time changes on the cost-revenue relationships of the HSGT modes. A series of runs was made, using the ground modes supply model, in which access/egress times were systematically varied for all modes at all terminals. (The variations were made about the empirically determined access/egress times.)

Figure T5-2 plots the costs, revenues and deficits for HSRA, HSRC, and TACV resulting from the variations of access/egress time. In each case the decrease of deficit with decrease in access/egress time is evident. However, even crude extrapolation of the deficit plots of Figure T5-2 indicates that a cost-revenue breakeven would only be reached if access/egress time were cut to less than half the values estimated for the alternative runs.

It is true that any increase in urban travel speed would be reflected in HSGT access time and patronage. However, halving the HSGT access time would require average urban speeds of 40 to 50 mph along routes to the terminals. Since the average inter-urban speed for the auto mode is only about 46 mph, the achievement of equivalent speeds within the cities appears unlikely.

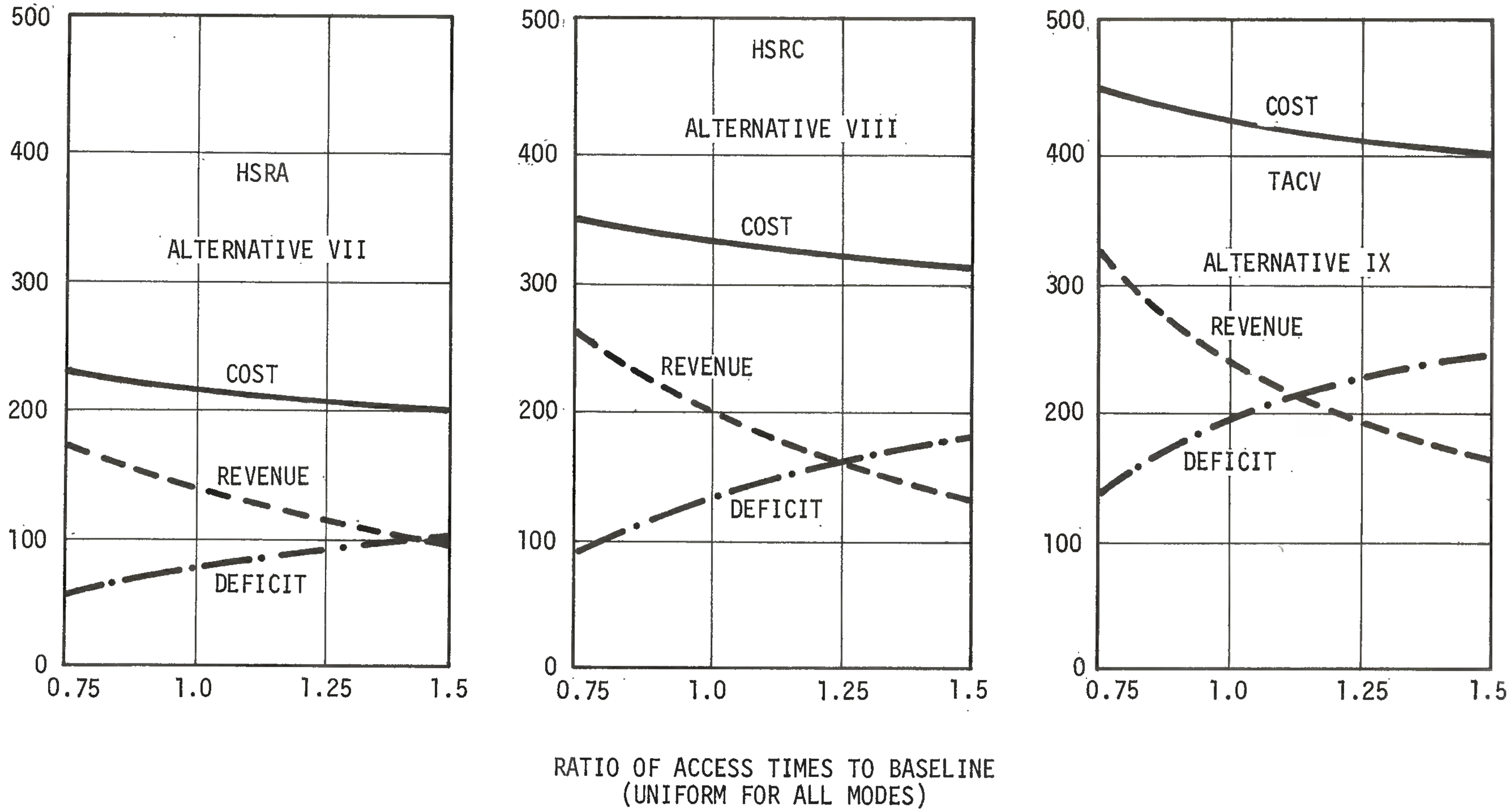


FIGURE T5-2

EFFECTS OF VARIATIONS IN ACCESS TIME ON COSTS AND REVENUES

PROJECTIONS OF HSGT COST-REVENUE THROUGH 1995

Analysis of the 1975 alternatives indicates that none of the HSGT modes--HSRA, HSRC, or TACV--is likely to have unadjusted revenues large enough to support itself in that year. Neither the limited variations in service nor the fare policies investigated by the runs can bring revenue up to cover costs of the large capital expenditures of the HSGT. A sharp decline in interest rates might lower costs, or a major decrease in urban access times might raise demand, to give a cost-revenue balance; however, neither appears to be a strong possibility in the immediate future. The effects on HSGT modes of the more precictable growth over time of population in the Corridor has been examined.

Three series of runs were made with alternatives VII, VIII, and IX as starting points and substituting population projections for 1980, 85, 90, and 95 for the 1975 data. Only the ground modes supply model was exercised for these runs i.e., schedules, costs, and frequencies were allowed to vary. VTOL and C/STOL, as well as auto and bus, were held non-reactive throughout at the 1975 service levels. Figure T5-3 plots the resulting estimates of cost and revenue for all three modes out to the breakeven intersection point.

The area of the triangle formed between the cost and revenue lines is a crude estimate of the aggregate deficit up to the breakeven point. For the three modes the total deficit would be:

HSRA ------ 355 million
HSRC ------ 810 million
TACV ------ 1180 million

It appears that all of the high speed ground modes would be self-supporting in the 1990's. The second order alternative investigations have indicated that a breakeven operating point in 1975 exists at a level of investment between DEMO and HSRA. The projection through 1995 suggests that a series of breakeven points with increasing investment in each year could be found to progress from DEMO to HSRA in 1990. Because the progression from DEMO to HSRA begins with an operating mode, the investments in service improvement may be controlled to keep capital costs compatible with revenues from expanding demand.

HSRC and TACV would require large initial capital expenditures for new rights-of-way and extensive guideway construction. The present high interest rates and the late breakeven dates combine to make postponement of large expenditures for HSRC or TACV attractive.

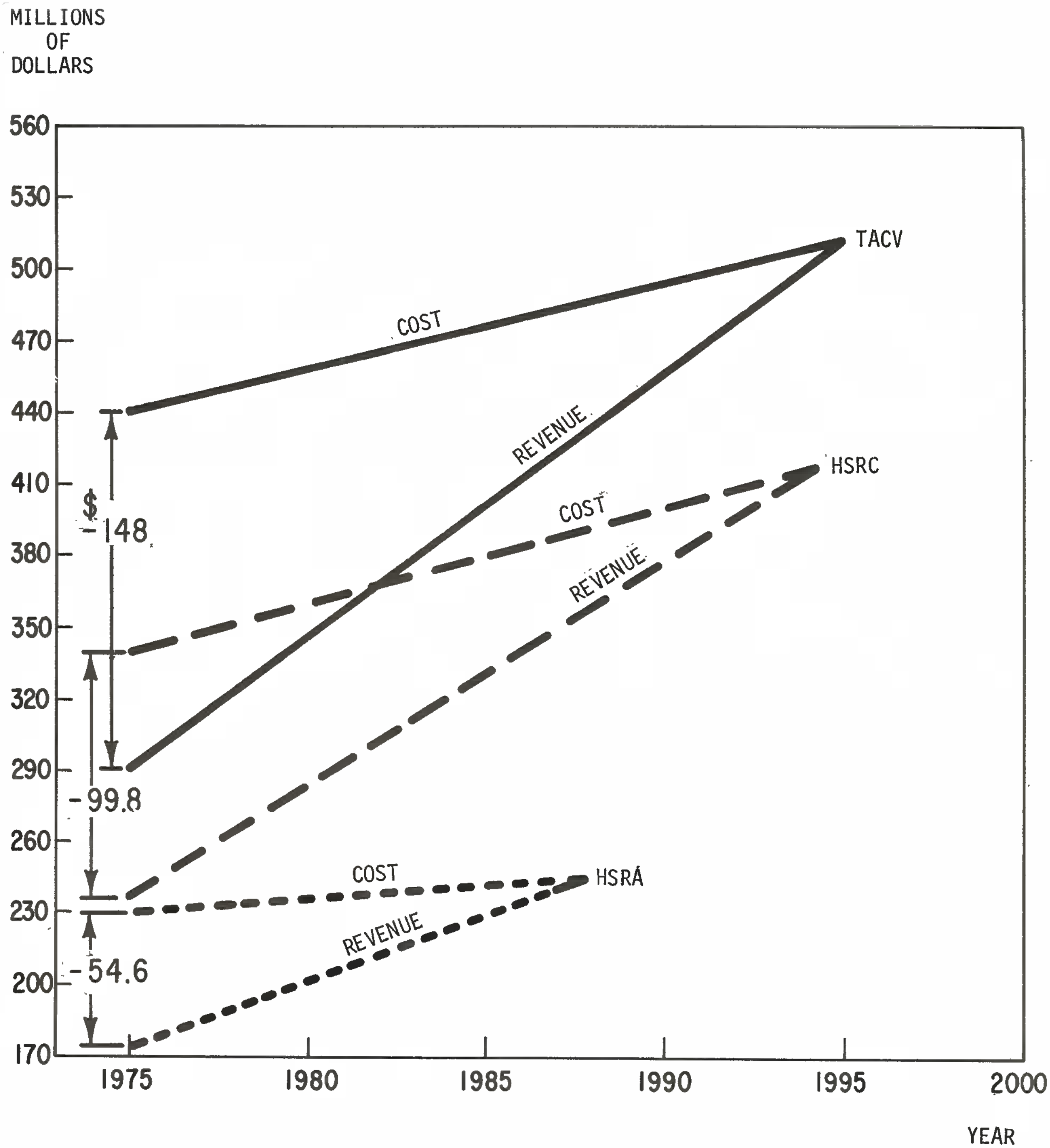


FIGURE T5-3

HSGT COST-REVENUE PROJECTION
(ALTERNATIVES VII, VIII AND IX)

Consideration of a delayed start on HSRC or TACV, however, raises serious problems because of the peculiar requirements for HSGT right-of-way. The need for extreme smoothness and straightness for the guideway places severe restrictions on the freedom of HSGT to detour obstructions. With the rapid urbanization of the Northeast Corridor, any delay in start of HSGT construction will increase the number and extent of man-made obstructions to be tunneled under or demolished.

If any HSGT mode is contemplated even twenty or more years in the future, long term planning for the right-of-way should begin now. Merely to acquire right-of-way now in order to preserve it for later HSGT use could involve major opportunity costs of the idle land. Rather, coordinated regional efforts should be made to control or influence the use of land along a prospective right-of-way to provide for productive use but to avoid development which will entail future high costs of demolition. A necessary first step may be the development of such long-range land-use control mechanisms.

STOL ROUTING EXPERIMENTS

The discussions of alternative VI noted that the STOL route structure was drastically reduced from its routes in the previous alternatives II through V. This route reduction resulted from a series of explorations which began with the observation that the STOL vehicle utilization* was very poor in alternatives also containing VTOL. The following brief discussion of these STOL explorations will highlight the tradeoffs available in a flexible system like STOL and will illustrate the continuing use of the model system.

The desired utilization for the STOL vehicle is 2500 hours a year, a value which vehicle maintenance requirements readily permit. In alternative II, utilization was only 1900 hours per year; utilization dropped to almost 1400 hours in alternative VII. Schedules requiring a large fleet to service peakloads accounted for the low utilization rate,** since large fleet sizes resulted in unused capacity over the remainder of the day. A very large number of links are served only once each way per day. These are all peak-period flights and require nearly simultaneous service on many dispersed links to provide connective travel through the network. During the remainder of the day, demand between pairs not enjoying non-stop service follows multileg paths.

One attack on the problem of STOL vehicle utilization was to prohibit directly once-per-day service by inserting a "threshold" in the routing portion of the air-mode supply model. No non-stop flights could be scheduled by the simulation between a city pair unless demand was high enough to require the "threshold" (2, 3, 4,...etc.) number of flights. The results were (1) to force re-routing of low patronage links over multi-leg paths even in peak periods; (2) to decrease fleet size and (3) to improve aircraft utilization. In the process, some pairs whose demand could not be rerouted lost service entirely.

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*As applied here, "utilization" refers to passenger carrying time and is computed as the sum of the scheduled block time hours.

**NEC air traffic is strongly peaked in late afternoon-early evening. The short business trip dominates the market and takes the form of the same-day round trip (depart morning, return evening) or overnight round trip (depart evening, return following evening). Many weekend non-business trips take the evening-evening form (Friday depart, Sunday return). The result is a concentration in afternoon-evening demand, about 60% of the daily total being between noon and 7 pm.

Computations of utilization are made in the air operator's supply model after the route-reduction and scheduling programs have established fleet-size requirements. The iterative procedure assumes, to start, that patronage will not be lost in the rerouting of passengers to indirect paths. In successive iterations, the simulation took account of the poorer service and drove supply-demand to a new convergence; losing in the process those passengers who could not be rerouted.

The initial estimates of the threshold effects are plotted in Figure T5-4. Expected utilization rose steadily to 2300 hours per year at a threshold of five, while patronage loss increased slowly to about six percent. For the threshold of five, a full iteration to equilibrium was then performed to find the true patronage loss. At equilibrium, patronage was down twelve percent rather than the expected six. Furthermore, the vehicle utilization on this smaller patronage base was only 2050 hours rather than the expected 2500. The equilibrium network was very "spinal" with suburban terminals linked only to the largest market area terminal and suburban-to-suburban flights between market areas almost eliminated.

The inference to be drawn from the results obtained is that improvements in vehicle utilization can be made by imposition of a threshold, but the prospective gain in utilization is limited by reductions in frequency and loss of patronage.

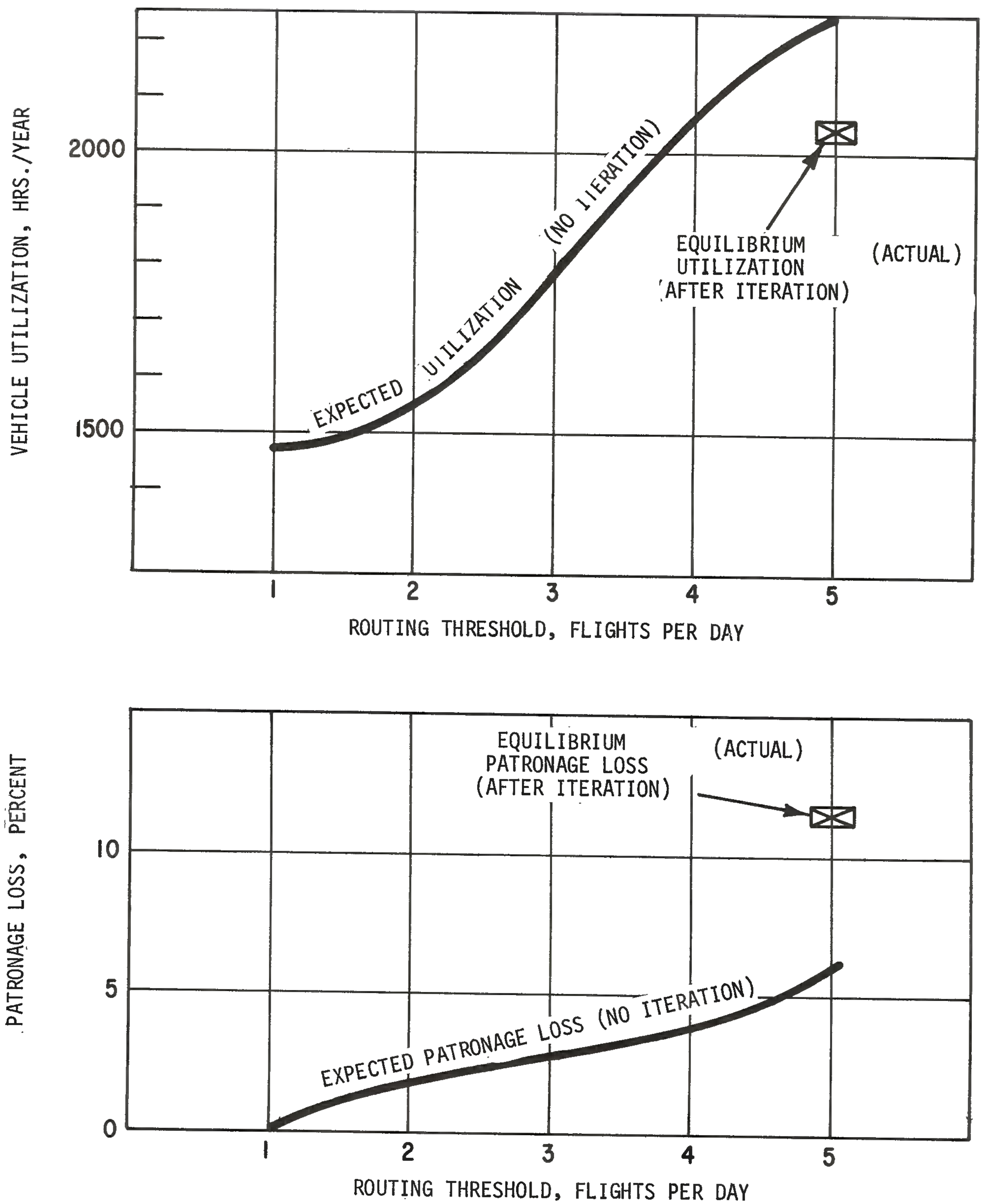

FIGURE T5-4

STOL THRESHOLD EFFECTS FOR INDIVIDUAL CITY PAIRS E ESTIMATES OF IMPROVED UTILIZATION AND PATRONAGE LOSSES.

STOL VEHICLE SIZE EXPLORATION

The real difficulty with STOL in alternative VII is not with the short-take-off-and-landing or the dispersed-terminal concepts, but with the size of the vehicle. Many of the O-D pairs in 1975 do not have total daily patronage large enough to allow good utilization of a 122 passenger aircraft. Similarly, the success of VTOL is not due entirely to the vertical-take-off-and-landing capability, but partly to the better fit of its 86-passenger vehicle to the market.* As an exploration of still smaller vehicles, the De Havilland DHC-7, a 48-passenger STOL aircraft also described in the CAB investigation, was substituted for the McDonnell-Douglas 210-G.

The change of STOL vehicles required re-estimation of many of the supply model equations. For comparison with the 122-passenger vhicle, the DHC-7 was substituted directly in the STOL network of alternative VII. The results are shown in Table T5-12.

The 48-passenger STOL provides a much better fit to the dispersed market than the 122-passenger vehicle. Utilization, revenue, passenger miles and patronage are all improved from alternative VII. The shorter trip distance is indicative of the DHC-7's better fit to the short haul market. The aircraft is more expensive per passenger to operate, as evidenced by the higher variable costs, but the demand increase spreads the fixed costs over a larger base and results in lower per-passenger costs. The improved flight frequency is one reason for the STOL patronage increase; a second reason is the shorter average trip times on many routes caused by more non-stop service.

VTOL is virtually unchanged between the two runs shown on Table T5-12. The differences between the two columns is about equal to the normal "noise" at equilibrium in the iteration convergence process.

The success of the 48-passenger STOL is largely due to vehicle size and not to design. The DHC-7 is a good aircraft in terms of 1965-70 technology. An aircraft designed for 1975-80 might be better in many respects but still would be effective only if it were sized to its market. The 122-passenger vehicle was sized to large-city markets.

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*Vehicle types were based on manufacturers' submissions to the CAB Northeast Corridor VTOL Investigation, Docket 19078, December, 1968, and were entered as given in the supply models.

TABLE T5-12 STOL VEHICLE SIZE EXPLORATION

		Alternative VII	Smaller STOL Exploration
STOL	Vehicle Capacity	122	48
	Superdistricts	21	21
	Fixed Fare, $	9.56	6.74
	Variable Fare, $	.0457	.0693
	Patronage/Day	36899	43139
	Passenger Miles/Day	5292862	5541636
	Average Trip Length, Miles	143	129
	Revenue/Day	556826	632730
	Utilization, Hours per Year	1417	2348
	Flights/Day	642	1496
VTOL	Vehicle Capacity	86	86
	Superdistricts	15	15
	Fixed Fare, $	4.36	4.36
	Variable Fare, $	.0638	.0636
	Patronage/Day	67466	67329
	Passenger Miles/Day	9077519	9058591
	Average Trip Length, Miles	135	136
	Revenue/Day	840216	844423
	Utilization, Hours per Year	2747	2796
	Flights/Day	1420	1426

Some general considerations relating to aircraft design apply to both STOL and VTOL. The demand forecasts are based on passenger acceptance of STOL or VTOL as being as safe, comfortable, and reliable as the present CTOL. The existence of the hypothesized terminals assumed community acceptance of the modes as good neighbors, a status which CTOL currently does not enjoy. In the development of future STOL or VTOl aircraft, attention needs to be concentrated on achieving both community and passenger acceptance.

In terms of safety and reliability, STOL and VTOL will need to solve the problems of all-weather air traffic control, both en route and in the terminal areas. The ability to fly very slowly or to hover increases the possibilities for precise aircraft location and control, but the capability for multi-aircraft all-weather control needs to be demonstrated.

For comfort, STOL and VTOL will need careful attention to onboard noise and vibration. Present jets are smooth and quiet internally and passenger acceptance of a return to propellers is doubtful if noise and vibration go with it. A special STOL/VTOL problem is the air turbulence at the low altitudes contemplated for short-haul flight. Low wing loading aircraft, good for short take-off, are poor under turbulent conditions. A major drawback of the 1965-70 technology STOL may be in its low wing loading and lack of gust alleviation devices. A STOL which achieves short field capability and high wing loading in flight begins to utilize the VTOL technology.

In terms of community acceptance, STOL and VTOL must overcome the image of the roar and the smoke trails associated with present CTOL jets without going to the buzz of most light propeller-driven aircraft or the popping of present helicopters. The technology holds promise of reducing both noise and smoke from aircraft at a moderate performance/cost penalty. Terminal location and design also must be highly sensitive to intrusion into the environment. Many of the VTOL port sites in the NECTP alternatives were located in industrial or commercial areas with over-water aircraft approach paths. Actual sites will need far more careful investigation plus an extensive community relations program if they are to be accepted.

The costs of these public acceptance prerequisites are not fully included in the STOL and VTOL cost estimates used in the analyses of NECTP alternatives.

REGIONAL SOCIO-ECONOMIC IMPACT

Chapter 1 included a general discussion of results of the application of a regional impact model to measurement of the socio-economic effects of changing passenger transportation facilities. The impacts of two alternative transportation systems were compared. The first or reference case, was a modified version of alternative I (designated alternative I-A in which 1965 rail was used instead of 1975 DEMO). The second transportation system for which impact measures were obtained was alternative V, which was selected as representing the case of maximal impact short of the addition of VTOL aircraft. This appendix section presents detailed quantitative results of the impact comparison which were not included in Chapter 1.

The results of impact measurement for the 29 superdistricts comprising the core portion of the Corridor are presented in Table T5-13 and T5-14. Where the impacts of alternative V exceed those of alternative I-A, i.e., where the changed transport system's impact exceeds that of the unchanged system, the sign of the change is positive.

A tendency toward decentralization along the north-south axis is indicated in the tables. Superdistricts 10 through 19, at the center of the Corridor, exhibit relative declines in both population and employment as a result of the improved transportation system.* A similar trend can be seen in superdistricts 7 and 8 in the Philadelphia area. In contrast, superdistricts 1 through 6, at the southern end of the Corridor, and superdistricts 20 through 29, from New Haven to Boston, show increases in employment and population resulting from the improved transportation system.

The magnitudes of employment changes for superdistricts are relatively small when looked at individually. However, a clear pattern of shifting distribution of employment is evidenced as those superdistricts in the center of the Corridor, i.e., New York and Newark, decline in their share of employment, while those farther away from the center gain in employment. The gain in employment tends to increase as distance from the center increases.

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*The unusually large declines in population predicted for the St. George superdistrict (Number 13) for 1990 are probably artifacts of the model resulting from the predicted generalized decline in the population concentration around New York City area as improved commuting from more distant places would become feasible. The mechanisms by which these decrements are allocated probably overpenalized the relatively small population of Staten Island (the St. George superdistrict).

TABLE T5-13 CHANGES IN LOCATION OF EMPLOYMENT AND POPULATION WITHIN THE CORE BY SUPERDISTRICT RESULTING FROM INTRODUCTION OF ALTERNATIVE V, FOR THE YEAR 1980

Superdistrict	Employment (x 1,000)			Population (x 1,000)		
	Alt I-A	Alt V	% Diff*	Alt I-A	Alt V	% Diff*
1. Washington, D.C.	850	852	.24	3,717	3,782	1.75
2. Cambridge, Md.	227	228	.44	1,070	1,109	3.64
3. Baltimore, Md.	832	833	.12	2,950	2,977	.92
4. Wilmington, Del.	247	247	.00	891	907	1.80
5. Atlantic City, N.J.	232	233	.43	826	844	2.18
6. Upper Darby, Pa.	297	297	.00	1,168	1,173	.43
7. Philadelphia, Pa.	947	946	-.11	1,795	1,793	-.11
8. Camden, N.J.	333	333	.00	1,365	1,361	-.29
9. Abington, Pa.	360	361	.28	1,231	1,244	1.06
10. Trenton, N.J.	142	142	.00	426	423	-.70
11. Woodbridge, N.J.	464	464	.00	1,740	1,726	-.80
12. Newark, N. J.	877	875	-.23	2,380	2,313	-2.82
13. St. George, N.Y.	112	111	-.89	436	399	-8.49
14. Brooklyn, N.Y.	1,481	1,480	-.07	4,311	4,276	-.81
15. Levittown, N.Y.	633	632	-.16	2,467	2,417	-2.03
16. Jersey City, N.J.	820	818	-.24	2,282	2,199	-3.64
17. New York, N.Y.	2,128	2,128	.00	2,502	2,490	-.48
18. Yonkers, N.Y.	591	589	-.34	2,016	1,933	-4.12
19. Norwalk, Conn.	310	310	.00	760	752	-1.05
20. New Haven, Conn.	308	308	.00	744	749	.67
21. Norwich, Conn.	254	255	.39	922	972	5.42
22. Providence, R.I.	443	444	.23	1,461	1,506	3.08
23. Fall River, Mass.	276	276	.00	777	797	2.57
24. Hyannis, Mass.	41	42	2.44	276	288	4.35
25. Torrington, Conn.	87	87	.00	466	474	1.72
26. Hartford, Conn.	374	374	.00	612	615	.49
27. Springfield, Mass.	386	386	.00	1,135	1,135	.00
28. Worcester, Mass.	263	263	.00	628	629	.16
29. Boston, Mass.	1,377	1,378	.07	3,270	3,323	1.62

* Per cent difference from alternative I-A to V

TABLE T5-14 CHANGES IN LOCATION OF EMPLOYMENT AND POPULATION WITHIN THE CORE BY SUPERDISTRICT RESULTING FROM INTRODUCTION OF ALTERNATIVE V, FOR THE YEAR 1990

Superdistrict	Employment (x 1,000)			Population (x 1,000)		
	Alt I-A	Alt V	% Diff*	Alt I-A	Alt V	% Diff*
1. Washington, D.C.	993	1,002	.91	4,237	4,379	3.35
2. Cambridge, Md.	337	345	2.37	1,750	1,892	8.11
3. Baltimore, Md.	943	945	.21	3,337	3,381	1.32
4. Wilmington, Del.	307	309	.65	1,114	1,147	2.96
5. Atlantic City, N.J.	295	298	1.02	1,022	1,061	3.82
6. Upper Darby, Pa.	352	352	.00	1,254	1,262	.64
7. Philadelphia, Pa.	920	919	-.11	1,699	1,682	-1.00
8. Camden, N.J.	416	415	-.24	1,619	1,596	-1.42
9. Abington, Pa.	418	419	.24	1,294	1,324	2.32
10. Trenton, N.J.	163	162	-.61	501	491	-2.00
11. Woodbridge, N.J.	577	574	-.52	2,017	2,051	-2.66
12. Newark, N.J.	957	949	-.84	2,507	2,366	-5.62
13. St. George, N.Y.	140	135	-3.57	550	445	-19.09
14. Brooklyn, N.Y.	1,560	1,557	-.19	4,019	3,970	-1.22
15. Levittown, N.Y.	722	716	.83	2,351	2,250	-4.30
16. Jersey City, N.J.	874	863	-1.26	2,276	2,080	-8.61
17. New York, N.Y.	1,918	1,916	-.10	2,428	2,394	-1.40
18. Yonkers, N.Y.	711	698	-1.83	2,334	2,114	-9.43
19. Norwalk, Conn.	329	327	-.61	723	698	-3.46
20. New Haven, Conn.	323	324	.31	683	695	1.76
21. Norwich, Conn.	333	340	2.10	1,198	1,329	10.93
22. Providence, R.I.	522	527	.96	1,758	1,854	5.46
23. Fall River, Mass.	304	307	.99	804	856	6.47
24. Hyannis, Mass.	67	69	2.99	475	502	5.68
25. Torrington, Conn.	122	123	.82	579	595	2.76
26. Hartford, Conn.	382	382	.00	569	567	-.35
27. Springfield, Mass.	452	452	.00	1,336	1,326	-.75
28. Worcester, Mass.	275	275	.00	577	576	-.17
29. Boston, Mass.	1,402	1,407	.36	3,062	3,121	1.93

* Per cent difference from alternative I-A to V

A similar conclusion may be drawn from analyzing the redistribution of propulation. However, the impact is greater here than the case of employment, quite probably, due to the increased willingness to commute longer distances to work brought about by improved passenger transportation, as for example, between New Haven and New York.