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# Modal Shifts in Short-Haul Passenger Travel and the Consequent Energy Impacts

**March 1980**

Prepared for:
U.S. Department of Energy
Assistant Secretary for
Conservation and Solar Energy
Under Contract No. EC-76-C-01-8439
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Prepared for:
U.S. Department of Energy
Assistant Secretary for
Conservation and Solar Energy
Washington, D.C. 20545

# FOREWORD

This study was performed under Contract EC-76-C-01-8439 to the Department of Energy. The DOE Technical monitor was Mr. Robert L. Bowles, Transportation Programs Office, Office of Conservation and Solar Applications. All phases of the study were directed by Mr. Frank W. Gobetz, the UTRC Program Manager, with the assistance of Mr. Alan P. Dubin, for model development and implementation, and Mr. John S. Foley, for the compilation of modal energy characteristics. The firm of Harbridge House, of Boston, Massachusetts, served as a subcontractor to UTRC for policy implications of modal-shift strategies. The Harbridge House effort was directed by Mr. Robert Brandwein, with the assistance of Ms. Sue McKittrick.

The body of this report is divided into two major sections: the first documents the methodology tasks (Tasks 1 to 4) which formed the analytical framework for the study, and the second describes the strategy evaluation (Tasks 5 and 6) in which results and conclusions were derived for each of the proposed modal shift strategies. The simulation program, by which characteristics of the modal shift were generated, is described in Appendix I. The major results of the study can be understood by an independent reading of the second section.

# Modal Shifts in Short-Haul Passenger Travel and the Consequent Energy Impacts

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## SUMMARY

A study was performed to evaluate the impacts of strategies to effect modal shifts in short-haul passenger travel (defined herein as intercity travel under 500 miles) from energy-intensive modes to those modes which are less energy-intensive. A series of individual strategies, ranging from incentives to the less energy-intensive modes (bus, rail) to penalties to the more energy-intensive modes (auto, air) was examined to determine energy saved and policy implications relative to strategy implementation. The most effective of the individual strategies were then combined in all permutations, and the analysis was repeated. As part of the analytical process, effects of factors other than energy (user cost and time, emissions, government subsidy, and travel fatalities) were examined in a benefit/cost analysis. Finally, energy savings, benefit/cost impacts, implementation considerations, and policy implications were evaluated to arrive at conclusions as to the effectiveness of the more influential strategies and to the overall effectiveness of induced modal-shifts.

The process used in the study was to generate a list of 48 SMSA-pairs (Standard Metropolitan Statistical Areas) selected to be representative of the national network of short-haul SMSA-pairs in the 67-to-500 mile distance category. For the representative SMSA-pair network, a fine-grained analysis of travel statistics, including public-mode access and zone-to-zone travel, was performed using the UTRC in-house Demand and Modal-Split Model which was refined to improve its applicability to short-haul traffic. For this analysis, a compilation of detailed performance, energy, and cost statistics was made for all competing modes, including automobile, bus, rail, and trunk, local service, and commuter air modes, as well as service frequencies for the public modes. Travel and energy statistics for the selected network were then expanded into the entire short-haul travel sector, including non-SMSA city-pairs and all city-pairs between 0 and 500 miles distant.

The principal conclusion of the study is that the maximum 1980 energy saving which might be realized by modal shifts, discounting the concurrent effects of demand suppression and improvement of mode efficiency, is approximately $83 \times 10^{12}$ Btu (46,500 bbl gasoline per day), 3.8 percent of the total projected 1980 energy consumption in the short-haul transportation sector and 0.23 percent of the total U.S. petroleum use. An evaluation of the economic and social impacts of these strategies on the national economy was conducted in a policy and implementation analysis. It is the Contractor's conclusion that strategies to achieve these small savings by modal shifts would result in significant economic, social, and business disruptions.

# CONCLUSIONS

1. In a short-term crisis situation, the only strategies which will result in significant energy conservation are those which also incur a significant suppression of travel demand. Implementation of the most severe combination of strategies examined would reduce short-haul energy consumption by 21%, but 81% of this reduction would result from suppression of travel demand and improvements in modal efficiency.

2. Those modal shift strategies or combinations of strategies which provide the greatest energy savings would be extremely difficult to implement from the standpoint of public acceptance, economic disruption, and transportation impacts, even in a period of severe petroleum shortage.

3. Strategies involving only incentives to the less energy-intensive modes result in minor modal shifts and, if implemented, would produce an increase in travel demand and total energy consumption.

4. Measures to conserve energy by stimulating a shift to bus travel by penalizing the auto and air modes could result in bus travel which exceeds projected maximum bus capacity, without a significant reduction in auto and air travel.

5. Measures to save energy by stimulating shifts to rail are relatively ineffective because rail service is not available on the majority of intercity routes. While rail travel could be significantly increased on routes where such service is offered, the overall rail share is presently so small (0.5%), that the energy impact of this diversion is negligible.

6. Although a small energy saving might result from the replacement of large aircraft by smaller aircraft on short-haul connecting flights, much of the potential savings might be negated by congestion delays resulting from increased flight frequencies. In addition, severe disruptions to long-haul passenger services and mail and freight operations might be incurred since the short-haul sector is not a distinct entity, but is an integral part of the domestic air system.

7. The adoption of a strategy which would force high load factors on short-haul air travel would adversely affect long-haul air travel because of through connections provided by the short-haul sector. In addition, it is the judgement of the Contractor that the achievement of average system load factors approaching 70% would saturate some segments of the air transport sector and would severely limit the availability of air travel during peak periods when demand is already high.

8. Strategies to effect modal shifts from energy-intensive (auto, air) modes of the short-haul transportation sector to less energy-intensive modes (bus, rail) would provide only small energy savings amounting to about one-fifth that of a 1.0 mpg improvement in the fuel economy of all automobiles in use in 1980. On the basis of the policy and implementation analyses conducted in the study, it is the Contractor's conclusion that strategies to achieve these small savings by modal shifts would result in significant economic, social, and business disruptions.

# INTRODUCTION

Petroleum currently used for transportation in the United States represents approximately 53% of the total consumption of this energy source. A breakdown of this sector indicates that approximately 85% of all trips are for intercity travel and 65% of all passenger miles are for distances of 500 miles or less. In 1973, approximately 90% of petroleum consumption in this short-haul travel sector was by automobiles; 9% by domestic air carriers; and the remainder by buses and passenger railroads.

One measure which can be taken to reduce fuel consumption in the transportation sector is to stimulate technological development of transportation media to reduce fuel consumption. For example, a 1 mpg improvement in the fuel utilization of automobiles in 1980 would result in an annual fuel savings of approximately $475 \times 10^{12}$ Btu out of the total $8{,}492 \times 10^{12}$ Btu estimated to be consumed in this mode. On a lesser scale, the same percentage decrease in fuel consumption of domestic air transport would result in an annual savings of approximately $103 \times 10^{12}$ Btu out of the $1{,}740 \times 10^{12}$ Btu consumed by this mode. Lesser savings would be derived from technological improvements of intercity bus and rail transportation due to the relatively low passenger traffic by these modes.

A second means of reducing fuel consumption in transportation is to reduce consumption per passenger mile through improvements in mode efficiency. Such measures include, for example, the imposition of regulations to stimulate increased load factors in all modes; regulation of speed limits for automobiles and buses; revision of traffic regulations to minimize nonproductive energy use, etc.

A third means of reducing fuel consumption, particularly in instances of severe petroleum shortages, is to suppress travel demand through fuel allocation or to impose regulations which cause sufficient inconvenience to reduce or eliminate all nonessential travel. Demand suppression, such as that induced by gasoline rationing during WW II, is thought to be a last-resort measure which would only be invoked in a national emergency more severe than that of 1973.

Another means for reducing energy consumption in transportation is to induce shifts from energy-intensive modes to less energy-intensive modes through Federal regulation or stimulation. Since 85% of all trips and over 65% of all passenger miles are for distances of 500 miles or less, it might be expected that modal shifts would be most applicable to short-haul segments of transportation.

The potential energy savings and social, economic, and business consequences resulting from implementation of the first three of the aforementioned measures are reasonably well defined. However, modal shift is a concept which has not been assessed in terms of its effectiveness or practicality, particularly in periods of severe petroleum shortages where immediate measures must be adopted on a temporary basis.

The projected 1980 petroleum consumption for different modes of the short-haul passenger transportation sector,* together with total transportation and total energy use, are given in the following table.

| | Energy Consumption $10^{12}$ Btu/Yr | % Total U.S. | % Short-Haul |
|---|---|---|---|
| Total U.S. | 35, 734 | 100 | - |
| Total Transportation | 19,047 | 53.3 | - |
| Short-Haul Passenger Trans. | 2,163 | 6.05 | 100 |
| Auto | 1827 | 5.11 | 84.5 |
| Air | 303 | 0.85 | 14.0 |
| Bus | 9 | 0.03 | 0.4 |
| Rail | 24 | 0.07 | 1.1 |

In evaluating these statistics, it would appear that the greatest savings relative to modal shift would come from a diversion from the most fuel-intensive ground mode (automobiles) to either of the more efficient ground modes (bus or rail). Although less than 15% of all short-haul intercity energy is consumed by domestic air transport, gains might also be expected by a shift from air to ground modes. A shift of short-haul air travel to a less fuel-intensive air mode (i.e., from large aircraft to smaller aircraft) might also be considered as a possible alternative. However, such a shift might disrupt air schedules due to the requirements for cargo and mail transport, short-haul legs at the beginning and end of a long-haul segment, and aircraft ferrying requirements. A paradox which emphasizes a difficulty in introducing a shift of mode from air to ground transportation was the experience during the OPEC oil embargo of 1973-74. In that situation, a modal shift from automobiles to air transportation occurred as a consequence of the uncertainties of fuel availability. Because modal choice is generally made on the basis of cost and convenience rather than fuel conservation, it is apparent that relatively severe strategies would have to be implemented to stimulate modal shifts which would have an appreciable effect on energy consumption.

In view of the foregoing and the Government's interest in exploring all possible means for minimizing petroleum consumption, the study reported herein was conducted to evaluate strategies for reducing energy consumption in short-haul intercity transportation, either by inducing modal shifts or through reduced reliance on large aircraft. A further objective was to identify policies which, if adopted by the Federal Government, would result in implementation of the most attractive short-haul energy conservation strategy.

* See pp 59 and 116 for derivation

## OVERALL APPROACH

Before proceeding with the discussion of individual tasks, a review of the overall plan is in order, particularly with regard to the relationships among the six parts of the technical program shown in Fig. 1. The first task made use of the extensive data base in the UTRC Demand Model to select, from a comprehensive list of 5311 short-haul (67-500 mile) SMSA-pairs, a set of 48 sample SMSA-pairs to represent carefully chosen categories descriptive of the entire national system of SMSAs. The use of SMSAs, rather than all cities in the U.S., was to permit a fine-grained analysis of travel and energy-use characteristics made possible by the availability of extensive data for SMSAs. Following the fine-grained analysis, the SMSA-pair results were expanded into the entire national short-haul system, as described below.

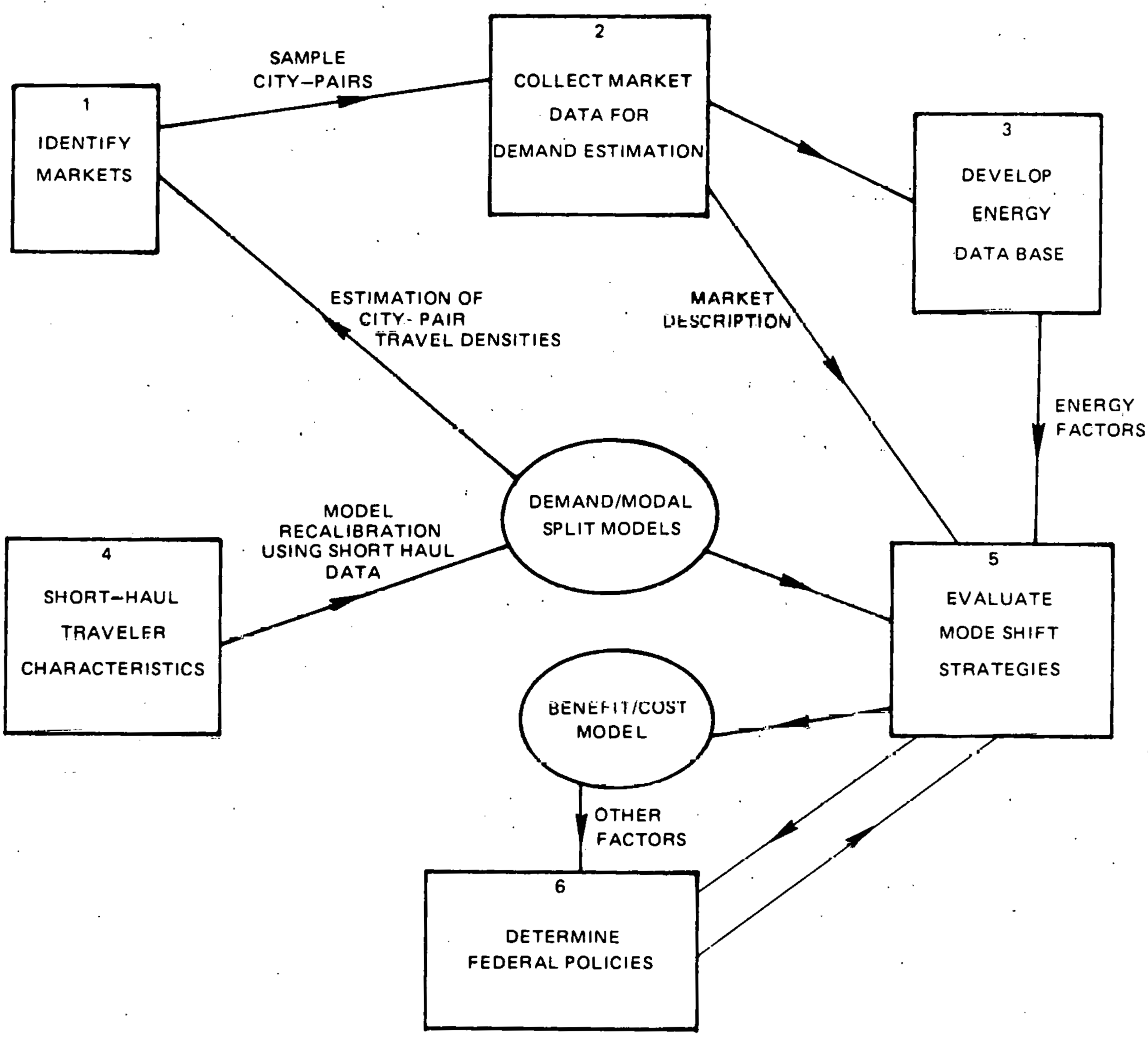
Data describing each of the 48 sample markets were assembled in Task 2 using published sources and unpublished information obtained from field work. In this task, many SMSAs which comprise the sample SMSA-pairs were divided into zones to achieve an accurate representation of local (access/egress) travel effects. Based on the detailed estimation of demand in each of the 48 SMSA-pairs, the effects of system variations could be extrapolated to each category and then to all 5311 short-haul SMSA-pairs.

Energy characteristics of the vehicles which serve the 48 sample SMSA-pairs were collected in Task 3 and a process of disaggregation was performed to account for vehicle mix and route-related effects on energy intensities of the four travel modes. The work in Task 4 was directed toward the determination of short-haul traveler characteristics, relying on the National Travel Survey data as the basic source, but incorporating data gleaned from alternative sources. A recalibration on the basis of the most reliable survey data from short-haul SMSA-pairs was performed to adapt the models specifically to short-haul travel.

The results of the first four tasks served as inputs to the Task 5 mode-shift strategy evaluations. In this task, individual strategies to effect modal shifts from fuel-intensive to fuel-conservative modes were formulated. The evaluation phase was then conducted, employing UTRC's Demand and Modal-Split models to compute demand (including induced demand), modal splits, and fuel used for each sample SMSA-pair as it was affected by each strategy. Demand and fuel usage were then expanded to the national short-haul system of SMSA-pairs and the strategies ranked according to overall fuel savings relative to the baseline case. (The UTRC Demand and Modal-Split models are described in Ref. 3; an example of their use in this study is given in Appendix I.)

The analytical evaluation of individual strategies in Task 5 was supplemented by a policy evaluation in Task 6 to select combination strategies which would maximize energy savings. These combination strategies were then subjected to an

## CONCEPTUAL PROGRAM PLAN



analytical evaluation back in Task 5 (see feedback loop in Fig. 1), and the results expanded into the total national short-haul system.

The expansion process involved two steps: (1) the estimation of travel and energy data for the system of city-pairs (in the 67-500 mile distance range) not involving SMSAs or involving an SMSA at only one of the end-points of intercity trips, and (2) the estimation of travel and energy data for all city-pairs in the 0-67 mile distance range. This latter category is important because of the dominance of auto travel in this range and the large potential fuel savings which could come from strategies designed to stimulate a shift to a more fuel-efficient mode (mainly bus). The data for all three categories (calculated data for SMSAs and estimated data for non-SMSAs and very short-distance city-pairs) were totaled for strategies which combined the most effective fuel saving measures to provide the major analytical results of the study.

The combination strategies were then subjected to a benefit/cost analysis to account for subsidiary effects (traveler cost and time, air pollution, safety, subsidies, etc.). In this way, an attempt was made to balance the fuel-saving potential of the strategies against the associated costs of the strategies. This information, together with statistics describing each of the final strategies, was then analyzed in Task 6 to evaluate policies by which the most effective modal-shift strategies might be implemented.

# SECTION I - DETAILED APPROACH

## Task 1 - Identification of Markets

The objective of this task was to categorize domestic SMSA-pairs (for simplification, referred to as city-pairs) in order to select a specific set whose characteristics represent a complete range with respect to demand density, distance, and service. Four criteria have been employed in the categorization process:

- Intercity distance
- Demand density
- Availability of rail service
- Availability of air service

Bus service and highway connections need not be considered as categorization criteria because coverage by these modes is universally good.

### Intercity Distance

Three distance categories were defined: 67-150 miles, 150-275 miles and 275-500 miles. The minimum of 67 miles corresponds to the definition of intercity travel in the 1972 National Travel Survey (Ref. 1), and is the minimum intercity distance at which the UTRC demand model has been used. The 500-mile maximum corresponds to the usual definition of short-haul travel. The distance categories were skewed toward the lower end because the modal-split process is more sensitive to distance at shorter distances than at longer distances. Thus, a single city-pair can represent a wider distance range at longer distances. Among the 218 SMSA markets described later, there are 598 city-pairs in the short-distance category, 1453 in the medium, and 3260 in the long, for a total of 5311 in the short-haul sector. The corresponding fractions of estimated SMSA-to-SMSA short-haul passenger miles (as determined from the demand calculations described below) are 22 percent, 37 percent, and 41 percent, respectively.

### Demand Density

The density of demand for each of the 5311 city-pairs was estimated using a version of the UTRC Demand Model developed under Corporate funds (Refs. 2 and 3). Additional short-haul city-pair data were included in the model calibration data base in order to improve the model's representation of short-haul travel.

### Availability of Rail Service

Examination of the complete Amtrak schedule for February 1976 revealed that 602 of the 5311 SMSA-pairs have rail service. For this determination, rail service was broadly defined to include all city-pairs served by thru trains (as few as three per week) as well as city-pairs served by connections, provided that at least one leg of the connection is a high-frequency route (i.e., six or more daily trains in each direction). Presently, there are only four high-frequency routes: Boston-New York-Washington, Hartford-New York-Washington, Albany-New York, and Milwaukee-Chicago. Thus, rail service city-pairs include those with a potential for adequate service as well as those already adequately served.

Availability of Air Service

The complete list of 247 SMSAs was examined to determine those SMSAs which have very little or no air service of their own, but which are served by an airport in another nearby SMSA. This is necessary to accurately distinguigh city-pairs which do or do not have air service. Two types of situations were found: (1) two or three SMSAs served by a single airport (such as Hartford/Springfield or Akron/Canton); and (2) a small SMSA served by a medium or large hub within 40 miles (such as Ann Arbor-Detroit or Lorain-Cleveland). In all, there are 22 such groups, comprising a total of 51 SMSAs which are treated as single entities. Along with the remaining 196 individual SMSAs (a few of which have no air service at all), there are a total of 218 markets (SMSA or SMSA groups) from which the 5311 city-pairs were formed.

The August 1, 1973 Official Airline Guide (OAG), (Ref. 4), was examined to determine which city-pairs have air service, and the type of air service available. The number of nonstop, one-stop, two-stop, and connecting flights provided by certificated and commuter carriers was determined for each city-pair having air service. Small intrastate or interstate operators using propeller equipment, and Allegheny commuters, were classified as commuters, while those intrastate operators using larger jet aircraft (i.e., PSA and Southwest) were treated as certificated. About 1300 city-pairs had some air service. Of these, 62 were served exclusively by commuter carriers, while 84 were jointly served by commuter and certificated carriers. Some of this latter group were reclassified as commuter-only because the commuter service is far more frequent than the certificated service. Of the remaining 1150 air-service city-pairs, those having no direct flights and very infrequent connecting service were treated as having no air service. (The OAG lists only a few of the many possible connections; since it is possible to construct a connection between almost any two cities having air service, it is necessary to establish such a lower limit so that a no-air-service category is properly defined.)

The number of air service categories was increased from the three originally proposed (none, commuter, and trunk/local service) to four with the addition of a category for city-pairs served by both commuter and trunk/local carriers. This addition was made because, even though commuters do not often compete directly with certificated carriers, a number of city-pairs do have competitive service, although usually at different airports. The minimum requirements for air service were set at one daily nonstop or one-stop flight in each direction, two daily two-stop flights, or three (listed) connections. Those city-pairs having commuter service clearly superior to that offered by the certificated carriers were classified as commuter routes. City-pairs were classified as having both commuter and certificated service if each offers more than one nonstop or two one-stop daily flights in each direction. (Additionally, if one carrier group offers more than four nonstop flights, the other must offer at least one nonstop flight.) The remaining city-pairs with air service were placed in the trunk/local service category.

Air service category assignments were initially based on data obtained from Ref. 4, but were revised using the April 15, 1976 OAG (Ref. 5) to account for both new, and discontinued, services. Thus, the air service categories reflect the current situation rather than 1973 data, and are preferable for making future projections. Of the 5311 short-haul city-pairs, 84 have commuter service only, 1239 are in the trunk/local service category, and 67 are served by both types of carriers.

Category Formation

Three demand categories were initially defined: 0-50,000; 50,000-500,000; and 500,000+ annual round-trip travelers. These arbitrary limits divided the total number of passenger-miles into three approximately equal parts. The combination of three demand, three distance, four air service, and two rail service categories gave 72 possible city-pair categories to which each of the 5311 city-pairs were assigned. However, as shown in Tables I to III, 21 of these categories contain no city-pairs, while others represent a negligible fraction of the total passenger-miles. Some categories comprise very large fractions of the total demand.

Two approaches were used to correct these imbalances. One involved combining small categories, each representing less than 0.25 percent of the total passenger-miles, across air service categories. Commuter-only routes were combined with city-pairs having no air service, while routes served by both commuter and trunk/local service carriers were combined with city-pairs having only certificated service. These shifts represent the permanence of certificated service relative to the free-entry, free-exit status of commuter carriers, as verified by the service changes which occurred between 1973 and 1976.

TABLE I

PRELIMINARY CITY-PAIR CATEGORIES: 67-150 Miles

Fraction of Total Passenger-Miles in Category
(Number of City-Pairs in Category)

| Demand - $10^3$ annual round-trip travelers | No Rail Service: No Air Service | No Rail Service: Commuter Only | No Rail Service: T/LS Only | No Rail Service: T/LS & Commuter | Rail Service: No Air Service | Rail Service: Commuter Only | Rail Service: T/LS Only | Rail Service: T/LS & Commuter |
|---|---|---|---|---|---|---|---|---|
| below 50 | 0.96% (248) | 0.10% (16) | 0.35% (76) | 0.05% (8) | 0.16% (23) | 0.01% (3) | 0.17% (25) | 0.01% (2) |
| 50–500 | 0.92% (40) | 0.33% (10) | 1.81% (41) | 0.49% (9) | 0.47% (18) | 0.49% (14) | 1.37% (25) | 0.68% (9) |
| above 500 | 0 | 0.27% (2) | 1.19% (5) | 0.47% (3) | 0 | 0.68% (3) | 6.36% (11) | 6.04% (7) |

TABLE II

PRELIMINARY CITY-PAIR CATEGORIES: 150 - 275 Miles

Fraction of Total Passenger-Miles in Category
(Number of City-Pairs in Category)

| Demand - $10^3$ annual round-trip travelers | No Rail Service | | | | Rail Service | | | |
|---|---|---|---|---|---|---|---|---|
| | No Air Service | Commuter Only | T/LS Only | T/LS & Commuter | No Air Service | Commuter Only | T/LS Only | T/LS & Commuter |
| < 50 | 4.40% (902) | 0.19% (18) | 1.23% (181) | 0.05% (6) | 0.85% (91) | 0.05% (5) | 0.42% (34) | 0.02% (3) |
| 50 – 500 | 0.61% (16) | 0.21% (5) | 6.47% (87) | 0.57% (9) | 0.30% (9) | 0.13% (3) | 4.93% (53) | 0.71% (9) |
| > 500 | 0 | 0 | 2.75% (4) | 0 | 0 | 0 | 10.95% (16) | 1.81% (2) |

TABLE III

PRELIMINARY CITY-PAIR CATEGORIES: 275 - 500 Miles

Fraction of Total Passenger-Miles in Category
(Number of City-Pairs in Category)

| Demand-$10^3$ annual round-trip travelers | No Rail Service: No Air Service | No Rail Service: Commuter Only | No Rail Service: T/LS Only | No Rail Service: T/LS & Commuter | Rail Service: No Air Service | Rail Service: Commuter Only | Rail Service: T/LS Only | Rail Service: T/LS & Commuter |
|---|---|---|---|---|---|---|---|---|
| below 50 | 8.20% (2413) | 0.02% (3) | 4.92% (433) | 0 | 0.81% (161) | 0.04% (2) | 1.78% (102) | 0 |
| 50 – 500 | 0 | 0 | 6.91% (73) | 0 | 0 | 0 | 6.45% (61) | 0 |
| above 500 | 0 | 0 | 0.93% (1) | 0 | 0 | 0 | 9.84% (11) | 0 |

The second type of adjustment involved shifting the demand categories within each column of Tables I to III (i.e., each specific combination of distance, rail service, and air service categories) to achieve a better balance among the passenger-miles represented by each category. Demand category limits were placed in natural "breaks" among the city-pairs in each column, resulting in from one to five demand categories per column. The result of this redistribution was the set of 48 city-pair categories shown in Tables IV to VI, along with the representative city-pairs whose selection is described below. These categories provide a more balanced representation of the short-haul market than the preliminary categories shown in Tables I to III.

Representative SMSA-Pairs

Each representative SMSA-pair was chosen mainly on the basis of how well it matched the average characteristics of its category. This was quantified by computing a score for each city-pair given by

$$S_i = \sum_j \left( \frac{x_{ij} - \bar{x}_j}{\bar{x}_j} \right)^2 .$$

where $x_{ij}$ is the jth characteristic of the ith city-pair and $\bar{x}_j$ is the average value of the jth characteristic for the particular city-pair category involved. The city-pair with the lowest score best represents the category. The six characteristics used were demand, distance, populations of the larger and smaller cities, regional location (as quantified by the longitude and latitude of each city-pair's midpoint), and the business share of the demand. These characteristics were selected because of their relevance and ease of computation. Distance and demand are fundamental quantities and were, therefore, double-weighted. Since longitude and latitude represent a single characteristic, i.e., regional location, each was given a weighting of one-half. The populations were included since they influence access characteristics, which in turn affect the modal-split. The business share is calculated as in the UTRC Model-Split Model; it is based on 1972 National Travel Survey data and is an increasing function of distance, with correction factors for about twenty large cities. It was included because business share has a strong influence on the overall modal-split.

In addition to the numerical scores, several other considerations were involved in selecting the representative city-pairs: achieving a wide geographic distribution, avoiding the use of one city in a disproportionate number of city-pairs, avoiding city-pairs which are significantly unrepresentative in some nonquantified characteristic, and minimizing the total number of cities in order to limit the scope of the associated zone and terminal access analyses in Task 2. The final selection of representative city-pairs is indicated in Tables IV to VI; they are also tabulated in Table VII and mapped in Fig. 2.

TABLE IV

FINAL CITY-PAIR CATEGORIES: 67 - 150 Miles

Fraction of Total Passenger-Miles in Category
(Number of City-Pairs in Category)
Representative City-Pair

<table>
<tr><th rowspan="2">Demand - $10^3$ annual round-trip travelers</th><th colspan="4">No Rail Service</th><th colspan="4">Rail Service</th></tr>
<tr><th>No Air Service</th><th>Commuter Only</th><th>T/LS Only</th><th>T/LS & Commuter</th><th>No Air Service</th><th>Commuter Only</th><th>T/LS Only</th><th>T/LS & Commuter</th></tr>
<tr><td>< 50</td><td colspan="2">1.09%<br>(264)<br>Kalamazoo/Battle Creek-Lima</td><td colspan="2" rowspan="2">0.90%<br>(111)<br>Nashville-Huntsville</td><td colspan="2">0.17%<br>(26)<br>Poughkeepsie-Trenton</td><td colspan="2" rowspan="2">0.31%<br>(33)<br>Birmingham-Montgomery Ala.</td></tr>
<tr><td>50 - 100</td><td rowspan="2">1.05%<br>(40)<br>Dayton-Ft. Wayne</td><td rowspan="2">0.39%<br>(9)<br>Cleveland-Mansfield</td><td rowspan="2">0.47%<br>(18)<br>Baltimore-Trenton</td><td rowspan="2">0.64%<br>(13)<br>Dallas-Killeen</td></tr>
<tr><td>100 - 500</td><td rowspan="2">1.69%<br>(22)<br>Atlanta-Huntsville</td><td>0.54%<br>(7)<br>Detroit-Ft. Wayne</td><td rowspan="2">2.16%<br>(28)<br>Washington-Richmond</td><td rowspan="2">0.80%<br>(8)<br>Detroit-Kalamazoo/Battle Creek</td></tr>
<tr><td>500 - 1000</td><td rowspan="4">0</td><td rowspan="2">0.85%<br>(3)<br>New York Reading</td><td rowspan="2">0.16%<br>(1)<br>Detroit Cleveland</td><td rowspan="4">0</td><td rowspan="3">1.08%<br>(4)<br>Phila.-Harrisburg</td></tr>
<tr><td>1000 - 2000</td><td rowspan="2">0.55%<br>(1)<br>L.A.-Bkrsfld.</td><td rowspan="2">2.11%<br>(4)<br>New York-Albany</td><td rowspan="2">2.03%<br>(4)<br>Chicago-Milwaukee</td></tr>
<tr><td>2000 - 5000</td><td rowspan="2">0</td><td rowspan="2">0</td></tr>
<tr><td>> 5000</td><td>0</td><td>0</td><td>2.61%<br>(1)<br>L. A.-San Diego</td><td>1.94%<br>(1)<br>New York-Phila.</td></tr>
</table>

TABLE V

FINAL CITY-PAIR CATEGORIES: 150 - 275 Miles

Fraction of Total Passenger-Miles in Category
(Number of City-Pairs in Category)
Representative City-Pair

<table>
<tr><th rowspan="2">Demand - $10^3$ annual round-trip travelers</th><th colspan="4">No Rail Service</th><th colspan="4">Rail Service</th></tr>
<tr><th>No Air Service</th><th>Commuter Only</th><th>T/LS Only</th><th>T/LS & Commuter</th><th>No Air Service</th><th>Commuter Only</th><th>T/LS Only</th><th>T/LS & Commuter</th></tr>
<tr><td>– 20</td><td colspan="2">2.91% (796) Nashville-Terre Haute</td><td colspan="2" rowspan="2">1.33% (188) Huntsville-Memphis</td><td colspan="2" rowspan="2">0.92% (94) Harrisburg-Poughkeepsie</td><td colspan="2" rowspan="3">1.14% (57) Baltimore-Raleigh</td></tr>
<tr><td>20 – 50</td><td rowspan="3">2.45% (131) Albany-Reading</td><td rowspan="3">0.45% (14) Washington-Binghamton</td></tr>
<tr><td>50 – 100</td><td rowspan="2">3.66% (71) St. Louis-Nashville</td><td rowspan="3">0.81% (6) Chicago-Appleton Oshkosh</td><td colspan="2" rowspan="2">0.56% (14) Milwaukee-Ft. Wayne</td></tr>
<tr><td>100 – 200</td><td rowspan="2">4.89% (39) Phila.-Albany</td><td rowspan="2">0.56% (5) Chicago-Spfld., Ill.</td></tr>
<tr><td>200 – 500</td><td rowspan="4">0</td><td rowspan="4">0</td><td rowspan="2">3.71% (21) Dallas-Tulsa</td><td colspan="2" rowspan="4">0</td></tr>
<tr><td>500 – 2000</td><td rowspan="3">0</td><td>5.73% (12) St. Louis-Kansas City</td><td>1.57% (2) Chicago-Detroit</td></tr>
<tr><td>2000 – 5000</td><td>2.46% (1) Los Angeles-Las Vegas</td><td>3.58% (2) New York-Boston</td><td rowspan="2">0</td></tr>
<tr><td>5000 –</td><td>0</td><td>0</td></tr>
</table>

TABLE VI

FINAL CITY-PAIR CATEGORIES: 275 - 500 Miles

Fraction of Total Passenger-Miles in Category
(Number of City-Pairs in Category)
Representative City-Pair

<table>
<tr><th rowspan="2">Demand - $10^3$ annual round-trip travelers</th><th colspan="4">No Rail Service</th><th colspan="4">Rail Service</th></tr>
<tr><th>No Air Service</th><th>Commuter Only</th><th>T/LS Only</th><th>T/LS & Commuter</th><th>No Air Service</th><th>Commuter Only</th><th>T/LS Only</th><th>T/LS & Commuter</th></tr>
<tr><td>below 8</td><td colspan="2">7.06%<br>(2243)<br>Tulsa-Spfld., Ill.</td><td rowspan="2">5.13%<br>(433)<br>Pittsburgh-South Bend</td><td rowspan="7">0</td><td colspan="2" rowspan="2">0.93%<br>(163)<br>Kansas City-Terre Haute</td><td rowspan="2">1.87%<br>(102)<br>Boston-Richmond</td><td rowspan="7">0</td></tr>
<tr><td>8 - 50</td><td colspan="2">1.59%<br>(173)<br>St. Louis-Lima</td></tr>
<tr><td>50 - 100</td><td colspan="2" rowspan="5">0</td><td>2.79%<br>(44)<br>Atlanta-Richmond</td><td colspan="2" rowspan="5">0</td><td>2.10%<br>(33)<br>Washington-Dayton</td></tr>
<tr><td>100 - 500</td><td>4.41%<br>(29)<br>Dallas-Memphis</td><td>4.63%<br>(28)<br>Chicago-Memphis</td></tr>
<tr><td>500 - 2000</td><td>1.14%<br>(1)<br>Los Angeles Sacramento</td><td>5.82%<br>(10)<br>New York-Pittsburgh</td></tr>
<tr><td>2000 - 10 000</td><td rowspan="2">0</td><td>4.36%<br>(1)<br>Los Angeles San. Fran.</td></tr>
<tr><td>above 10 000</td><td>0</td></tr>
</table>

TABLE VII

REPRESENTATIVE CITY-PAIRS

| | |
|---|---|
| New York - Albany | Milwaukee - Fort Wayne, Ind. |
| " - Boston | Detroit - Fort Wayne, Ind. |
| " - Philadelphia | " - Kalamazoo/Battle Creek, Mich. |
| " - Pittsburgh | Dayton/Springfield - Fort Wayne, Ind. |
| " - Reading | Kalamazoo/Battle Creek, Mich. - Lima, Ohio |
| Philadelphia - Albany | St. Louis - Kansas City |
| " - Harrisburg/York | " - Lima, Ohio |
| Baltimore - Raleigh/Durham | " - Nashville |
| " - Trenton | Kansas City - Terre Haute, Ind. |
| Washington - Binghamton, N.Y. | Nashville - Huntsville |
| " - Dayton/Springfield, Ohio | " - Terre Haute, Ind. |
| " - Richmond/Petersburg | Atlanta - Huntsville |
| Albany - Reading | " - Richmond/Petersburg |
| Poughkeepsie, N.Y. - Harrisburg/York | Dallas/Ft. Worth - Killeen/Temple, Texas |
| " - Trenton | " - Memphis |
| Boston-Richmond/Petersburg | " - Tulsa |
| Pittsburgh - South Bend, Ind. | Memphis - Huntsville |
| Cleveland - Detroit | Tulsa - Springfield, Ill. |
| " - Mansfield, Ohio | Los Angeles - San Francisco/San Jose |
| Chicago - Appleton/Oshkosh, Wis. | " - San Diego |
| " - Detroit | " - Sacramento |
| " - Memphis | " - Las Vegas |
| " - Milwaukee | " - Bakersfield |
| " - Springfield, Ill. | Birmingham - Montgomery, Ala. |

## REPRESENTATIVE CITY–PAIRS

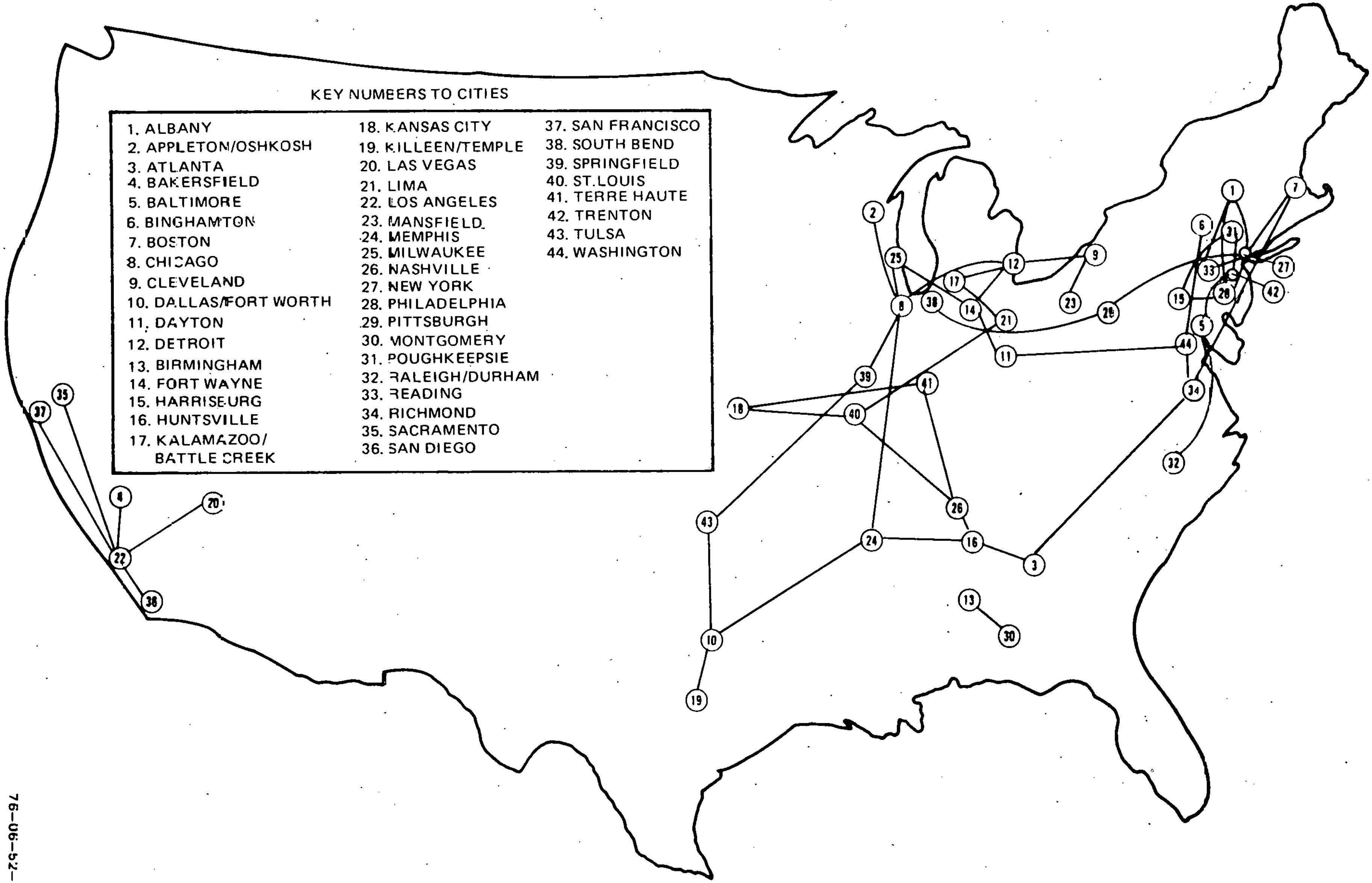



FIG. 2



76–06–52–1

## Task 2 - Data Collection for Sample SMSA-Pairs

The access/egress portions of a short-haul intercity trip take on special importance because they constitute significant fractions of the total trip time relative to the line-haul portion of the trip. For this reason, it was proposed that the cities which make up the 48 representative city-pairs be subdivided into zones, and that access time and cost values be calculated for each zone rather than as averages for an entire SMSA. A total of 44 cities are involved in the 48 representative city-pairs. However, many of these cities are too small to justify zonal breakdowns. An additional part of Task 2 was a survey of commuter airlines; the survey is desdescribed separately, in Appendix II, because it does not provide input to the analytical process as do other elements of this task.

### Zone Breakdowns

In Table VIII, the 44 cities are divided into three groups: 1) those which are small enough to be represented by a single zone, 2) two-zone cities, which include either SMSA's consisting of two small cities or small neighboring SMSA's, and 3) large cities for which three or more zones are required for a thorough analysis. The number of zones applicable to each city in the third group is indicated in Table VIII. Based on the numbers of zones in the table, the total number of zone-pairs which were considered to represent the 48 representative city-pairs was 554.

The ultimate purpose of the zone breakdowns was to generate sufficient information to treat each zone-pair. There are two basic parts to this analysis: 1) estimation of modal splits for each zone, and 2) estimation of total demand by zone-pairs.

#### Modal Split Estimates

In the first part, each of the 44 cities (SMSA's) is divided into zones, the number of zones being dependent on city size (population), and the zone boundaries being chosen to follow either county lines or geographic divisions (rivers, major highways). The central business district (CBD), as defined by 1970 census tracts, is always one zone because, relative to its population, the CBD always generates a large percentage of SMSA origins and destinations. The next step is to locate terminals for the public modes, including all rail and bus stops, and airports used by trunk/local service and/or commuter carriers. For auto trips, cordon points are specified at locations through which intercity trips will tend to flow to link the city-pairs. Once the terminal locations are known, access/egress distances, times, and costs can be estimated for each zone to each appropriate terminal. These access data, along with data describing the intercity modal characteristics, are sufficient to permit a modal split to be made for each zone pair. An example of the process used in developing zone-pair travel statistics is presented in Appendix I.

TABLE VIII

ZONAL BREAKDOWN OF CITIES

| One-Zone | Two-Zones | Multi-Zone | No. Zones |
|---|---|---|---|
| Albany | Harrisburg/York | Atlanta | 3 |
| Bakersfield | Dayton/Springfield, Ohio | Baltimore | 3 |
| Binghamton | Kalamazoo/Battle Creek | Boston | 5 |
| Birmingham | Richmond/Petersburg | Chicago | 6 |
| Fort Wayne | Raleigh/Durham | Cleveland | 4 |
| Huntsville | Appleton/Oshkosh | Dallas/Ft. Worth | 4 |
| Las Vegas | Killeen/Temple | Detroit | 4 |
| Lima | | Kansas City | 3 |
| Mansfield | | Los Angeles | 10 |
| Memphis | | Milwaukee | 3 |
| Montgomery | | New York | 12 |
| Nashville | | Philadelphia | 6 |
| Poughkeepsie | | Pittsburgh | 3 |
| Reading | | St. Louis | 5 |
| Sacramento | | San Diego | 3 |
| South Bend | | San Francisco | 7 |
| Springfield, Ill. | | Washington, D.C. | 5 |
| Terre Haute | | | |
| Trenton | | | |
| Tulsa | | | |

Demand Estimates

The second part of the analysis determines the distribution of total demand by zone. Trip purpose plays an important role in this phase because some zones are more important trip generators than others (e.g., CBD vs suburban zone). Three characteristics have been identified to determine the demand distribution by zone. These are the percentages of: residences, employment, and hotel/motel rooms. Depending on trip purpose, these characteristics determine where trip origins and destinations will be concentrated. For example, data from airport access surveys for Cleveland (Ref. 6) and New York (Ref. 7) suggest similar divisions of traveler origins using these criteria. Although these data are informative, they apply specifically to air travelers, whereas this study must consider travel by all modes. Since the NTS trip-purpose characteristics for short-haul travelers were available for use in this study (see Task 4), intuitive reasoning was used to derive the following demand distribution rules using the NTS categories. These rules are qualitatively similar to the trends found in the airport access studies, but they are considered to be less selective with respect to specific locality and, therefore, more appropriate for general application to the wide range of cities under study.

| | NTS Category | Local Residents | Visitors |
|---|---|---|---|
| Business | Business | 50/50 Residence/Employment | 100% Employment |
| | Convention | " | 100% Hotel |
| Personal | Visit Friends & Relatives | 100% Residence | 100% Residence |
| | Recreation, Entertainment, Sightseeing | " | 100% Hotel |
| | Personal Affairs | " | 50/50 Residence/ Hotel |

Using the county-level NTS data tape, primary trip purpose was established for the 44 cities in the study so that estimates could be made of the percentage of travelers originating or arriving at a destination in each of the three categories. Residence, employment, and hotel/motel counts made for each zone of each city were used to determine zonal demand distributions.

The listing in Table IX documents the zones for each multi-zone SMSA, with makeup of each zone comprising counties as the primary descriptor, and those zone characteristics - residence, employment, and hotel/motel count - which were used to distribute total demand among the zones.

With the zones defined as in Table IX, terminal locations for each mode were specified geographically in order that access/egress times and distances could be determined. Local maps were used to select access/egress routes from the computed centroid of each zone (population center) to appropriate airports, bus and rail

(Text continued on page 27)

TABLE IX

CHARACTERISTICS OF SMSA ZONES

| SMSA | Zones | Zone Description (City/County) | % Resid. | % Employ. | % Hotel |
|---|---|---|---|---|---|
| Atlanta | 3 | 1 Atlanta CBD | 0.16 | 8.6 | 32.0 |
| | | 2 Fulton less CBD; Cobb | 55.0 | 67.2 | 41.6 |
| | | 3 Dekalb; Clayton; Gwinett | 44.84 | 24.2 | 26.4 |
| Baltimore | 3 | 1 Baltimore CBD | 0.3 | 7.2 | 52.4 |
| | | 2 Baltimore less CBD; Harford | 77.4 | 78.5 | 33.6 |
| | | 3 Carroll; Howard; Anne Arundel | 22.3 | 14.3 | 14.0 |
| Boston | 5 | 1 Boston CBD | 3.4 | 8.1 | 9.9 |
| | | 2 Essex; part of Suffolk | 21.5 | 10.9 | 12.4 |
| | | 3 Most of Middlesex | 37.0 | 35.5 | 17.2 |
| | | 4 Norfolk; parts of Suffolk, Middlesex | 31.7 | 43.7 | 56.2 |
| | | 5 Plymouth | 6.3 | 1.7 | 4.4 |
| Chicago/ Gary-Hammond-East Chicago | 6 | 1 Chicago CBD | 0.07 | 7.8 | 30.5 |
| | | 2 Chicago less CBD | 42.48 | 41.9 | 30.6 |
| | | 3 Bal. of Cook (central); Kane (south); DuPage | 18.64 | 16.3 | 23.8 |
| | | 4 Bal. of Cook (south); Will | 13.10 | 11.5 | 1.8 |
| | | 5 Bal. of Cook(north); Kane(north); McHenry; Lake (Ill.) | 17.34 | 15.0 | 12.4 |
| | | 6 Lake (Ind.); Porter (Ind.) | 8.37 | 7.5 | 0.9 |
| Cleveland/ Lorain-Elyria | 4 | 1 Cleveland CBD | 0.3 | 8.3 | 29.6 |
| | | 2 Bal. of Cuyahoga | 72.7 | 73.7 | 62.1 |
| | | 3 Lake; Geauga | 11.7 | 6.7 | 6.8 |
| | | 4 Medina; Lorain | 15.3 | 11.3 | 1.4 |
| Dallas-Ft. Worth | 4 | 1 Dallas City CBD | 0.15 | 7.2 | 28.5 |
| | | 2 Bal. of Dallas(north); Denton; Collin; Rockwall | 25.25 | 22.6 | 3.6 |
| | | 3 Bal. of Dallas(south); Dallas City less CBD; Ellis; Kaufman | 42.55 | 44.4 | 42.5 |
| | | 4 Johnson; Tarrant | 32.05 | 25.8 | 25.4 |

TABLE IX (Cont'd)

CHARACTERISTICS OF SMSA ZONES (Cont'd.)

| SMSA | Zones | Zone Description (City/County) | % Resid. | % Employ. | % Hotel |
|---|---|---|---|---|---|
| Detroit/ Ann Arbor | 4 | 1 Detroit CBD | 0.1 | 5.7 | 29.2 |
| | | 2 Bal. of Detroit | 34.3 | 32.6 | 9.9 |
| | | 3 Bal. of Wayne; Washtenaw | 30.2 | 31.4 | 39.3 |
| | | 4 Macomb; Oakland | 35.4 | 30.3 | 21.6 |
| Kansas City/ St. Joseph | 3 | 1 Kansas City, Mo. CBD | 0.1 | 6.8 | 32.2 |
| | | 2 Jackson less CBD; Cass, Mo; Clay, Mo. | 60.3 | 64.8 | 44.8 |
| | | 3 Buchanan, Mo.; Platte, Mo.; Johnson, Kan.; Wyandotte, Kan. | 39.6 | 28.4 | 23.0 |
| Los Angeles-Long Beach/ Anaheim-Santa Ana-Garden Grove/ Riverside-San Bernardino | 10 | 1 Los Angeles CBD | 0.1 | 3.5 | 10.3 |
| | | 2 Los Angeles City (south) less LA CBD | 21.1 | 23.6 | 35.2 |
| | | 3 Long Beach CBD | 0.1 | 0.2 | 0.2 |
| | | 4 Los Angeles (southwest) less LB CBD | 13.2 | 13.3 | 10.0 |
| | | 5 Los Angeles (southeast) | 11.7 | 11.7 | 2.0 |
| | | 6 Los Angeles (northeast) | 16.2 | 16.4 | 2.7 |
| | | 7 Los Angeles (northwest) | 10.9 | 10.9 | 4.6 |
| | | 8 Riverside; San Bernardino | 11.9 | 7.4 | 14.2 |
| | | 9 Orange (north) | 7.9 | 6.5 | 15.1 |
| | | 10 Orange (south) | 6.9 | 6.5 | 5.7 |
| Milwaukee/ Racine/ Kenosha | 3 | 1 Milwaukee CBD | 0.1 | 7.5 | 43.5 |
| | | 2 Bal. of Milwaukee | 61.6 | 62.8 | 30.8 |
| | | 3 Ozaukee; Washington; Waukesha; Racine; Kenosha | 38.3 | 29.7 | 25.7 |
| New York/ Newark/Nassau-Suffolk/ Fairfield | 12 | 1 Upper Manhattan | 11.8 | 3.9 | 16.1 |
| | | 2 Mideast Manhattan | 1.0 | 8.3 | 25.1 |
| | | 3 Midwest Manhattan | 0.8 | 8.8 | 33.4 |
| | | 4 Lower Manhattan (CBD) | 4.1 | 12.2 | 3.2 |
| | | 5 Bronx | 3.9 | 3.2 | 0 |
| | | 6 Kings | 7.8 | 8.0 | 0.7 |

TABLE IX (Cont'd)

CHARACTERISTICS OF SMSA ZONES (Cont'd)

| SMSA | Zones | Zone Description (City/County) | % Resid. | % Employ. | % Hotel |
|---|---|---|---|---|---|
| New York/ etc., cont'd. | | 7 Queens | 9.8 | 6.9 | 2.3 |
| | | 8 Nassau; Suffolk | 15.7 | 10.0 | 3.9 |
| | | 9 Westchester; Putnam; Fairfield, Conn. | 15.7 | 8.6 | 4.7 |
| | | 10 Richmond; Essex; N.J.; Union, N.J.; Morris, N.J.; Hudson, N.J. | 13.7 | 15.3 | 3.8 |
| | | 11 Rockland; Orange; Bergen, N.J.; Passaic, N.J. | 9.8 | 9.4 | 3.5 |
| | | 12 Middlesex, N.J.; Monmouth, N.J.; Somerset, N.J. | 5.9 | 5.4 | 3.3 |
| Philadelphia/ Wilmington/ Vineland-Millville-Bridgeton | 6 | 1 Philadelphia CBD | 1.1 | 6.1 | 31.9 |
| | | 2 Philadelphia (north) less CBD | 22.5 | 24.8 | 8.3 |
| | | 3 Philadelphia (southwest) less CBD | 21.2 | 19.3 | 14.7 |
| | | 4 New Jersey Counties: Burlington; Camden; Salem; Cumberland; Gloucester | 21.8 | 16.3 | 16.1 |
| | | 5 Chester; New Castle, Del.; Cecil, Md. | 13.8 | 13.3 | 11.8 |
| | | 6 Bucks; Montgomery | 19.6 | 20.2 | 17.2 |
| Pittsburgh/ Steubenville-Weirton | 3 | 1 Pittsburgh CBD | 0.12 | 8.7 | 48.0 |
| | | 2 Bal. of Allegheny (north); Westmoreland | 55.29 | 49.8 | 25.2 |
| | | 3 Bal. of Allegheny (south); Beaver; Brooke; Hancock; Jefferson; Washington | 44.59 | 41.5 | 26.8 |
| St. Louis | 5 | 1 St. Louis CBD | 0.03 | 4.1 | 20.7 |
| | | 2 Bal. of St. Louis City | 23.97 | 39.5 | 25.1 |
| | | 3 Bal. of St. Louis; St. Charles | 45.57 | 33.9 | 45.7 |
| | | 4 Franklin; Jefferson | 7.45 | 3.1 | 0 |
| | | 5 Madison, Ill.; St. Clair, Ill. | 22.98 | 19.4 | 8.5 |
| San Diego | 3 | 1 San Diego CBD | 0.4 | 4.2 | 30.5 |
| | | 2 San Diego (south) | 51.4 | 47.9 | 36.9 |
| | | 3 San Diego (north) | 48.2 | 47.9 | 32.6 |

TABLE IX (Cont'd)

CHARACTERISTICS OF SMSA ZONES (Cont'd)

| SMSA | Zones | Zone Descriptions (City/County) | % Resid. | % Employ. | % Hotel |
|---|---|---|---|---|---|
| San Francisco-Oakland/ San Jose | 7 | 1 San Francisco CBD | 0.6 | 10.4 | 51.9 |
| | | 2 Bal. of San Francisco | 15.0 | 19.1 | 15.0 |
| | | 3 San Mateo | 13.1 | 11.9 | 12.6 |
| | | 4 San Jose CBD | 0.4 | 0.9 | 0 |
| | | 5 Bal. of Santa Clara | 26.3 | 25.0 | 9.7 |
| | | 6 Alameda | 25.9 | 22.4 | 9.5 |
| | | 7 Contra Costa; Marin | 18.7 | 10.3 | 1.3 |
| Washington, D.C. | 5 | 1 Washington CBD | 1.4 | 15.8 | 34.9 |
| | | 2 DC (north) | 22.8 | 24.2 | 28.5 |
| | | 3 DC (south); Arlington, VA; Falls Church (city); Alexandria (city) | 9.4 | 14.0 | 18.3 |
| | | 4 Prince Georges, Md.; Charles, Md. | 24.8 | 15.4 | 9.5 |
| | | 5 Montgomery, Md.; Louden, Va.; Prince William, Va; Fairfax, Va. | 41.6 | 30.6 | 8.8 |

terminals, and auto cordon points. Since public-mode access points are often numerous, particulary for bus, the most likely terminal was chosen for each zone. Note that the major SMSA's are generally connected to more than one other SMSA in the city-pair list; therefore, the choice of terminals for a particular zone often varied with city-pair.

Each terminal was assigned a code number and a list of terminal-pairs was made for each zone-pair. An itemization of the numbers of zone-pairs and terminal-pairs for each city-pair appears in Table X. As indicated, a total of 554 zone-pairs are used to describe the 48 representative city-pairs selected in Task 1. The total number of terminal-pairs required to analyze the access/egress portions of intercity trips is 363, where auto cordon points are used to represent the division between local and intercity portions of auto trips.

In addition to the zone breakdowns, data were gathered to describe service levels, including intercity distances, block times, fares, and frequencies. For the air mode, the 1976 OAG tape was interrogated to obtain frequencies for each terminal-pair among the 48 city-pairs. These data were processed manually for bus and rail, using published schedules. This complete documentation of the time and distance characteristics of all trips between the representative city-pairs was entered into the modal-split program as the primary data base for determining the modal split for each zone-pair.

Demand, modal split, and energy consumption forecasts for the 48 representative city-pairs were aggregated to the total 5311 SMSA-pair, short-haul system by applying an expansion factor to each representative city-pair. These factors were computed by taking the ratio of the total passenger-miles of all the SMSA-pairs in each category to the passenger-miles of the representative SMSA-pair. Since each representative city-pair was chosen, in part, to have demand and distance characteristics near its category average, the expansion factors are approximately equal to the number of city-pairs in each category, shown in Tables IV-VI.

TABLE X

NUMBERS OF ZONE AND TERMINAL PAIRS

| No. | City Pair | | Zone Pairs | Terminal Pairs T/LS | Commuter | Rail | Bus | Auto* |
|---|---|---|---|---|---|---|---|---|
| 1 | New York | -Albany | 12 | 3 | - | 2 | 2 | 1 |
| 2 | | -Boston | 60 | 3 | - | 10 | 2 | 1 |
| 3 | | -Philadelphia | 72 | 3 | 5 | 15 | 6 | 1 |
| 4 | | -Pittsburgh | 36 | 3 | - | 2 | 2 | 1 |
| 5 | | -Reading | 12 | - | 2 | - | 2 | 1 |
| 6 | Philadelphia | -Albany | 6 | 1 | - | 3 | 3 | 1 |
| 7 | | -Harrisburg | 12 | - | 1 | 4 | 3 | 1 |
| 8 | Baltimore | -Raleigh | 6 | 1 | - | 1 | 2 | 1 |
| 9 | | -Trenton | 3 | - | - | 1 | 1 | 1 |
| 10 | Washington | -Binghamton | 5 | - | 2 | - | 1 | 1 |
| 11 | | -Dayton | 10 | 2 | - | 1 | 2 | 1 |
| 12 | | -Richmond | 10 | 2 | - | 4 | 5 | 1 |
| 13 | Albany | -Reading | 1 | - | - | - | 1 | 1 |
| 14 | Poughkeepsie | -Harrisburg | 2 | - | - | 1 | 1 | 1 |
| 15 | | -Trenton | 1 | - | - | 1 | 1 | 1 |
| 16 | Boston | -Richmond | 10 | 1 | - | 4 | 3 | 1 |
| 17 | Pittsburgh | -South Bend | 3 | 1 | - | - | 1 | 1 |
| 18 | Cleveland | -Detroit | 16 | 1 | 1 | - | 6 | 1 |
| 19 | | -Mansfield | 4 | - | 1 | - | 2 | 1 |
| 20 | Chicago | -Appleton | 12 | 1 | 1 | - | 4 | 1 |
| 21 | | -Detroit | 24 | 1 | 1 | 2 | 4 | 1 |
| 22 | | -Memphis | 6 | 1 | - | 2 | 2 | 1 |
| 23 | | -Milwaukee | 18 | 1 | 1 | 4 | 4 | 1 |
| 24 | | -Springfield | 6 | 1 | 1 | 2 | 2 | 1 |
| 25 | Milwaukee | -Ft. Wayne | 3 | - | - | 2 | 2 | 1 |
| 26 | Detroit | -Ft. Wayne | 4 | 1 | 1 | - | 2 | 1 |
| 27 | | -Kalamazoo | 8 | 1 | 1 | 4 | 4 | 1 |
| 28 | Dayton | -Ft. Wayne | 2 | - | - | - | 2 | 1 |
| 29 | Kalamazoo | -Lima | 2 | - | - | - | 2 | 1 |
| 30 | St. Louis | -Kansas City | 15 | 1 | - | 2 | 6 | 1 |
| 31 | | -Lima | 5 | - | - | - | 2 | 1 |
| 32 | | -Nashville | 5 | 1 | - | - | 2 | 1 |
| 33 | Kansas City | -Terre Haute | 3 | - | - | 1 | 1 | 1 |
| 34 | Nashville | -Huntsville | 1 | 1 | - | - | 1 | 1 |
| 35 | | -Terre Haute | 1 | - | - | - | 1 | 1 |
| 36 | Atlanta | -Huntsville | 3 | 1 | - | - | 1 | 1 |
| 37 | | -Richmond | 6 | 1 | - | - | 2 | 1 |
| 38 | Dallas | -Killeen | 8 | - | 2 | 2 | 3 | 1 |
| 39 | | -Memphis | 4 | 1 | - | - | 2 | 1 |
| 40 | | -Tulsa | 4 | 1 | - | - | 3 | 1 |
| 41 | Memphis | -Huntsville | 1 | 1 | - | - | 1 | 1 |
| 42 | Tulsa | -Springfield | 1 | - | | - | 1 | 1 |
| 43 | Los Angeles | -San Francisco | 70 | 13 | - | 8 | 20 | 1 |
| 44 | | -San Diego | 30 | 4 | - | 4 | 10 | 1 |
| 45 | | -Sacramento | 10 | 3 | - | - | 6 | 1 |
| 46 | | -Las Vegas | 10 | 4 | - | - | 7 | 1 |
| 47 | | -Bakersfield | 10 | 1 | - | - | 6 | 1 |
| 48 | Birmingham | -Montgomery | 1 | 1 | - | 1 | 1 | 1 |
| | TOTAL | | 554 | 62 | 20 | 83 | 150 | 48 |

* Auto terminals correspond to cordon points located on major highways near each city.

## Task 3 - Development of Energy Data Base

The objective of Task 3 was to develop energy intensity factors for each short-haul transportation mode. These factors were used to estimate fuel consumed for each strategy evaluated in Task 5. The basic approach was to compile data on each mode from the extensive array of literature sources available, disaggregate these data as required, and construct block fuel-vs-distance curves for each vehicle type. For all public modes, access travel was computed, in detail, as described in Appendix I, assuming automobile access from specific origin points in each city, to the appropriate terminal, and from the terminal, in each destination city, to the destination zone.

### Airplane Fuel Consumption

Most of the data required to document fuel intensity of commercial aircraft was on hand at UTRC prior to the initiation of this study with the exception of some of the smallest aircraft presently operated by commuter carriers. As indicated in Table XII, seven aircraft classes were defined and data were assembled to document fuel intensity of the primary aircraft in each class based on commuter, local service, and domestic trunk airline experience.

The available seating capacity and fuel usage for the airplanes in Class 1 are based on manufacturers' data from Ref. 8. The performance and seating capacity for all other classes of airplanes are based on the experience of the local service and domestic trunk airlines as reported in Refs. 9 and 10. To insure that the block fuel for each airplane reflects realistic usage by the airplane industry, the weighted average stage length and block fuel for each airplane type were determined from 1974 data (Ref. 9) and extrapolated to other stage lengths based on manufacturers recommended data and airline experience as given in Refs. 11 to 13. When a conflict existed between the manufacturer's specification data (as in Ref. 12) and airline experience (as used in Ref. 13), the latter were used. Such data (in the case of Ref. 13) reflect an agreement among Lockheed, McDonnell Douglas, and United Airlines as to realistic values for a recent NASA study (RECAT).*

The energy consumption of short-range commuter and local service airplanes (Classes 1 and 2) is given in Fig. 3. The left-hand portion of the figure shows the gallons of fuel burned for stage lengths up to 500 miles Block fuel increases with size of airplane (seating capacity) and length of haul. The right-hand portion of Fig. 3 shows the energy intensity of these airplanes as a function of range. Conversion factors from gallons to Btu's for the different fuels used in this study are given in Table XIII. In all cases, the lower heating value is used, following common practice, since the heat of condensation of the fuel is, for the most part, not gained in the engine cycle.

The de Havilland DHC-6 and the Beech 99 airplanes cannot carry full payload 500 miles. Therefore, at the range where payload is off-loaded, energy intensity begins to increase because of the loss in available seats. In general, the energy intensity of small, piston-engine commuter airplanes is about 2000 Btu per available seat mile (Btu/ASM), while the turboprop-powered local service airplanes show energy intensities of about 3500 Btu/ASM.

*Cost/Benefit Tradeoffs for Reducing the Energy Consumption of Commercial Air Transportation. NASA CR-137877, June 1976.

TABLE XII

TRANSPORT AIRCRAFT ANALYZED

| Airplane Class | Number Engines & Engine Type | Seats | Aircraft |
|---|---|---|---|
| 1 | 1-2 Piston | 5-10 | PA-32-300, Cessna 402B |
| 2 | 2-4 Turboprops | 15-50 | Beech 99, DHC-6, N262, SD3-30, DHC-7, FH-227, CV-580 |
| 3 | 2 Turbofans | 75-100 | DC-9, B737 |
| 4 | 3 Turbofans | 102-132 | B727 |
| 5 | 4 Turbofans | 162 | DC-8, B707 |
| 6 | 3 Turbofans | 275 | DC-10-10 |
| 7 | 4 Turbofans | 386 | B747 |

| Designation | Manufacturer |
|---|---|
| 99 | Beech |
| B707, B727, | Boeing |
| B737, B747 | Boeing |
| 402B | Cessna |
| CV-580 | General Dynamics/Convair |
| DHC-6, DHC-7 | de Havilland |
| FH-227 | Fairchild |
| DC-8, DC-9, DC-10-10 | McDonnell Douglas |
| N262 | Nord Aviation, SNECMA |
| PA-32-300 | Piper |
| SD3-30 | Short Bros. & Harland, Ltd. |

TABLE XIII

SELECTED VALUES FOR HEATING VALUE OF PETROLEUM FUELS

| Fuel Type | Ref. | Spec. Gravity | Lower Heating Value | | Higher Heating Value | |
|---|---|---|---|---|---|---|
| | | | Btu/lb | Btu/gal | Btu/lb | Btu/gal |
| Gasoline | 14 | 0.755 | 18,500 | 116,400 | 20,170 | 126,900 |
| Aviation Gasoline | 15 | 0.705 | 19,040 | 112,000 | 20,440 | 120,200 |
| Jet Fuel | 15 | 0.816 | 18,560 | 126,200 | 19,810 | 134,700 |
| Diesel Fuel | 16 | 0.853 | 18,360 | 130,900 | 19,500 | 138,840 |

## ENERGY CONSUMPTION DATA FOR SHORT-RANGE COMMUTER AND LOCAL SERVICE AIRCRAFT

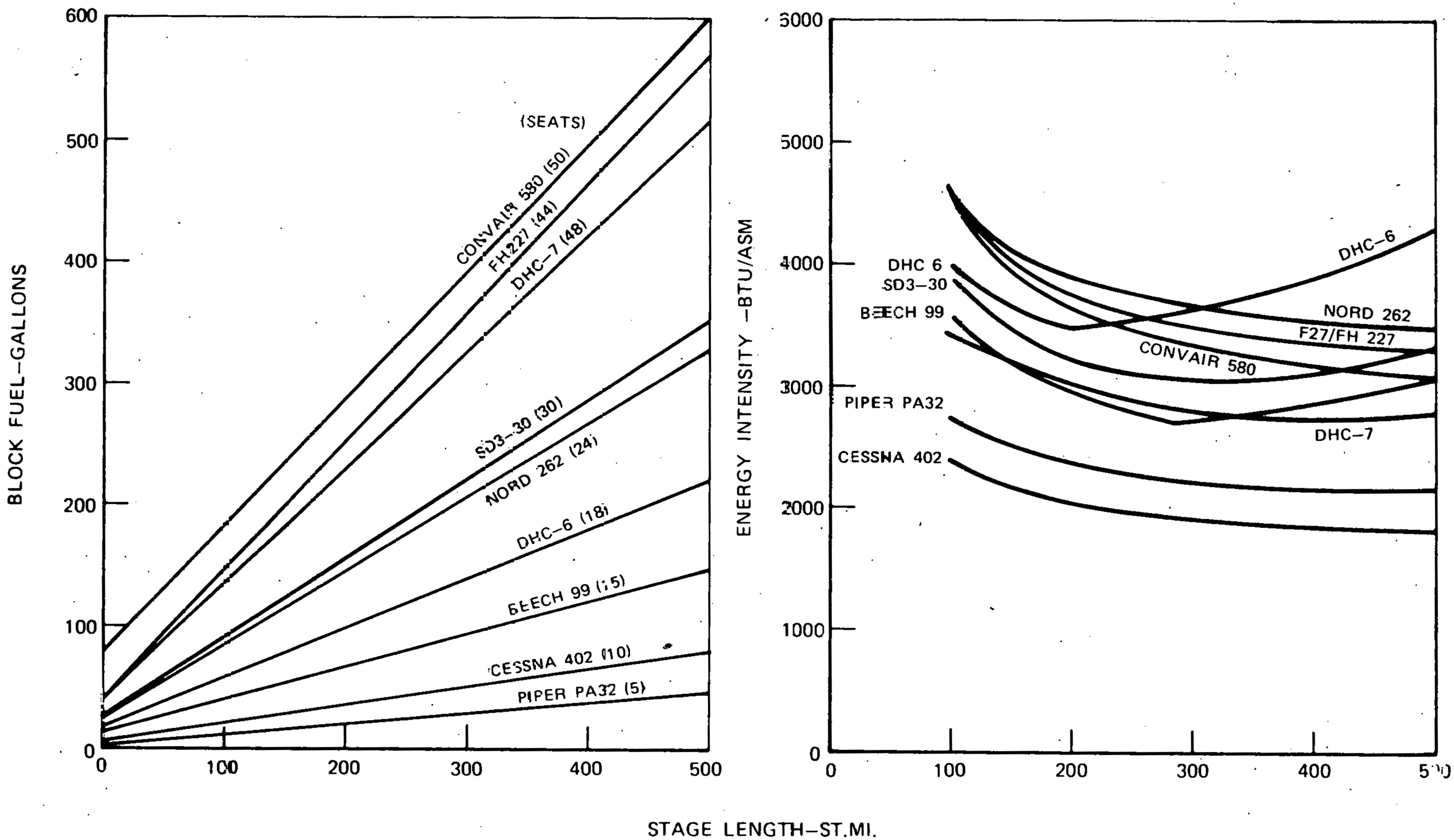



FIG. 3



76-05-39-1

Figures 4 and 5 present block fuel and energy intensity for the turbofan-powered airplanes in use with local service and domestic trunk airlines. Figure 4 shows the performance for the medium-range 2- and 3-engine turbofan-powered transports, with energy intensity of representative aircraft from Fig. 3 in dashed curves to add perspective. These medium-range transports show energy intensities as much as three times that of the commuter airplanes at ranges less than 200 miles. However, at ranges greater than 200 miles, the fuel intensities of the DC-9-30 and B-737-200 aircraft become equal to or better than the turboprop airplanes (such as the Convair 580) used by local service airlines. Figure 5 presents block fuel and energy intensity for long-haul trunk airplanes, with representative aircraft from Figs. 3 and 4, again to show perspective.

Figure 6 summarizes the energy intensities of all classes of aircraft considered. It is evident that the large airplanes are inefficient at ranges less than 500 mi, but at longer ranges have fuel intensities equal to or better than the smaller turboprop-powered transports.

Automobile Fuel Consumption

Fuel consumption of automobiles on intercity trips is subject to a wide range of variables: vehicle mix, driver habits, highway speeds, and terrain variations. Vehicle variations include automobile size, weight, model year distribution, power options, and mechanical condition. Since adequate source data are not available to treat the effects of all of these factors on fuel economy explicitly, an "average" automobile was defined. The definition is intended to represent the population of automobiles that will be on the highways in 1980. It accounts for such considerations as sales-weighted automobile size, model year distribution, and EPA fuel economy ratings.

Figure 7 shows the automobile sales-weighted fuel economy (SWMPG) for car model years from 1967 to 1980. The SWMPG for car model years 1967 to 1975 are taken from Ref. 17; the SWMPG values for 1978 to 1980 are the 1975 Congressionally mandated levels (Ref. 18) imposed on the automobile industry for those years.

To achieve the 1980 MPG level will require improvements of about 25 percent over the fuel economy typical of pre-emissions control automobiles (1957 to 1967 models). Figure 8 shows the 1957-1967 levels of fuel economy as a function of car inertia weight (Ref. 19), and the potential 1980 improvements and theoretical limits for conventional engines quoted by the task force on motor vehicle goals (Ref. 20)*. Also shown on Fig. 8 is the level of fuel economy for a 25 percent increase over pre-emissions control automobiles.

* Reference 21 also shows levels of fuel economy similar to the 1975-1985 theoretical limit of Ref. 20.

(Test continues on Page 39)

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## ENERGY CONSUMPTION DATA FOR MEDIUM-RANGE TRUNK AND LOCAL SERVICE AIRCRAFT

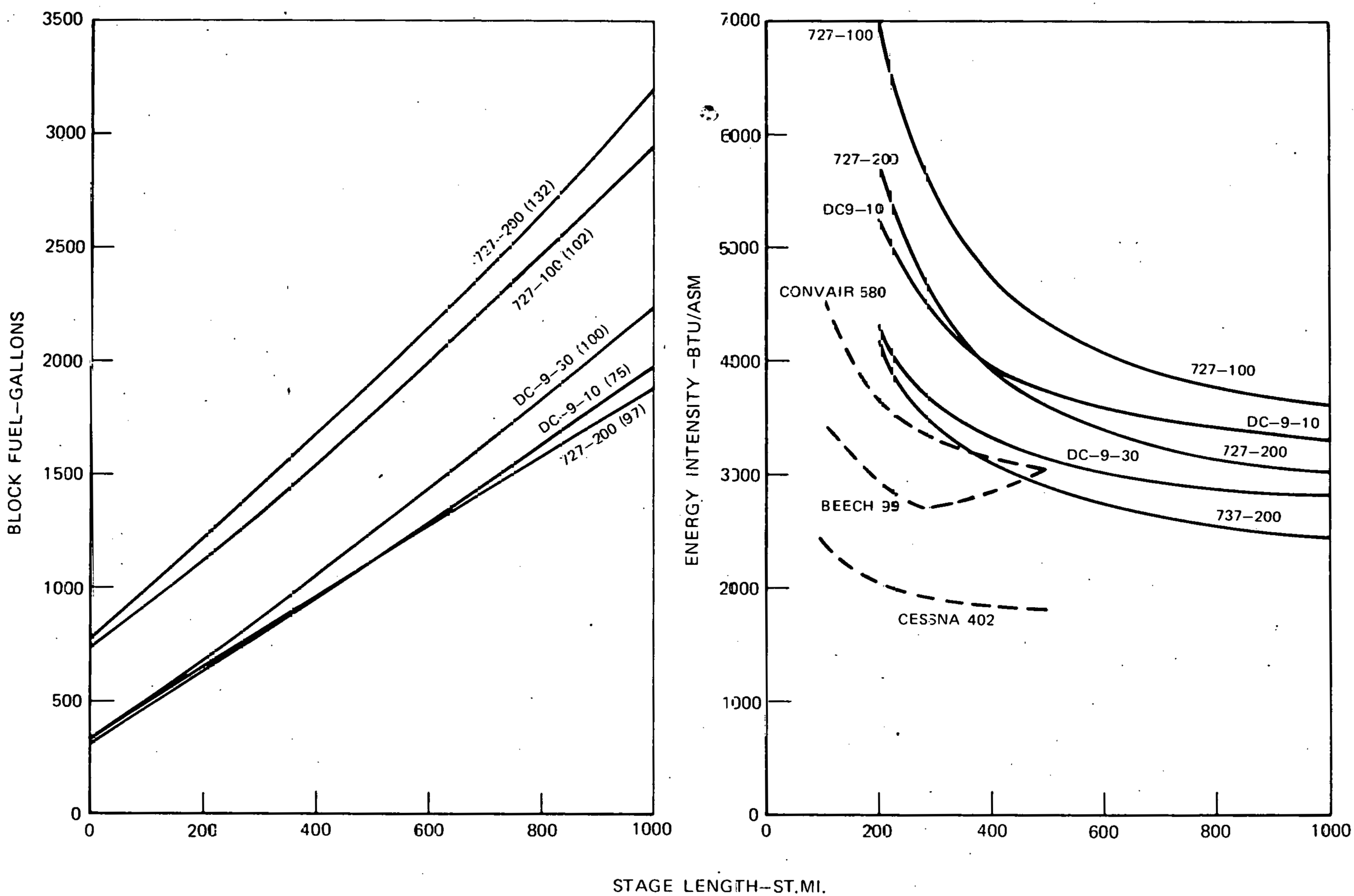



FIG. 4

76–05–39–3

## ENERGY CONSUMPTION DATA FOR LONG-RANGE TRUNK AIRCRAFT

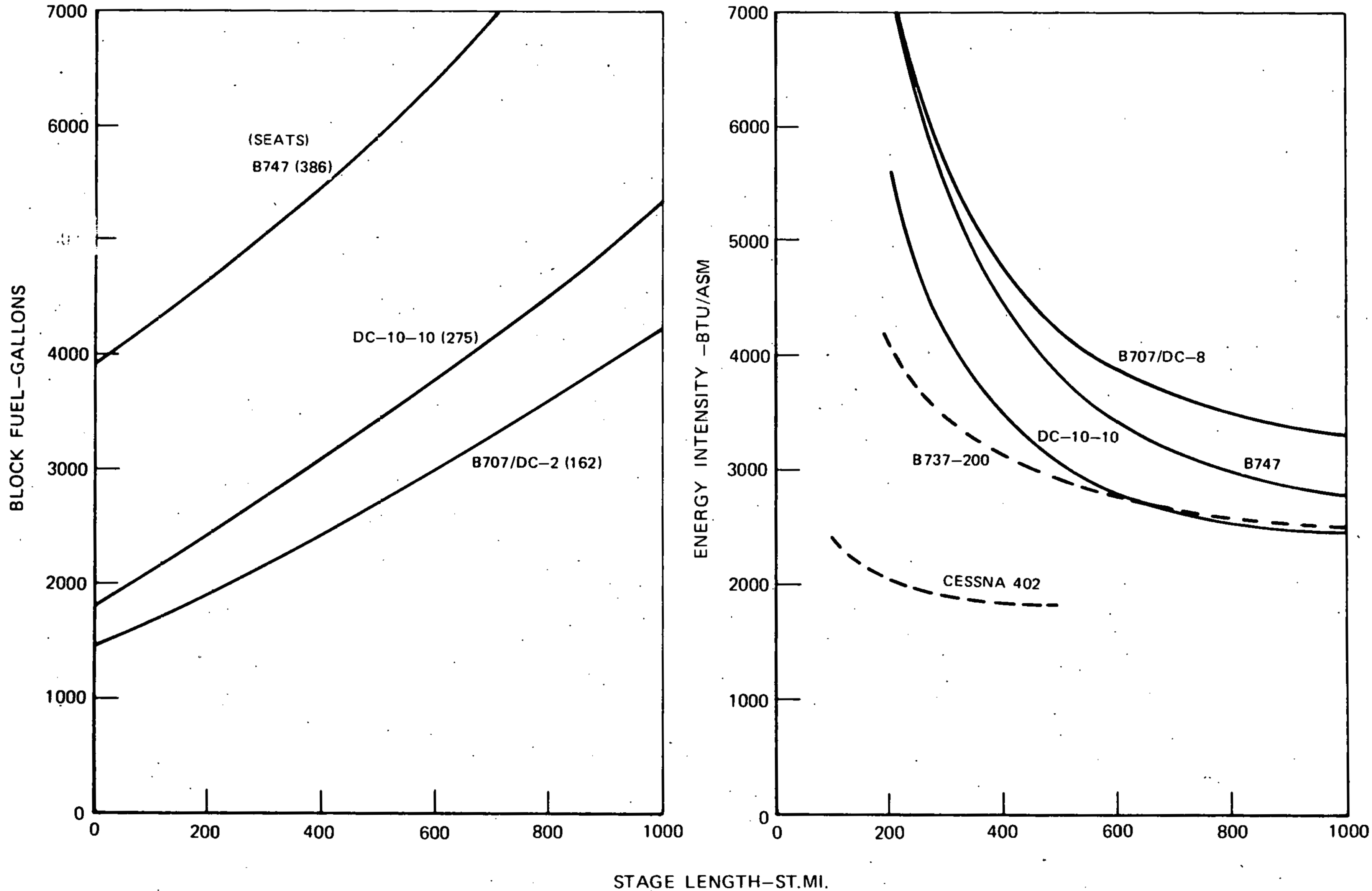



FIG. 5

76-05-39-2

## COMPARISON OF ENERGY INTENSITY

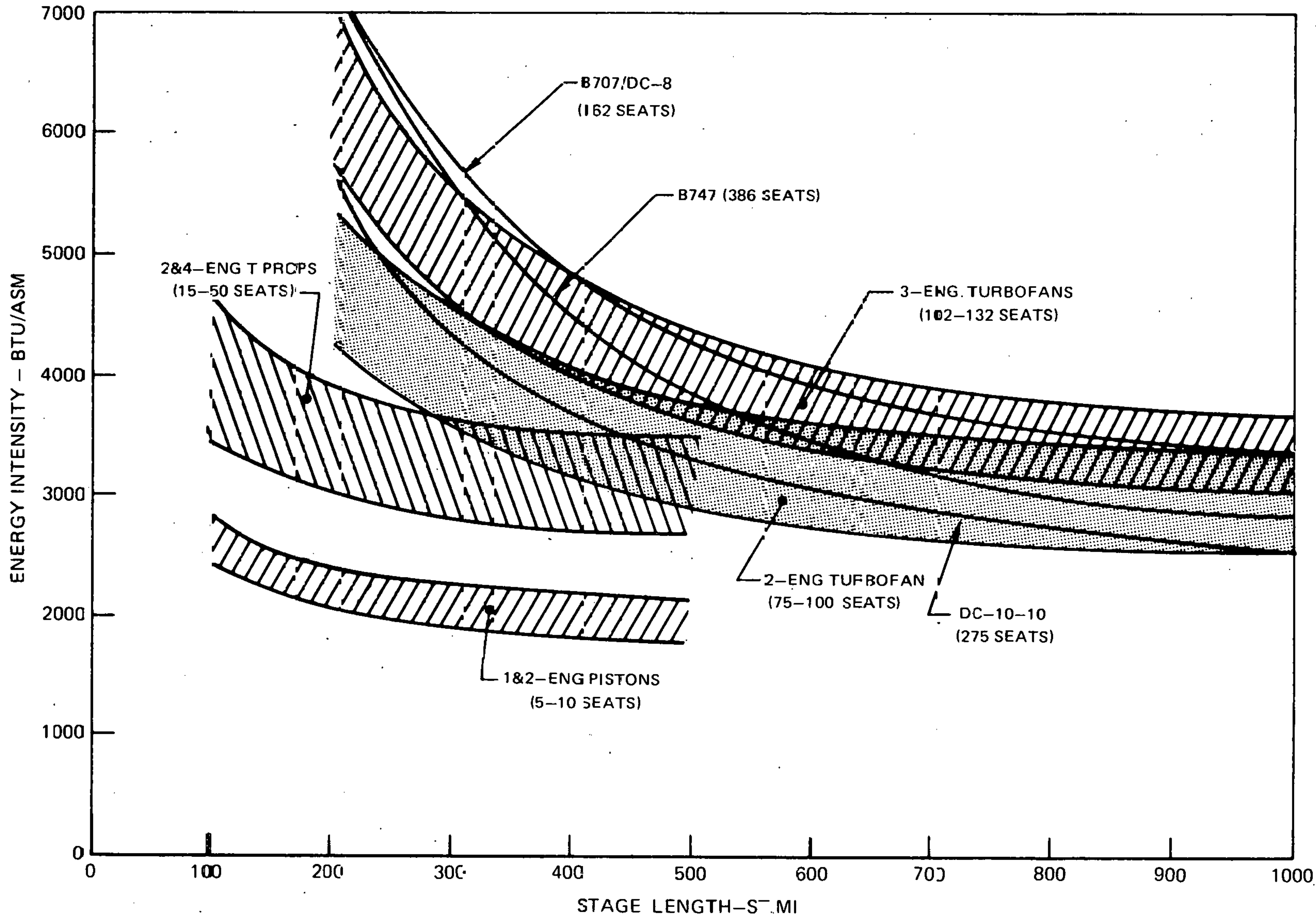



FIG. 6



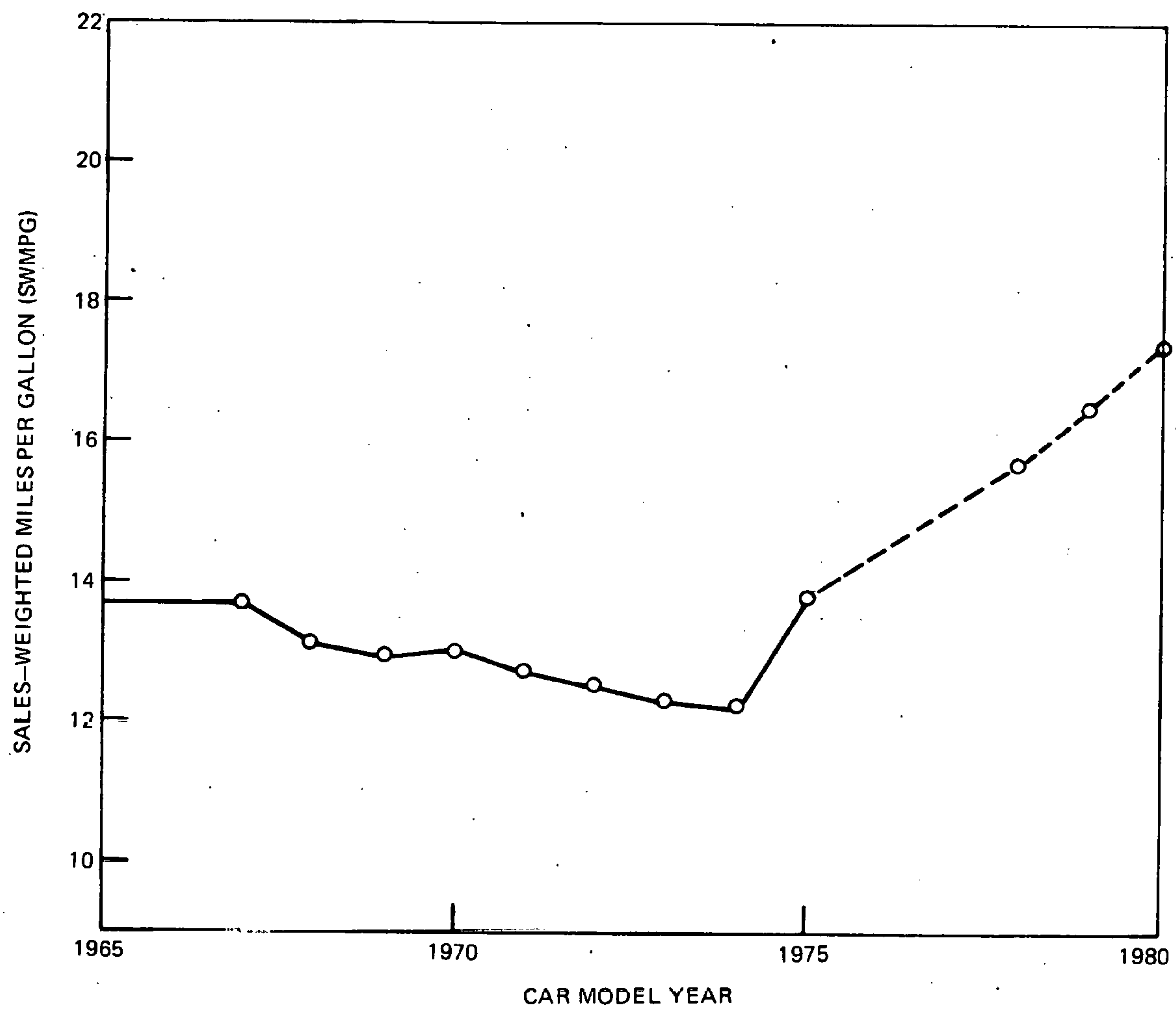
76–05–39–4

**AUTOMOBILE FUEL ECONOMY**
(URBAN DRIVING CYCLE)

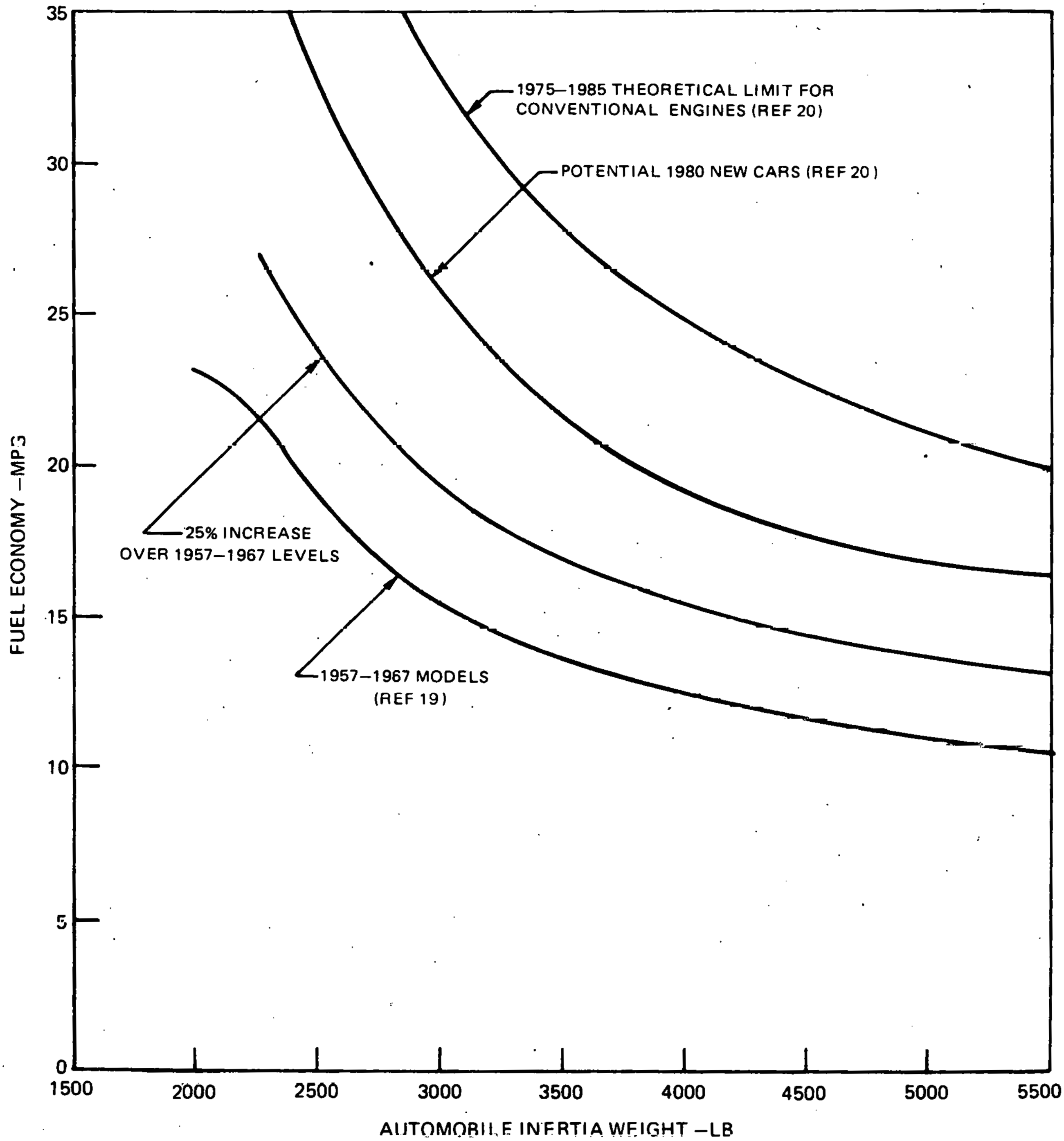
$$SWMPG = \frac{1}{\sum \frac{S_i}{MPG_i}}$$

$S_i$ – SALES FRACTION OF AUTOMOBILE CLASS i

$MPG_i$ – FUEL ECONOMY (MI/GAL) OF AUTOMOBILE CLASS i



# AUTOMOBILE FUEL ECONOMY VARIATION WITH VEHICLE WEIGHT
(URBAN DRIVING CYCLE)

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Based on 1980 sales fraction estimates (Ref. 22) shown in Fig. 9, the SWMPG of 1980 model year cars was estimated for the three projected 1980 fuel economy levels shown in Fig. 8. As can be seen in Table XIV, the assumed 25 percent increase over 1957-1967 cars comes close to achieving the 17.3 MPG target mandated by Congress for 1980 cars.

The average automobile miles per gallon (AMPG) of the fleet of cars that will be on the highways in 1980 is given by Eq. (1).

$$AMPG = \frac{\Sigma\, m_i N_i}{\Sigma\, m_i N_i / SWMPG_i} \qquad (1)$$

where

(1) i is the model year for 1960 to 1980
(2) $m_i$ is the miles traveled by cars of model year i in 1980
(3) $N_i$ is the number of cars of model year i in use in 1980
(4) $SWMPG_i$ is the sales-weighted miles per gallon of cars of model year i.

The annual miles per automobile ($m_i$) as a function of automobile age is given in Fig. 10, based on date from the 1969-1970 Nationwide Personal Transportation Survey (Ref. 24). As can be seen, the annual car miles tends to decrease from 18,000 miles in the first year to 6,600 miles for automobiles over 10 years of age.

The estimate of the population of automobiles in use in 1980, taken from Ref. 25, was combined with data from Figs. 7 and 10, as shown in Table XV, to give the 1980 average car fuel economy of 14.4 MPG. This estimate of the AMPG represents the fuel economy of the average automobile over the Federal Test Procedure (FTP) representing an urban driving cycle.

Figure 11 shows that, based on the EPA highway driving cycle, highway driving will improve fuel economy of 1975 cars by about 40 percent over the urban driving cycle. This factor can therefore be applied to convert the urban value of AMPG to give an estimate of average highway fuel economy. The result is that the urban fuel economy figure of 14.4 MPG is equivalent to 20.2 MPG for highway driving. The implicit assumption in this process is that the ratio of city fuel economy to highway fuel economy is the same for each car model year, and that the distribution of cars making intercity trips is the same as the distribution of sales in each model year. In other words, the incidence of cars on intercity trips by age and weight distribution is proportional to the original sales distribution of each car model.

Automobile fuel consumption is strongly affected by cruise speed, as indicated by test data for driving at constant speed over a level road (Refs. 26 and 12). Therefore, to model the effect of changes in highway speeds of fuel economy, the least-squares curve fit (Ref. 12) of the FHWA speed test data (Ref. 26) was weighted by the 1971 vehicle mix (Fig. 9) to obtain the variation of fuel economy with speed

(Text continued on Page 45)

TABLE XIV

SALES-WEIGHTED FUEL ECONOMY OF 1980 MODEL CARS

| Automobile Class | Weight (lb) | % Sales (Ref. 20) | Fuel Economy, MPG | | |
|---|---|---|---|---|---|
| | | | 25% Incr. Over 1957-1967 | 1980 Potential | Theoretical |
| Subcompact | 2400-2800 | 30 | 23 | 31 | 39 |
| Compact | 2800-3200 | 20 | 19 | 26 | 33 |
| Intermediate | 3600-4000 | 20 | 16 | 20 | 26 |
| Standard | 4000-4400 | 15 | 15 | 18 | 24 |
| Luxury | 4700-5400 | 15 | 14 | 17 | 21 |
| Sales-Weighted Fuel Economy (SWMPG) | | 100 | 17.6 | 22.5 | 28.7 |

TABLE XV

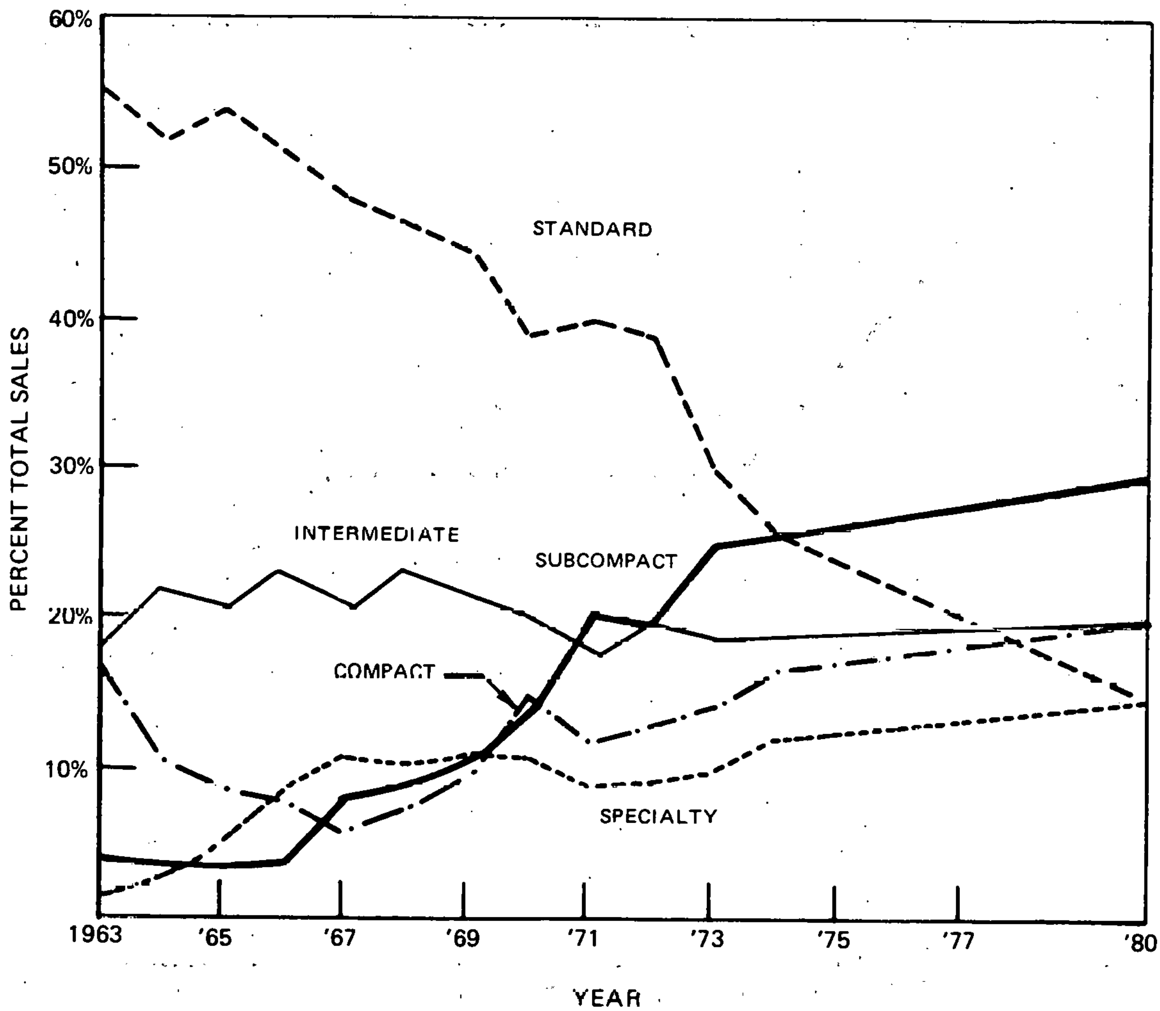
AUTOMOBILE FUEL ECONOMY IN 1980

| (1) Car Model Year | (2) Cars in Use (July 1980) $N_i$ $10^6$ | (3) Annual Car Mileage $m_i$ $10^3$ | (4) SWMPG | (5) Car Miles (2)x(3) $10^9$ | (6) Gallons Fuel (5)/(4) $10^9$ |
|---|---|---|---|---|---|
| 1980 | 8.310 | 18.0 | 17.3 | 149.58 | 8.65 |
| 1979 | 11.319 | 16.8 | 16.4 | 190.16 | 11.60 |
| 1978 | 10.804 | 14.6 | 15.6 | 157.74 | 10.11 |
| 1977 | 10.728 | 12.6 | 15.0 | 135.17 | 9.01 |
| 1976 | 10.420 | 10.5 | 14.4 | 109.41 | 7.60 |
| 1975 | 10.054 | 10.5 | 13.8 | 105.57 | 7.65 |
| 1974 | 9.274 | 10.5 | 12.2 | 97.38 | 7.98 |
| 1973 | 8.164 | 10.5 | 12.25 | 85.72 | 7.00 |
| 1972 | 6.877 | 10.5 | 12.5 | 72.21 | 5.78 |
| 1971 | 5.557 | 9.0 | 12.7 | 50.01 | 3.94 |
| 1970 | 4.337 | 7.0 | 13.0 | 30.36 | 2.34 |
| 1969 | 3.313 | 6.6 | 12.9 | 21.87 | 1.70 |
| 1968 | 2.634 | 6.6 | 13.1 | 17.38 | 1.33 |
| 1967 | 1.852 | 6.6 | 13.7 | 12.22 | 0.89 |
| 1966 | 1.420 | 6.6 | 13.7 | 9.37 | 0.68 |
| 1965 | 0.979 | 6.6 | 13.7 | 6.46 | 0.47 |
| 1964 | 0.543 | 6.6 | 13.7 | 3.58 | 0.26 |
| 1963 | 0.316 | 6.6 | 13.7 | 2.09 | 0.15 |
| 1962 | 0.169 | 6.6 | 13.7 | 1.12 | 0.08 |
| 1961 | 0.079 | 6.6 | 13.7 | 0.52 | 0.04 |
| 1960 | 0.049 | 6.6 | 13.7 | 0.32 | 0.02 |
| TOTAL | 107.198 | | | 1258.24 | 87.27 |

$$AMPG = \frac{1258.24}{87.27} = 14.4$$

# PASSENGER CAR SALES BY MARKET CLASS, INCLUDING IMPORTS

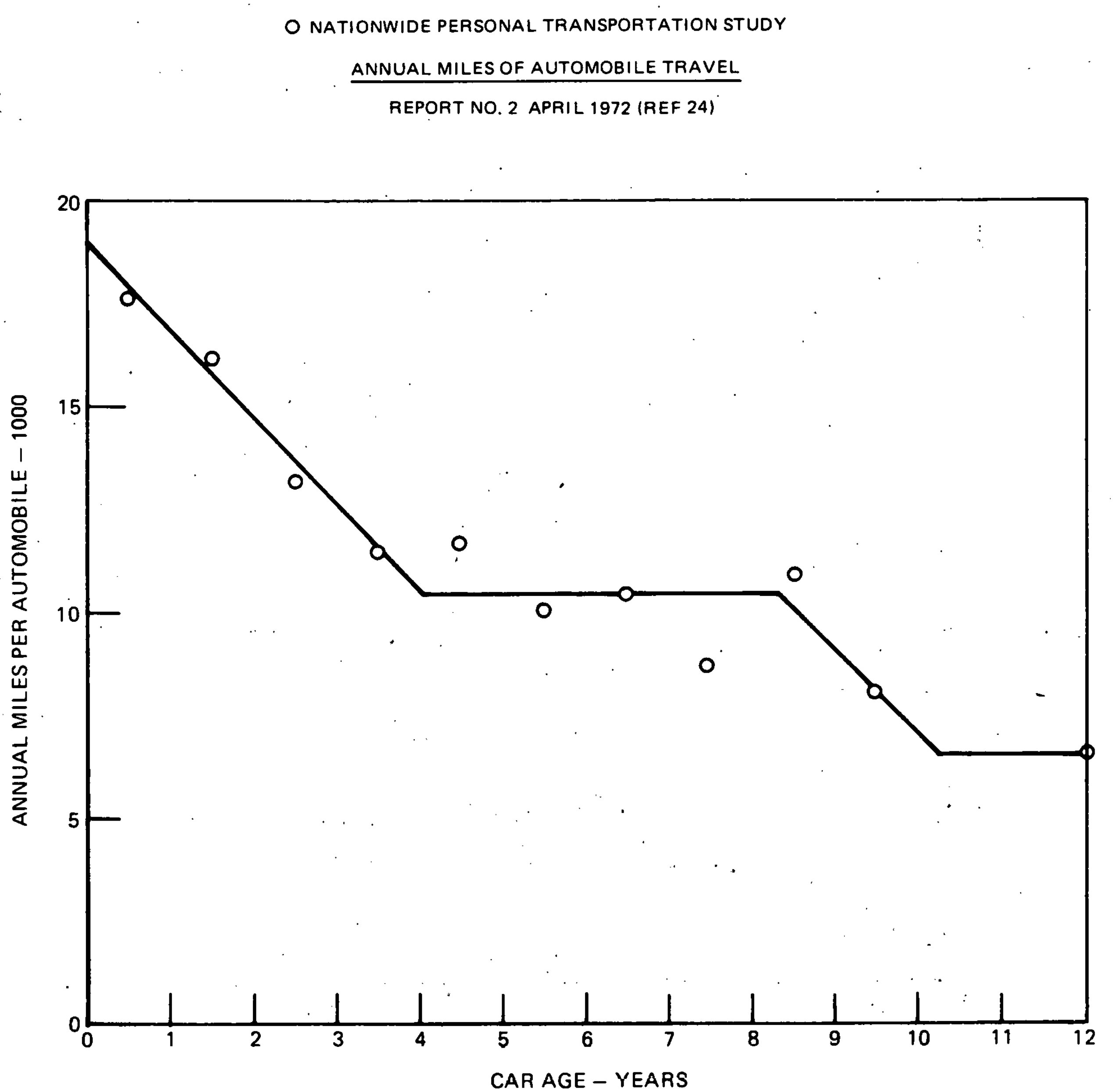
(REF 22, 23)






76–06–51–3

## ANNUAL AUTOMOBILE MILEAGE

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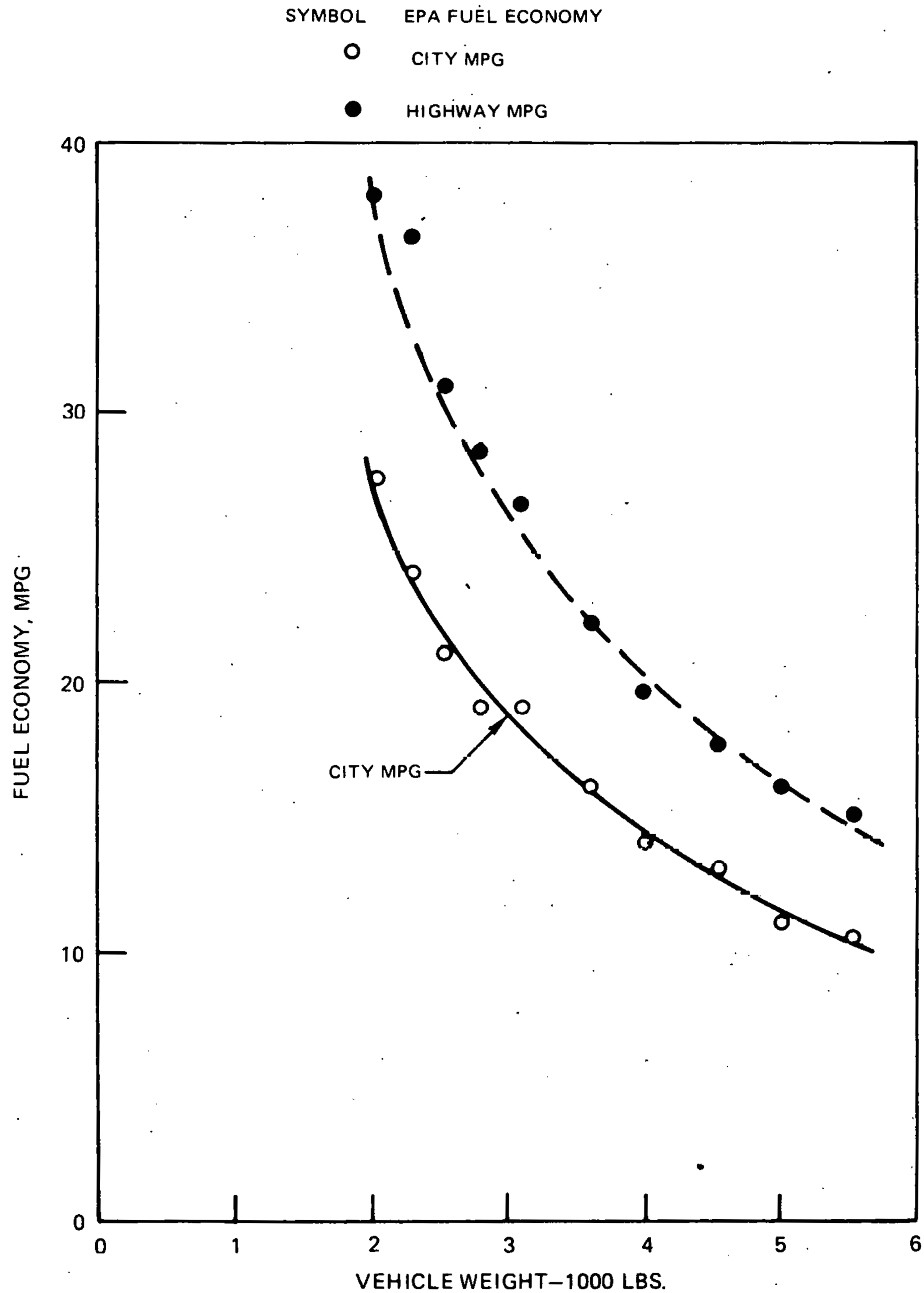
## SALES–WEIGHTED FUEL ECOMONY OF 1975 CARS BY TEST WEIGHT CLASS

(REF 17)




76–06–51–5

shown in Fig. 12. The data in Fig. 12 were first normalized to the 1971 SWMPG fuel economy of the EPA urban driving cycle (upper curve) and then adjusted to give a fuel economy ratio of 1.40 at 55 mph. Thus, the lower curve approximates speed effects on the EPA highway driving cycle. The estimated fuel economy of the average automobile in use in 1980 is tabulated in Table XVI as a function of highway cruising speed.

Having defined the "average" automobile, the fuel to travel between two cities, A and B, R miles apart, is given by Eq. (2)

$$\text{Trip Fuel} = \left[ \frac{R_A+R_B}{(AMPG)_u} + \frac{R-(R_A+R_B)}{(AMPG)_H} \right] CIR, \qquad (2)$$

where: (1) CIR is the circuity between the two cities.

(2) $R_A$ and $R_B$ are the radii of cities A and B, respectively, within which automobile fuel consumption is approximated by the weighted average city miles per gallon $(AMPG)_u$ from the Federal Test Procedure (FTP).

(3) $(AMPG)_H$ is the weighted average fuel economy for the highway portion of a trip at the specified cruise speed selected to simulate highway driving.

(4) R is the great circle distance between cities A and B.

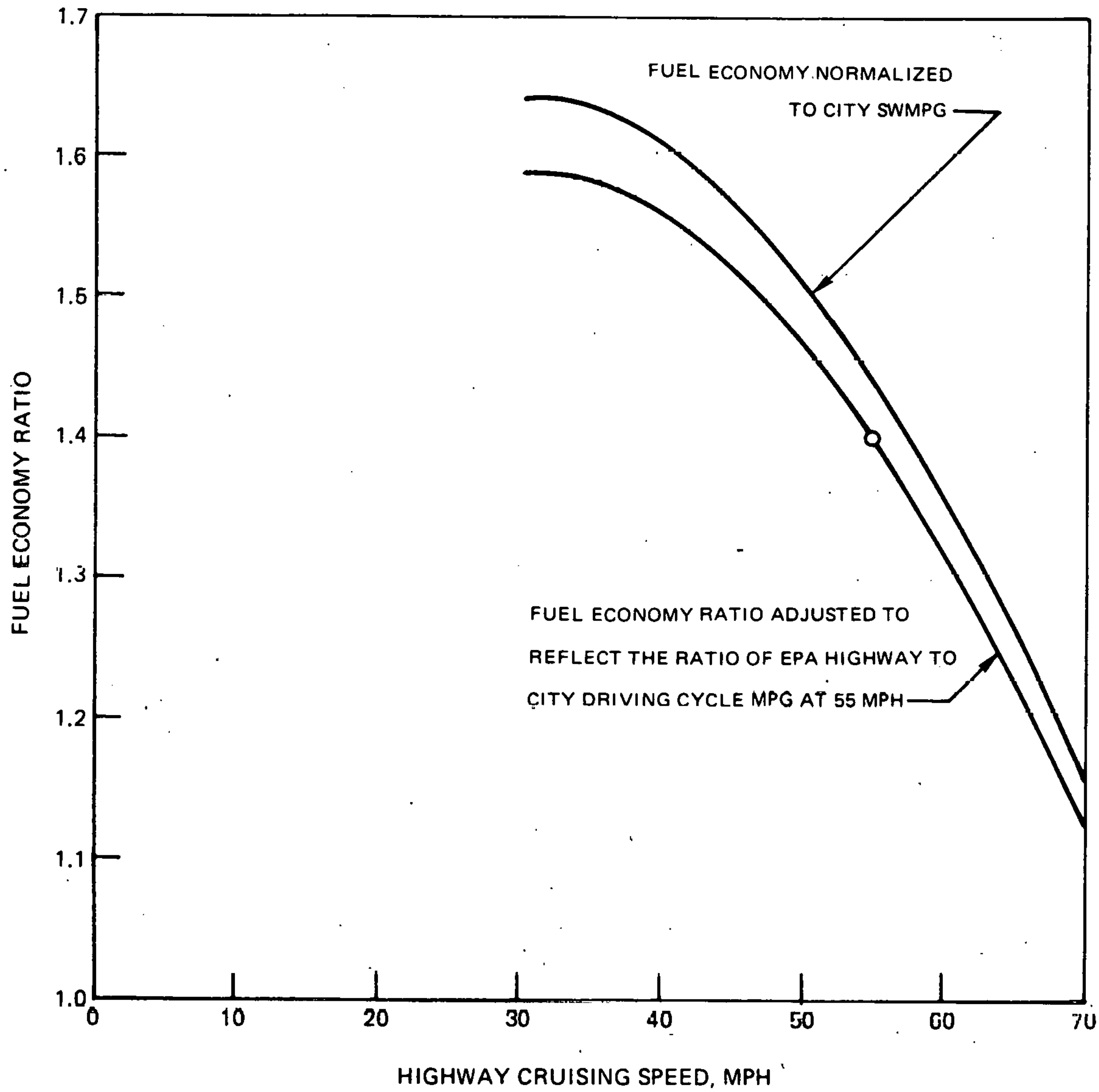
The automobile energy intensity, based on Eq. (2) and the data in Table XVI, varies between about 6000 and 8000 Btu per car route mile, as shown in Fig. 13. The automobile energy intensity shows a stronger variation with the fraction of the trip performed at highway speed than with the level of highway speed. Based on a typical circuity factor of 25 percent, and an average seating availability of 5, the automobile uses between 1500 and 2000 Btu per available seat mile. However, occupancy and type of automobile used for intercity trips will vary with the trip, as well; auto fuel economy statistics presented in the final results account for these factors.

Intercity Bus Fuel Consumption

Data for intercity bus energy intensity taken from Refs. 12 to 34 are shown in Table XVII. All data shown are for regional and national averages because intercity bus operators do not report fuel consumption data by route or type of service. Only Ref. 29 attempts to define bus fuel consumption based on a simulation of urban and highway fuel economies. Therefore, because of a lack of route-specific bus data

(Text continued on Page 50)

# EFFECT OF CRUISE SPEED ON AUTOMOBILE FUEL ECONOMY






76–06–51–6

TABLE XVI

AVERAGE FUEL ECONOMY OF
AUTOMOBILES IN USE IN 1980

| Highway Speed mph | Fuel Economy MPG | % Increase in MPG Over City Driving |
|---|---|---|
| City Driving | 14.4 | 0 |
| 30 | 22.9 | 59 |
| 40 | 22.5 | 56 |
| 50 | 21.0 | 46 |
| 55 | 20.0 | 40 |
| 60 | 18.9 | 31 |
| 70 | 16.3 | 13 |

## AVERAGE ENERGY INTENSITY OF AN AUTOMOBILE TRIP IN 1980

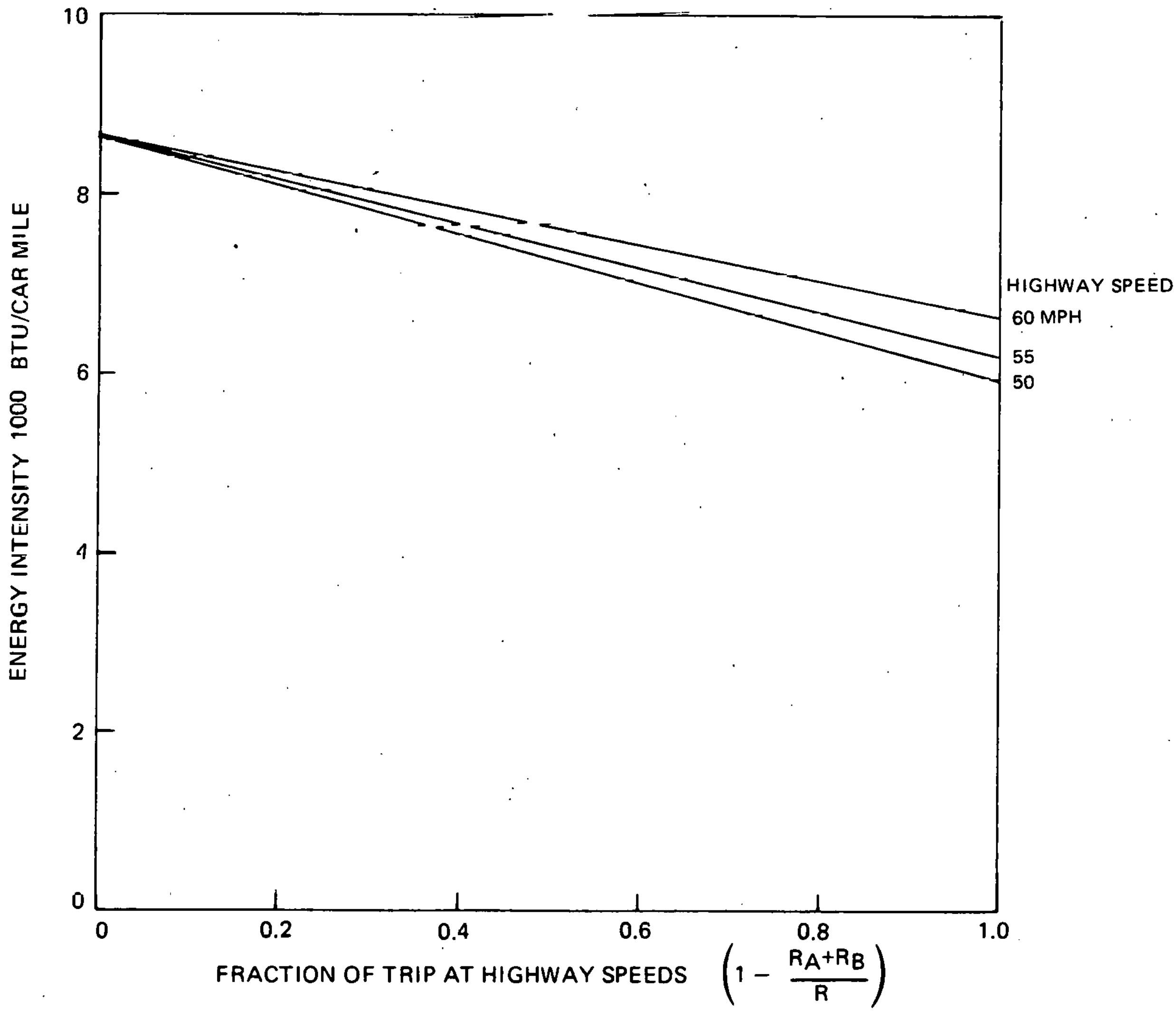


TABLE XVII

BUS FUEL USE DATA

| Number of Seats | | Fuel Economy | | | Reference | Remarks |
|---|---|---|---|---|---|---|
| Available | Passengers | MPG | ASM/GAL | RPM/GAL | | |
| 43 | NA* | 6.0 | 253 | NA | 12 | National average for all Class I buses. Seating varies between 34 to 57 |
| NA | NA | 6.2 | NA | NA | 12 | Average achieved by Greyhound |
| NA | NA | 5.5 | NA | NA | 12 | Average achieved by Trailways |
| 46 | 19.4 | 6.0 | 276 | 116.4 | 21 | Energy intensiveness for current intercity buses (1972) |
| 50 | NA | 10.0 | 500 | NA | | Possible improvement by 1985 |
| NA | NA | 4.39 | NA | NA | 27 | Average of transit and intercity buses (1972) |
| NA | NA | 8.0 | NA | NA | 28 | Limited data for bus runs with good interstate highway access. Report shows that variation of MPG with highway speed depends on terrain. In general, shows weak variation of MPG with speeds between 50 and 60 MPH |
| 46 | NA | 4.2 | 193 | NA | 29 | Estimate for urban bus driving cycle |
| 46 | NA | 7.0 | 322 | NA | | Estimate for intercity portion of trip |
| NA | 21 | 6.1 | NA | 128 | 30 | 1969 average for intercity buses, including both gasoline- and diesel-powered |
| NA | 22 | 5.5 | NA | 121 | 31 | 1970 data |
| 46 | 21 | 7.0 | 322 | 150 | 32 | Seating capacity varies between 41 to 53 with an average load factor of 46% |
| NA | 22 | 6.25 | NA | 136 | 33 | |
| NA | NA | NA | NA | 125 | 34 | Based on Texas regional data |

* NA - Not Available

on which to base the analysis, the use of typical values for bus fuel consumption was selected. However, route-specific data on bus circuity was used for all 48 representative city-pairs.

Table XVII shows that Class I intercity buses have between 34 and 57 seats, with a typical bus showing 46 seats and the national average on a seat-mile basis being 43. These buses use fuel at from 4.2 to 8.0 MPG, depending on speed, type of driving, and terrain. The national average is 6.0 MPG. Based on typical values, the intercity bus fuel data are summarized below:

| | |
|---|---|
| Average Seating | 43 |
| Bus Fuel Economy | 6.0 MPG |
| Seating Fuel Economy | 258 ASMPG |
| Energy Intensity | 538 Btu/ASM |

Consideration was given to the impact of speed limits between 50 and 60 mph on bus fuel economy, as reflected in Department of Transportation tests (Ref. 28). These tests showed that the fuel economy variations with speed are terrain-dependent, and generally small. Therefore, the effects of highway speed variations on intercity bus fuel economy were ignored.

Intercity Rail Fuel Consumption

Rail energy consumption for intercity passenger service depends, among other things, on the type of equipment, size of trains, track conditions, terrain variations, and season of the year. Since adequate source data on fuel consumption are not available on passenger trains to treat these variables explicitly for individual city-pairs, average values are used which represent operations of various types of trains differing primarily in power plant type. Train energy data listed in Table XVIII are divided into four categories labeled rail, diesel-electric, Metroliner, and Turboliner trains. Rail is listed as a separate class, either because the source data did not identify it further or because these data represent national averages which include electric, diesel, Metroliner, and Turboliner data. But, since electric and diesel-electric trains have about the same energy intensity (Ref. 35) and the Metroliner and Turboliner produce less than 10 percent of the rail passenger miles, the rail category data therefore reflect, basically, diesel-electric train operations. Other rail energy data are given in Refs. 12 to 46.

In each train category, the data tend to fall into two groupings, high and low energy intensity, with the low energy intensity being about half the high energy intensity. The difference between the two groupings is typified by the data presented by Boeing (Ref. 12) and Aerospace Corp. (Ref. 42) for diesel-electric trains. The Boeing analysis includes the effect on fuel consumption of block speed, grade and track variation, scheduled stops, air-conditioning (passenger compartment heating and cooling), and auxiliary requirements, whereas the Aerospace analysis considers only block speed effects. Heating alone can account for up to 25 percent of the energy requirements during the winter months; therefore, to more nearly represent the rail energy consumption, the average of the higher levels of energy intensity given in Table XVIII are used and values which represent cruise performance only are ignored. The recommended train energy intensities are listed below.

| Train | Energy Intensity Btu/AMS |
|---|---|
| Electric | 1200 |
| Diesel-electric | 1200 |
| Metroliner | 1550 |
| Turboliner | 1400 |

Using these data, train types and schedules appropriate to representative city-pairs were determined and composite train energy intensity values calculated. Specific train consists corresponding to current service were not considered; consequently, when a long-distance, full-service train is used for short-haul operations the higher fuel intensity was not accounted for. This simplification gives some small benefit to the rail mode.

Cargo Carried on Passenger Vehicles

A factor which was not explicitly accounted for in the energy data base is the credit to a mode for its ability to carry cargo (freight, mail, express) in addition to passengers. Such a credit would result in a reduction in the apparent energy intensity of a mode by apportioning some part of the fuel consumed to cargo, the remaining part being that associated with carrying passengers. This process would have an effect on modal comparisons if different modes carry different percentages of their payloads in cargo. While data on these percentages are not conveniently available, some insight can be gained for the public modes. The problem arises when trying to determine such a percentage for the auto mode which dominates intercity travel. It would appear that the only means of determining the cargo percentage in intercity auto trips would be by means of a survey which, to be done comprehensively, would be a large and expensive task. Accordingly, the tacit assumption was made that all modes would be equally affected by a cargo correction to fuel intensity so that the correction would, in effect, wash out.

However, it is interesting to compare the public modes in this respect so that judgmental factors can be applied to the study results should the correction appear to be different for each of those modes. Table XI has been prepared to provide this comparison. Data are available from the sources noted to provide a direct comparison in terms of revenue for passenger and cargo operations. For domestic trunk air carriers (all distances) in 1974, 9.4% of revenue was derived from the three identified classes of cargo (freight, mail, and express). The local service airlines earned about 6.1% from cargo, probably a closer reflection of the short-haul situation than the trunk carriers as a whole. The regular-route intercity bus carriers, on the other hand, earned some 16.1% of revenue from the transport of mail and express shipments. The rail mode, as represented by Amtrak operations, earned 3.0% from combined mail and express shipments.

TABLE XI

CARGO CARRIED ON PASSENGER VEHICLES - 1974

| | Domestic Trunk Air Carrier (1) | Local Service Air Carrier (1) | Regular-Route Intercity Bus (2) | Amtrak (3) |
|---|---|---|---|---|
| Revenue ($$10^6$) | | | | |
| Passenger (intercity) | 8510 | 1091.1 | 643.3 | 217.1 |
| Freight | 575 | 49.7 | - | - |
| Mail | 158 | 17.0 | 1.9 | 6.09 |
| Express | 26 | 4.1 | 122.0 | 0.68 |
| ΣNonpassenger | 759 | 70.8 | 123.9 | 6.77 |
| Total Pass. & Nonpass. | 8037 | 1161.9 | 767.2 | 223.9 |
| Nonpassenger % | 9.4 | 6.1 | 16.1 | 3.0 |
| Service ($10^6$ ton-mi) | | | | |
| Passenger Equiv. (4) | 11762 | 1081 | 1460 | 410.2 |
| Freight | 2245 | 68.6 | - | - |
| Mail | 620 | 33.4 | NA | NA |
| Express | 71 | 6.9 | NA | NA |
| ΣNonpassenger | 2936 | 108.9 | NA | NA |
| Total Pass. & Nonpass. | 14698 | 1189.9 | NA | NA |
| Nonpassenger % | 20.0 | 9.2 | NA | NA |

(1) "Air Transport 1977," Annual Report of the U.S. Scheduled Airline Industry, AIA
(2) "One-Half Century of Service to America," Annual Report of the National Association of Motor Bus Operators (NAMBO), 1976; Class I Carriers
(3) Summary of National Transportation Statistics, Report DOT-TSC-OST-76-11, June 1976
(4) Passenger equiv. ton-mi = Rev. pass.- mi x $\frac{200 \text{ lb/pass}}{2000 \text{ lb/ton}}$

NA Not Available

Unfortunately, a comparative picture on the basis of weight is not possible due to the absence of ton-mile data for the bus and rail modes. Discussions with bus and rail officials confirm that such data are not compiled. On Amtrak, only a limited express service is offered, and mail (mostly parcel post) is carried on a contract basis on the basis of linear feet of baggage car devoted to mail. Bus express is a significant portion of revenue, and is a very popular service because of the ubiquitous nature of bus transportation.

In the lower half of Table XI, ton-mile data show that cargo constitutes about 20% of the combined cargo-plus-passenger (converted to ton-miles) loads for trunk airlines over all distances. Local service carriers carry about 9% in cargo. The local service carrier experience was assumed to be more applicable for the purposes of this study. Thus, a correction to fuel intensity values to account for cargo would be on the order of 10% for air, meaning that the 7700 Btu/RPM average for trunk and local service air carriers derived in the study would be about 7000 Btu/RPM considering only the fuel allocated to passenger transportation. A corresponding correction for bus and rail is not known, due to lack of published data. However, based on conversations with bus personnel, it is expected that cargo constitutes about 8-1/2% of the total ton-miles, about half the revenue percentage. Consequently, the bus and air percentages are apparently not too different. Data for rail are completely lacking.

Although the fuel intensities used in the study did not account for cargo, the omission does not appear to influence the results to a great extent. Whatever difference does exist would appear to favor the air mode slightly.

## Task 4 - Data Collection for Short-Haul Travelers

### Short-Haul Traveler Characteristics

The 1972 National Travel Survey (Ref. 1) was used as the primary source for short-haul traveler characteristics. Although other data sources exist, they are generally restricted to one region or city-pair and often do not represent all modes on an equal basis. The NTS, on the other hand, is a uniform sample of all intercity travelers. For this study, a special version of the NTS public-use data tape was obtained which includes the county codes for the origin and destination of each trip record.

The NTS tape was interrogated to determine average traveler characteristics for each of the 48 city-pair categories defined in Tables IV-VI. Although 23,543 of the 75,101 NTS trip records contained data for the 5311 city-pairs, there were insufficient records for many categories to form a statistically significant sample. This difficulty was circumvented by combining categories so that each had a sufficient number of records. Categories having similar demand and distance characteristics but differing in the availability of rail and/or air service were combined since the former are probably more relevant to traveler characteristics than the latter. For example, the two categories represented by Kalamazoo/Battle Creek - Lima and Poughkeepsie - Trenton were combined because the latter had insufficient records. Both categories are of short distance and low density with no air service; they differ only in the availability of rail service.

TABLE XVIII

RAIL ENERGY CONSUMPTION DATA

| Train Type | Seats | Load Factor | ASM/Gal | PM/Gal | Btu*/ASM | Btu*/PM | Reference | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| Rail | - | 37% | 106 | 39 | 1307 | 3533 | 45 | Pollard | --- |
| | - | 37% | 129 | 48 | 1100 | 2900 | 36,37 | Hirst | 1970 National average for intercity rail |
| | - | 37% | 137 | 51 | 1010 | 2730 | 31 | Fraize | --- |
| | - | - | - | 53 | - | 2620 | 38,43 | Mooz | Includes commutation and intercity rail |
| | - | - | - | 80 | - | 1700 | 41 | Hirst | References Rice as source |
| | - | - | - | 100 | - | 1390 | 30 | DOT | |
| Diesel-Electric | - | - | 106 | - | 1310 | - | 12 | AMTRAK | Empire Builder train - Seattle-Harve. Montana |
| | - | - | 82 | - | 1690 | - | 12 | Boeing | Southern Crescent train - Atlanta-Washington (est.) |
| | - | - | 137 | - | 1014 | - | 39 | IDH | --- |
| | - | 37% | 149 | 55 | 934 | 2524 | 32 | Goss | --- |
| | 360 | - | 240 | - | 583 | - | 21 | FRA | --- |
| | 457 | - | 320 | - | 434 | - | 42 | Aerospace | 1.43 Gal/Mi |
| | - | - | 241 | - | 575 | - | 33 | Rice | Cruise performance; 1940 technology |
| | - | - | 363 | - | 383 | - | 33 | Rice | Cruise performance; 1960 technology |
| | - | - | - | 69 | - | 2000 | 40 | Cooper | --- |
| Metroliner | 382 | - | 75 | - | 1850 | - | 32 | Boeing | --- |
| | - | - | 95 | - | 1467 | - | 45 | Pollard | 440 Btu/ASM (at catenary) |
| | 76/car | - | 104 | - | 1332 | - | 44 | Mod. Rail | 8.9 kwh/car mi** |
| | 382 | - | 198 | - | 700 | - | 31,39,46 | Fraize | Cruise performance at 125 mph |
| | 386 | - | 137 | - | 1014 | - | 31,46 | Fraize | Cruise performance at 160 mph |
| | 384 | - | 181 | - | 765 | - | 29 | Sokolsky | New York-Washington estimate |
| | 308 | - | 206 | - | 675 | - | 42 | Aerospace | 18.34 kwh/mi** - Boston-New York |
| | 390 | - | 194 | - | 716 | - | 42 | Aerospace | 24.56 kwh/mi** - New York-Washington |
| | - | 37% | 243 | 90 | 576 | 1543 | 32 | Goss | --- |
| | 382 | - | 318 | - | 440 | - | 21 | FRA | --- |
| | - | - | - | 77 | - | 1800 | 40 | Cooper | --- |
| Turboliner | 296 | - | 98 | - | 1420 | - | 12 | Boeing | Chicago-St. Louis AMTRAK data |
| | - | 37% | 135 | 50 | 1027 | 2777 | 32 | Goss | --- |
| | 314 | - | 204 | - | 690 | - | 31 | FRA | --- |
| | 326 | - | 224 | - | 620 | - | 31,39,46 | Fraize | Cruise performance at 125 mph |
| | 144 | - | 174 | - | 300 | - | 31,46 | Fraize | Cruise performance at 125 mph |

* Diesel fuel at 138,840 Btu/Gal (HHV)
** 11,375 Btu/kwh at 30% overall efficiency
\- Not applicable or not given

In some instances, categories consisting of only one city-pair were combined with other city-pairs likely to be similar. Thus, referring to Table IV, Los Angeles - Bakersfield was combined with Los Angeles - San Diego, which, although being higher in demand, is intuitively a better match than Detroit - Cleveland, which has about the same demand. In the unique case of Los Angeles - Las Vegas, insufficient records exist for round-trips originating in Las Vegas; average data for all short-haul trips with Los Angeles destinations were used instead.

The resulting short-haul traveler characteristics are shown in Table XIX which also gives the groupings of the city-pair categories and the total number of NTS records for each group. The characteristics shown are average travel party size, length of stay at destination, and value of time. Four values are given for each city-pair grouping, corresponding to the two major trip purposes (business, personal) and both travel directions (small SMSA-to-large SMSA and return, and large SMSA-to-small SMSA and return). The terms "small" and "large" are, of course, relative to each city-pair; thus, in the case of New York-to-Philadelphia, Philadelphia is the "small" SMSA.

Destination transportation is normally required on a trip by a public mode. It has been assumed that such transportation would be by rental car and would be 100 miles for each day of stay at destination. While 100 miles per day may be high for a short-haul intercity trip, the car rental charge is dominated by the daily rate so that a lower mileage value would not change the costs significantly. To whatever extent this assumption is high, it gives some small benefit to the auto mode in the results of the study.

These traveler characteristics, along with the modal characteristics developed in Task 2, were used to compute the travel disutilities for each mode required for the four modal splits to be performed for each zone-pair of each representative city-pair (two travel purposes, two travel directions). The values of time were computed by dividing household income by number of residents (personal travel) or number of travelers (business travel), and then dividing by 2080 (40 hours/week, 52 weeks/year). While every traveler has a unique perception of value of time, and while very few travelers would accept the above value as accurate, this evaluation, together with all other costs in the travel disutility term, does correlate well with existing travel statistics and was verified during the calibration of the UTRC Modal-Split Model. The data shown reflect the 1971 income data contained in the NTS data base; these were updated to 1980 values using projected 1971-1980 income growth. Also shown in Table XIX are business fractions of the total demand for each travel direction; these are used to combine the business and personal modal splits into an overall modal split for each city-pair.

It is important to keep in mind that the data given in Table XIX apply to the entire category represented by each city-pair rather than to just the city-pairs shown. This is appropriate, since each city-pair was used as a surrogate for its

TABLE XIX

SHORT-HAUL TRAVELER CHARACTERISTICS

| City-Pair Number | Representative City-Pair | Total NTS Records | Travel Party Size: Business Small* | Travel Party Size: Business Large* | Travel Party Size: Personal Small | Travel Party Size: Personal Large | Days at Destination: Business Small | Days at Destination: Business Large | Days at Destination: Personal Small | Days at Destination: Personal Large | 1971 Value of Time (1971 $/hr): Business Small | 1971 Value of Time (1971 $/hr): Business Large | 1971 Value of Time (1971 $/hr): Personal Small | 1971 Value of Time (1971 $/hr): Personal Large | Business Fraction: Small | Business Fraction: Large |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.<br>7.<br>18.<br>23. | New York-Albany<br>Philadelphia-Harrisburg<br>Cleveland-Detroit<br>Chicago-Milwaukee | 2242 | 1.2 | 1.3 | 2.9 | 3.1 | 2.0 | 2.2 | 2.1 | 2.2 | 7.93 | 7.33 | 2.01 | 2.48 | 0.24 | 0.18 |
| 2. | New York-Boston | 820 | 1.4 | 1.4 | 2.8 | 2.9 | 2.1 | 2.4 | 3.0 | 3.1 | 7.27 | 8.53 | 2.38 | 2.57 | 0.35 | 0.20 |
| 3. | New York- Philadelphia | 445 | 2.1 | 1.1 | 2.5 | 2.9 | 1.9 | 1.1 | 1.9 | 1.6 | 7.57 | 5.84 | 2.12 | 2.21 | 0.30 | 0.38 |
| 4. | New York-Pittsburgh | 718 | 1.2 | 1.2 | 2.7 | 2.6 | 3.4 | 3.6 | 4.2 | 3.3 | 8.51 | 9.06 | 2.20 | 1.98 | 0.41 | 0.42 |
| 5.<br>9.<br>19.<br>28.<br>38. | New York-Reading<br>Baltimore-Trenton<br>Cleveland-Mansfield<br>Dayton-Fort Wayne<br>Dallas-Killeen | 1320 | 1.3 | [illegible] | 3.2 | 3.3 | 1.6 | 2.8 | 2.3 | 2.3 | 7.18 | 6.88 | 2.03 | 1.92 | 0.19 | 0.16 |
| 6.<br>24. | Philadelphia-Albany<br>Chicago-Springfield | 1264 | 1.5 | 1.2 | 2.8 | 2.8 | 2.0 | 2.5 | 2.6 | 3.0 | 6.44 | 7.89 | 1.85 | 2.04 | 0.32 | 0.29 |
| 8.<br>41. | Baltimore-Raleigh<br>Memphis-Huntsville | 1201 | 1.4 | 1.5 | 2.7 | 3.1 | 3.0 | 2.8 | 2.8 | 2.7 | 5.88 | 6.20 | 2.06 | 1.85 | 0.33 | 0.37 |
| 10.<br>13.<br>14.<br>25.<br>35. | Washington-Binghamton<br>Albany-Reading<br>Poughkeepsie-Harrisburg<br>Milwaukee-Fort Wayne<br>Nashville-Terre Haute | 1413 | 1.4 | 1.6 | 3.2 | 3.3 | 2.5 | 1.8 | 2.9 | 2.7 | 5.64 | 5.28 | 1.72 | 1.89 | 0.20 | 0.20 |
| 11.<br>37. | Washington-Dayton<br>Atlanta-Richmond | 607 | 1.2 | 1.1 | 2.9 | 2.6 | 4.0 | 3.0 | 3.9 | 3.9 | 7.09 | 7.73 | 1.96 | 2.25 | 0.36 | 0.34 |
| 12.<br>27. | Washington-Richmond<br>Detroit-Kalamazoo | 1384 | 1.8 | 1.1 | 3.2 | 3.0 | 2.0 | 1.8 | 1.7 | 1.8 | 4.53 | 6.97 | 1.85 | 2.24 | 0.26 | 0.34 |
| 15.<br>29. | Poughkeepsie-Trenton<br>Kalamazoo-Lima | 1072 | 1.8 | 1.8 | 3.0 | 3.2 | 2.3 | 1.7 | 2.0 | 2.0 | 4.45 | 5.17 | 1.80 | 1.54 | 0.20 | 0.29 |
| 16.<br>17. | Boston-Richmond<br>Pittsburgh-South Bend | 921 | 1.8 | 1.3 | 2.8 | 2.8 | 3.2 | 3.0 | 4.6 | 4.4 | 5.46 | 7.11 | 1.82 | 1.88 | 0.26 | 0.27 |
| 20.<br>32. | Chicago-Oshkosh<br>St. Louis-Nashville | 727 | 1.3 | 1.5 | 2.9 | 2.9 | 2.3 | 2.9 | 2.8 | 2.8 | 6.16 | 6.37 | 1.76 | 2.00 | 0.30 | 0.29 |
| 21.<br>30. | Chicago-Detroit<br>St. Louis-Kansas City | 1293 | 1.5 | 1.4 | 2.8 | 2.5 | 2.3 | 3.0 | 2.6 | 2.8 | 8.23 | 7.27 | 1.70 | 2.07 | 0.31 | 0.35 |
| 22.<br>39. | Chicago-Memphis<br>Dallas-Memphis | 1120 | 1.6 | 1.2 | 2.9 | 2.9 | 2.9 | 3.1 | 4.3 | 4.4 | 7.04 | 8.29 | 1.92 | 2.16 | 0.39 | 0.34 |
| 26.<br>36. | Detroit-Fort Wayne<br>Atlanta-Huntsville | 1390 | 1.4 | 1.3 | 3.3 | 3.1 | 1.9 | 1.9 | 1.9 | 2.3 | 5.43 | 6.71 | 1.69 | 2.21 | 0.34 | 0.24 |
| 31.<br>33.<br>42. | St. Louis-Lima<br>Kansas City-Terre Haute<br>Tulsa-Springfield | 729 | 1.6 | 1.3 | 2.9 | 3.6 | 3.9 | 3.3 | [illegible] | 3.6 | 6.49 | 7.47 | 1.82 | 1.82 | 0.22 | 0.21 |
| 34.<br>48. | Nashville-Huntsville<br>Birmingham-Montgomery | 2215 | 1.5 | 1.3 | 3.1 | 3.6 | 1.9 | 2.0 | 1.7 | 1.6 | 6.06 | 6.31 | 1.70 | 1.48 | 0.25 | 0.26 |
| 40. | Dallas-Tulsa | 830 | 1.5 | 1.3 | 2.9 | 3.0 | 2.2 | 2.8 | 3.2 | 3.1 | 5.65 | 8.13 | 1.82 | 2.17 | 0.35 | 0.36 |
| 43.<br>45. | Los Angeles-San Francisco<br>Los Angeles-Sacramento | 704 | 1.3 | 1.3 | 2.9 | 2.7 | 2.5 | 2.2 | 3.8 | 4.9 | 8.89 | 8.54 | 2.40 | 2.28 | 0.35 | 0.29 |
| 44.<br>47. | Los Angeles-San Diego<br>Los Angeles-Bakersfield | 919 | 1.4 | 1.8 | 3.7 | 3.0 | [illegible] | 2.4 | 2.2 | 1.9 | 6.19 | [illegible] | 1.57 | 2.19 | 0.24 | 0.17 |
| 46. | Los Angeles-Las Vegas | [illegible] | 1.4 | 1.4 | 3.3 | 2.3 | 2.0 | 1.8 | 2.8 | 2.3 | 7.37 | 5.58 | 1.87 | 2.38 | 0.29 | 0.12 |
| Total or Avg. for 5311 City-Pairs | | 23543 | 1.5 | 1.4 | 3.0 | 3.1 | 2.3 | 2.4 | 2.5 | 2.6 | 6.56 | 6.95 | 1.87 | 2.03 | 0.28 | 0.26 |

*The notation "small" and "large" refer to origin SMSA.

category; also, insufficient data exist for most individual city-pairs. It was found that the standard deviations of many of the data elements in Table XIX were fairly large; however, this is at least partly due to the discrete nature of the data. Party size and days at destination have only integer values, while household income is given only as a broad range, with most travelers having incomes in the three highest and broadest categories ($10K-$15K, $15K-$25K, and $25K+). Thus, despite high standard deviations, the differences between the data for each city-pair group and the overall 5311 city-pair averages shown at the bottom of the table are probably significant. Some of these differences are readily explained by the differences among the city-pair groups themselves. For example, there is a strong correlation between length of stay and distance, while income (value of time) is probably related to density since higher-density city-pairs tend to involve larger cities, which in turn have higher average incomes. There is also a direct relationship between business party size and value of time due to the definition of the latter. The longer lengths of stay associated with the larger business travel party sizes probably reflect a greater tendency to combine personal and business trips in certain markets. This tendency, along with other variations in the data, is probably related to unquantifiable regional differences in travel patterns.

Travel Demand for Selected City-Pairs

To calibrate the UTRC Demand Model, it is necessary to compile historical origin-destination travel demand for as many city-pairs as possible. In previous work which concentrated on medium- to long-range travel, the paucity of such data could be circumvented by noting that such travel is dominated by the air mode and thus the O-D data compiled by the CAB are quite comprehensive. In such cases, the air demand could be divided by the air fraction to result in a fairly accurate estimate of total demand. However, for the short-haul market, air is usually not the dominant mode, and inconsistencies could be expected in following this approach.

Inasmuch as there is no central source of data for total O-D demand (or even for travel by auto which is the dominant mode in the short-haul market), it was necessary to search many different sources for whatever data are available. Aside from individual studies of discrete markets, no travel data for city-pairs which cross state lines could be found. For intrastate travel, a telephone survey of state departments of transportation for those states containing one or more of the study city-pairs uncovered useful data, at least for the dominant, auto mode. In most cases, the data source is a cordon survey conducted by the agency contacted.

The survey data were converted into total demand data by either having data for the other modes (NYC - Albany and L.A. - Las Vegas) or by adding the auto and air modes and adjusting the result for the typically small bus and rail contribution associated with such travel. These data were combined with demand data obtained from other sources and added to Table XX. In this way, data for 20 of the 48 study city-pairs were obtained, probably a sufficient sample for the purpose intended. It is

TABLE XX

1973 TOTAL DEMAND DATA

| | | 1973 Tot. Demand ($10^3$ R.T./Yr.) | Year(s) | Mode(s) | Ref(s)* |
|---|---|---|---|---|---|
| 1. | N.Y. - Albany | 1175 | 1968 | ground | 50 |
| 2. | N.Y. - Boston | 3415 | 1968,69 | all | 48,49 |
| 3. | N.Y. Phila. | 9035 | 1968 | all | 48,51 |
| 6. | Phila. - Albany | 142 | 1968 | ground | 50 |
| 7. | Phila. - Harris./York | 773 | 1963 | auto | 60 |
| 9. | Balt. - Trenton | 84 | 1968,69 | ground | 48,49,51 |
| 10. | Wash. - Binghamton | 46 | 1968 | ground | 50 |
| 12. | Wash. - Richmond | 910 | 1971 | auto | 52 |
| 18. | Cleve./Detroit | 685 | 1967 | all | 54 |
| 19. | Cleve. - Mansfield | 350 | 1967 | auto | 61 |
| 21. | Chicago - Detroit | 1355 | 1967 | all | 54 |
| 23. | Chicago - Milwaukee | 3600 | 1971 | all | 52,53 |
| 24. | Chicago - Springfield | 475 | 1971 | all | 52,53 |
| 27. | Detroit - Kal./Bat. Creek | 405 | 1966 | auto | 59 |
| 30. | St. Louis - Kansas City | 1095 | 1971 | auto | 58 |
| 43. | L.A. - San Fran./San Jose | 5170 | 1966 | auto | 55 |
| 44. | L.A. - San Diego | 10030 | 1966 | auto | 55 |
| 45. | L.A. - Sacramento | 1270 | 1966 | auto | 55 |
| 46. | L.A. - Las Vegas | 4470 | 1974 | ground | 57 |
| 47. | L.A. - Bakersfield | 2160 | 1966 | auto | 55 |

* 1973 CAB and California P.U.C. data were also used for city-pairs having significant air demand.

noted that the raw data are for many different years between 1960 and 1974. These were converted to 1973 data by applying escalation factors obtained either from the source of the basic data or by assuming O-D travel to follow the national passenger-mile trend given in Ref. 47.

In addition to calibrating the demand model against available total demand data, the Modal-Split Model was also calibrated so that, in combination with the demand model, known individual modal demands were duplicated. Modal demand data were available for all modes for the twenty city-pairs listed in Table XX as well as air demand (T/LS and/or commuter) for the remaining city-pairs.

It should be emphasized that, throughout this discussion, only SMSA-SMSA travel data are being simulated in the model. Following the Task 5 analysis of alternative individual strategies for SMSA travel, combination strategies were formulated and analyzed, and the SMSA travel expanded into the total short-haul market for final analysis and policy evaluation.

Calculation of Baseline Travel Statistics

In the next task, energy-conserving strategies were developed and then analyzed by computing travel statistics for the city-pair network and comparing them with each other and with a baseline case which is merely a projection of the present-day situation as calculated using the same methodology. Computed statistics for the baseline cases are presented in Table XXI. These data correspond to the entire short-haul (67 to 500 mile), SMSA-SMSA, transportation system (5311 city-pairs).

The pertinent baseline and all modal shift strategies are evaluated for the year 1980. Although the 1973 results are taken directly from the simulation, they are in good agreement with such sources as the 1972 National Travel Survey and the 1973 CAB Origin-Destination Survey. The major assumptions in the 1980 Baseline are:

1) Population and real income will grow as forecasted by the Bureau of Economic Analysis, U.S. Dept. of Commerce. Population projections reflect the Census Bureau's Series E projections, while per-capita, real income increases at about 3 percent annually.

2) Fares (expressed in 1973 constant-value dollars) and travel times for each mode remain unchanged from mid-1976 values, except for a 30-minute improvement in New York-to-Washington Metroliner service.

3) Service frequencies and load factors were computed according to the rationale presented on p. 64.

4) Fuel consumption remains unchanged for each vehicle type, except for auto improvements reflecting the addition of late-1970s automobiles to the fleet. (Baseline economies are: 17 MPG at 60-mph in 1973 and 20 MPG at 55-mph in 1980.)

The parameters summarized in Table XXI include: passenger-miles and the modal share captured by each of the modes*; total user cost borne by passengers; total user time experienced by passengers and the associated average speed; total energy expended and its modal distribution; and overall energy intensity.

TABLE XXI

BASELINE TRAVEL STATISTICS

| | 1973 | 1980 Baseline |
|---|---|---|
| Pass. Miles ($10^9$) | 79.845 | 100.099 |
| Modal Shares: T/LS Air | .1574 | .2274 |
| Commuter Air | .0011 | .0026 |
| Rail & Metro | .0099 | .0121 |
| Bus | .0214 | .0265 |
| Auto | .8102 | .7293 |
| Total User Cost ($10^9$\$) | 6.741 | 9.977 |
| Cost/Pass.-Mile (\$/Mile) | .0844 | .0997 |
| Total User Time ($10^9$ Hrs) | 1.714 | 2.195 |
| Time/Pass.-Mile (Hrs/Mile) | .0215 | .0219 |
| Avg. Travel Speed (MPH) | 48.2 | 47.3 |
| Total Energy ($10^{12}$ Btu) | 440.650 | 489.875 |
| Modal Shares: T/LS Air | .2847 | .3815 |
| Commuter Air | .0015 | .0036 |
| Rail & Metro | .0070 | .0085 |
| Bus | .0071 | .0089 |
| Auto | .6997 | .5975 |
| Energy Intensity ($10^3$ Btu/P. Mile) | 5.519 | 4.894 |
| (% Improvement) | - | - |
| Load Factors: (See p. 64) | | |
| T/LS Air | 53.7 | 60.4 |
| Commuter Air | 60.2 | 62.3 |
| Rail & Metro | 41.9 | 56.2 |
| Bus | 46.0 | 56.6 |
| Auto | 43.8 | 45.6 |

Note: All costs in 1973 \$
All distances straight-line

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* Note that the air mode has been divided into trunk and local service (T/LS) and commuter air to delineate the industry segments which use large and small aircraft.

Comparing the 1980 baseline with 1973, a 3.3 percent annual increase in demand occurs because of higher real incomes and populations. The shift from auto to other modes (mainly air) is due to the longer auto travel times caused by the 55-mph speed limit, as well as increases in real income which create a stronger preference for the high-speed, higher-cost air mode. Both user cost/passenger-mile (expressed in constant 1973 dollars) and user time/passenger-mile increase between 1973 and 1980 due to higher fares, higher auto operating costs, and the 55-mph speed limit. However, the rise in real income is more than sufficient to offset these cost increases, so that per-capita travel increases. Because of the assumed load factor increases for 1980 on all modes, higher air seating densities, and improved auto fuel economy, energy intensity improves by 12.8 percent to 4894 Btu/passenger-mile. Thus, energy consumption grows at only 1.5 percent annually, less than half the demand growth rate.

## SECTION II - STRATEGY EVALUATION

The objective of this study was to formulate and evaluate strategies which might effect modal shifts in short-haul intercity travel to reduce fuel use. Using the analytical procedures developed in the methodology tasks (Tasks 1 to 4 in Fig. 1), Tasks 5 and 6 were directed to the generation and evaluation of potential energy savings for each strategy. These tasks included the identification and quantification of individual fuel-conserving measures, formulation and further evaluation of strategies combining the most effective measures, and consideration of policy implications and cost/benefits associated with the strategies.

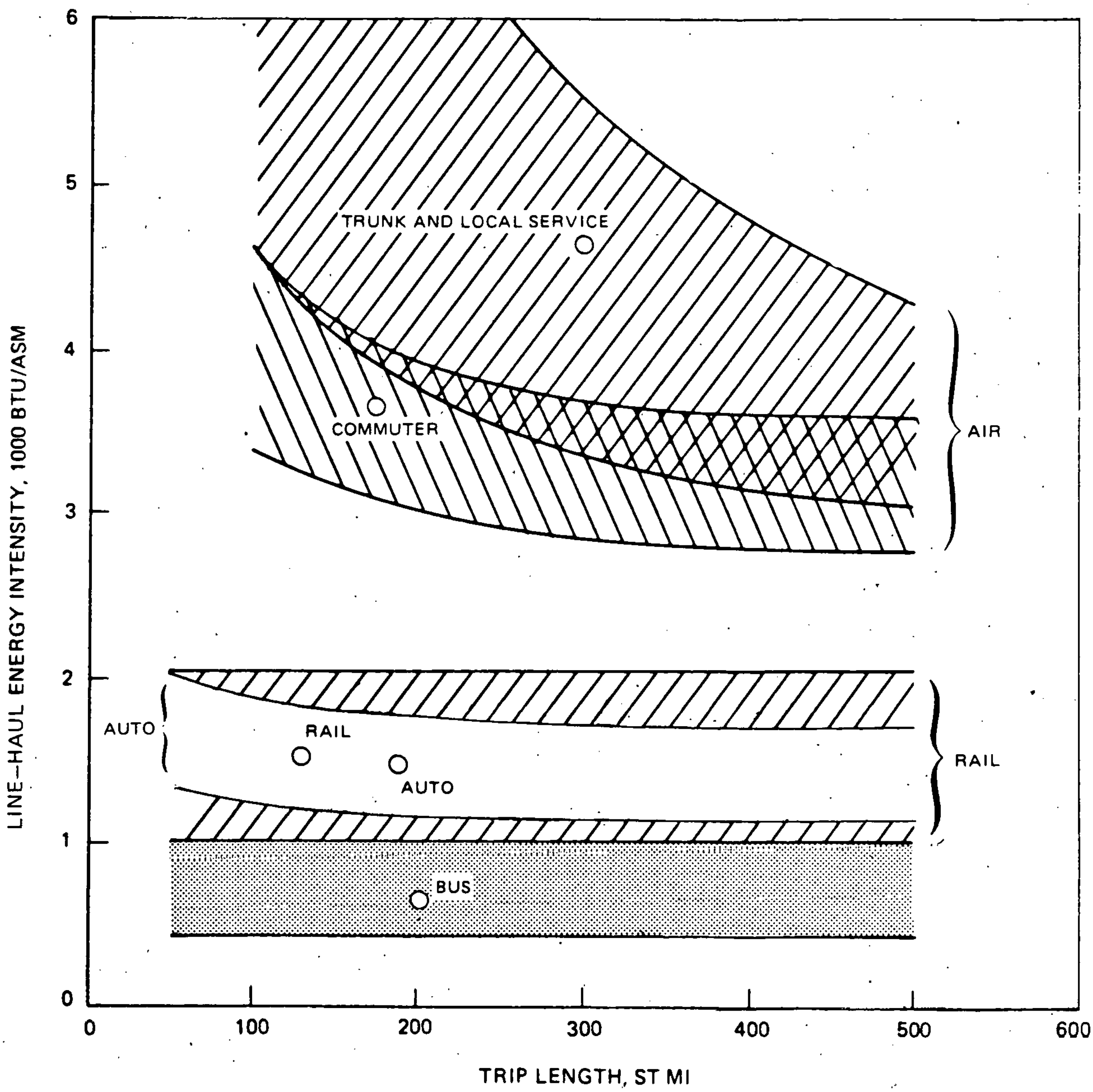
Every strategy which can be conceived to induce modal shifts will probably have the additional compound effects of suppressing travel demand or changing mode efficiency. Suppression of demand represents a limitation on freedom of mobility, but could be accomplished by more direct means if the need were great enough. Likewise, improvements in mode efficiency are being accomplished by more effective measures (improved auto fuel economy, increased aircraft efficiency) than the use of regulation or stimulation of induced modal shifts. To determine the true effectiveness of strategies to induce modal shifts, the compound effects of changes in travel demand should be normalized.

For convenience in the performance of the present study, it was decided to first assess the effectiveness of individual strategies on the basis of total energy savings including the compound effects of changes in demand and mode efficiency. This approach provided a preliminary screening to identify strategies which could then be combined to give an indication of maximum potential savings resulting from modal shifts. In the subsequent analysis of combination strategies, the energy savings resulting directly from induced modal shifts are determined, together with the savings attributable to the effects of demand suppression and improvements in mode efficiency.

### INDIVIDUAL MODE-SHIFT STRATEGIES

The general conclusion of the energy data base analysis of Task 3 was that the least energy-intensive short-haul, intercity, travel mode is bus; this conclusion is widely accepted. Considerations which influence the relative energy intensities of rail, auto and air include: load factor; spread and mix of vehicle types; fuel or energy source; speed, altitude, operator and terrain variations; circuity; maintenance effects; and Federal and state regulations. Even though shifts from all modes to bus might be universally acknowledged to produce energy savings, additional savings must be considered through shifts among the other modes. The energy intensity comparison in Fig. 14 is a useful starting point. This diagram incorporates the

ENERGY INTENSITY COMPARISONS
BTU/ASM

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findings of the Task 3 effort, described earlier, in a plot of Btu/ASM vs intercity distance (noncircuitous miles). It also includes assumed seating densities and proposed auto fuel efficiency for 1980. The spread in energy intensity of each mode is caused by equipment and circuity variations; the circled points were computed using average values for the 48 representative city-pairs analyzed in detail in this study.

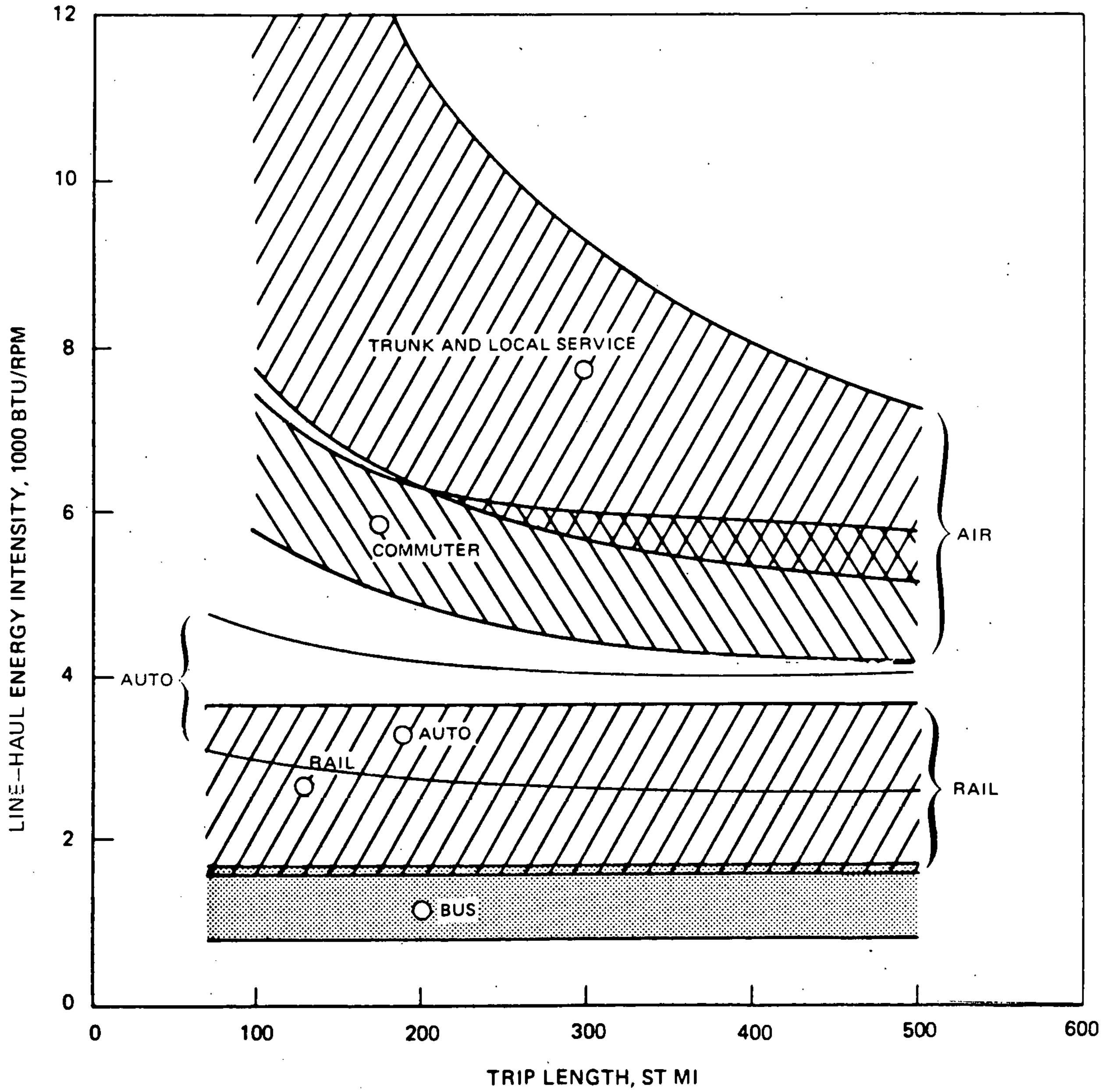
Based on the relative energy intensities depicted in Fig. 14, air and bus are shown to occupy the extreme positions when load factor effects are excluded. The delineation between rail and auto is not clear, however, because of the substantial overlap between their zones. Even the average values for rail and auto compare very closely. A more definitive comparison results when projected 1980 load factors are incorporated, as in Fig. 15. All load factors used in preparing Fig. 15 are somewhat higher than 1973 base values, as shown below:

| | Load Factor, % | |
|---|---|---|
| Mode | 1973 | 1980 |
| Auto | 43.8 | 45.6 |
| Bus | 46.0 | 56.6 |
| Rail | 41.9 | 56.2 |
| T/LS Air | 53.7 | 60.4 |
| Commuter Air | 60.2 | 62.3 |
| Overall | 45.2 | 48.7 |

In projecting load factors for 1980, service frequencies for rail, bus and commuter air were held at current levels unless demand would force load factor above 65%, in which case frequency was increased. (For rail, however, half of the demand growth was accommodated by lengthening trains and only the other half by adding new trains.) Because of routing restrictions, trunk and local service air load factors were prespecified from 0 to 12% above 1973 levels, reflecting an overall load factor increase from 54% to 60%, and frequencies are calculated accordingly. The equipment mix on each route remained unchanged, except that 50% of all trunk/local service turboprops and four-engined, narrow-bodied aircraft were replaced (on a one-for-two basis) by DC-9-30 and wide-body tri-jets, respectively. Seating capacities were increased from 1973 levels for three- and four-engine aircraft, reflecting current trends. Auto seating capacities were decreased slightly from 5.1 in 1973 to 4.9 in 1980 in accordance with the projected shift to smaller cars during the 1970s.

The above load factors were used in Fig. 15 for purposes of illustration only. All computations in the strategy evaluation utilized the calculated party size, for both personal and business travel (as it varied among modes), which is more a function of city-pair (see Table XIX) than of distance, per se. The city-pair effect is responsible for the wide scatter in correlations of auto occupancy rate with distance, such as given in Ref. 12.

## ENERGY INTENSITY COMPARISONS
BTU/ REV. PASS–MI.




77–01–84–2

Since auto is the dominant short-haul intercity mode, the largest total energy saving could be achieved by shifting auto passengers to bus and rail, even though the Btu/RPM advantage indicated in Fig. 15 would be less than for air-to-ground shifts. With these considerations in mind, preliminary mode shift measures were conceived for each mode in order to identify the most effective strategies.

## Bus Improvement Measures

Four independent measures were selected to make the bus more attractive to passengers:

- Reduce fare
- Reduce trip time
- Offer destination transportation discounts
- Offer enroute meal and lodging discounts

Note that, at this point, the means by which these improvements might be effected are left unspecified. In addition, the improvements are stated in purely qualitative terms; the impact of each will vary according to its magnitude (e.g., how much of a fare reduction?). Consideration was given to realistic bounds on each improvement, including the policy and implementation problems discussed further on. As a result, the following bus improvement measures were adopted in the preliminary strategy evaluations:

- 50% reduction of bus fares (about $6.38/trip)

- 10% decrease in overall bus terminal-to-terminal time, which would require a more than 10% improvement in cruise speed to offset congestion and local street travel near each end

- $5.00 discount for bus travelers on their destination transportation costs incurred because they do not have their own cars for this purpose (about 50% of the destination transportation cost)

- 50% discount for bus travelers on the extra meal and lodging costs due to the relative slowness of the bus (about $5.34/trip)

Each of these measures was simulated as an independent modal shift strategy using the modeling approach described earlier. Results of these simulations are summarized in Table XXII, which also includes the two reference (baseline) columns described under Task 4. It should be noted that, in Table XXII and subsequent tables up to Table XXXIII, the results are restricted to only short-haul (67-500 mi) SMSA-to-SMSA travel. Once all strategies have been evaluated, the results will be expanded to the entire short-haul travel sector, including intercity travel below 67 miles and non-SMSA travel.

Each bus improvement strategy results in a significant growth in bus travel, raising its passenger-mile share from 2.85% to 3.70-5.12%; however, the number of travelers using bus remains relatively small and the impact on energy intensity is quite modest. Furthermore, enough new travel is induced by attractive bus service that total energy consumption increases rather than decreases. To properly evaluate energy savings, therefore, it is necessary to account for this increased demand. The result is the "demand-normalized energy saved" column shown in Table XXII, which is the strategy demand multiplied by the baseline energy intensity, less energy actually used. These savings thus represent the difference between the energy actually used and what would have been used had the baseline intensity prevailed. A demand-normalized saving illustrates an allowance for growth in the system without a proportional increase in energy. For the case of a 50% fare reduction, for example, total travel could increase by $1.68 \times 10^9$ passenger-miles per year (or 1.68%) without incurring an increase over the baseline energy. For the bus-improvement strategies, normalized energy savings of 0.75% to 1.69% were computed.

The three strategies which subsidize bus travel costs reduce the overall cost of bus travel by from 12% to 17%, resulting in the small decreases in overall travel costs shown in Table XXII. These are accompanied by small increases in average travel time, however, due to modal shifts to bus which is slower than auto because of its access time. The 10% bus block time-reduction strategy, resulting in an 8.2% reduction in overall bus travel time when access time is considered, raises average travel costs by shifting travelers from auto to bus, a mode having greater out-of-pocket costs. Overall travel time remains the same.

Each bus cost-reduction strategy has a directly measurable subsidy, as shown. (The time-reduction strategy, while having no direct subsidy, might have a measurable cost, e.g., the cost of establishing separate intercity bus lanes to separate the buses from slower auto traffic.) The subsidy cost per unit of (normalized) energy saved ranges from $18.12 to $20.86/10$^6$ Btu and is very high when compared to the crude petroleum cost of $2.30/10$^6$ Btu ($12/barrel). It can be concluded that improvements to the bus mode alone are not effective energy-saving strategies, either in terms of total energy saved or in terms of the subsidy cost of such savings. In combination with penalities on energy-intensive modes, however, bus improvements could be effective. Such combination strategies are considered later.

## Rail Improvement Measures

Rail improvement measures (reduce fare, reduce trip time, destination transportation discounts, and meal and lodging discounts) are directly parallel to the bus measures except that they were applied to conventional rail only and not to the Northeast Corridor Metroliner service. The reasons for excluding improvements to the Metroliner are: 1) it is a premium-fare service for which discounts and subsidies would be contradictory; and 2) its present operating speed is already high and cannot be increased appreciably without expensive right-of-way improvements.

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# TABLE XXII

## 1980 PRELIMINARY MODAL-SHIFT STRATEGY RESULTS -- ALL SHORT-HAUL SMSA-SMSA TRAVEL

### Bus Improvement Measures

| | 1973 | 1980 Baseline | Bus Improvements: 50% Fare Reduction | Bus Improvements: 10% Time Reduction | Bus Improvements: $5 Dest. Transp. Discount | Bus Improvements: 50% Meal & Lodging Discount |
|---|---|---|---|---|---|---|
| Pass. Miles ($10^9$) | 79.845 | 100.099 | 102.180 | 100.971 | 101.633 | 101.798 |
| Modal Shares: T/LS Air | .1574 | .2274 | .2214 | .2250 | .2233 | .2227 |
| Commuter Air | .0011 | .0026 | .0025 | .0025 | .0025 | .0025 |
| Rail & Metro | .0099 | .0121 | .0112 | .0116 | .0112 | .0113 |
| Bus | .0214 | .0285 | .0512 | .0370 | .0441 | .0456 |
| Auto | .8102 | .7293 | .7138 | .7238 | .7189 | .7178 |
| Total User Cost ($10^9$ $) | 6.741 | 9.977 | 10.156 | 10.095 | 10.109 | 10.121 |
| Cost/Pass.-Mile ($/Mile) | .0844 | .0997 | .0994 | .1000 | .0995 | .0994 |
| Total User Time ($10^9$ Hrs) | 1.714 | 2.195 | 2.272 | 2.216 | 2.250 | 2.256 |
| Time/Pass.-Mile (Hrs/Mile) | .0215 | .0219 | .0222 | .0219 | .0221 | .0222 |
| Avg. Travel Speed (MPH) | 48.2 | 47.3 | 46.7 | 47.3 | 46.9 | 46.9 |
| Subsidy Req'd ($10^9$ $) | - | - | .1538 | 0 | .1225 | .1185 |
| Subsidy/Bus Pass. ($) | - | - | 6.38 | 0 | 5.00 | 5.34 |
| Total Energy ($10^{12}$ Btu) | 440.650 | 489.875 | 491.758 | 490.490 | 491.510 | 491.650 |
| Modal Shares: T/LS Air | .2847 | .3815 | .3775 | .3800 | .3788 | .3784 |
| Commuter Air | .0015 | .0036 | .0035 | .0035 | .0035 | .0035 |
| Rail & Metro | .0070 | .0085 | .0080 | .0083 | .0080 | .0081 |
| Bus | .0071 | .0089 | .0161 | .0117 | .0141 | .0144 |
| Auto | .6997 | .5975 | .5948 | .5965 | .5957 | .5956 |
| Energy Intensity ($10^3$ Btu/P. Mile) | 5.519 | 4.894 | 4.813 | 4.858 | 4.836 | 4.830 |
| (% Improvement) | - | - | 1.66% | 0.74% | 1.18% | 1.31% |
| Energy Saved ($10^{12}$ Btu): Actual | - | - | -1.883 | -0.615 | -1.635 | -1.775 |
| (%) | - | - | -0.38% | -0.13% | -0.33% | -0.36% |
| Demand-Normalized | - | - | 8.132 | 3.621 | 5.784 | 6.431 |
| (%) | - | - | 1.66% | 0.74% | 1.18% | 1.31% |
| Subsidy Cost of Normalized Energy Saved ($/$10^6$ Btu) | | - | 18.91 | 0 | 21.18 | 18.43 |

Note: All costs in 1973 $
All distances straight-line

The results of the rail strategies are qualitatively similar to the corresponding bus strategies, but the effects are smaller in magnitude, as shown in Table XXIII. Three reasons for this reduced effectiveness are:

1) City-pairs having rail service represent only 41% of SMSA-to-SMSA short-haul demand, while all city-pairs have bus service.

2) Rail energy consumption is approximately twice that of bus.

3) Except in very dense corridors, the large seating capacity of a train relative to a bus prevents adequate service frequencies, except with very low load factors.

It is of interest to single out the effects of bus and rail improvements on the Northeast Corridor (NEC) city-pairs since their shares in those markets are higher than the national averages. A comparison of the NEC with all short-haul travel for bus and rail fare reductions is provided in Table XXIV; this comparison is based on the 108 NEC city-pairs which have rail service. Although these city-pairs represent only 2% of all short-haul SMSA-pairs, it can be seen that they account for 14% of the passenger-miles and energy used. Also, the modal shares in the NEC are noticeably different from the national system, bus and rail receiving much larger shares, primarily at the expense of air.

Despite the greater dependence on energy-efficient public modes in the NEC, overall energy intensity is higher among these city-pairs than for all short-haul SMSA travel. There are several reasons for this poorer energy performance, including a much shorter average trip distance in the NEC, making access a relatively more important factor, and the use of Metroliners with higher speed and energy intensity compared with conventional trains. Somewhat higher public-mode load factors in the NEC tend to compensate for these effects, but NEC energy intensity is still above the national average.

The impacts of 50% fare reductions are seen to be greater in the NEC than for all short-haul travel, particularly in the percentage improvements in energy intensity and energy saved. Modal shifts to rail and bus are more easily achieved in the NEC, thereby resulting in a larger energy saving from these shifted passenger trips.

## Auto Penalty Measures

Three measures which would stimulate shifts from auto to bus or rail were evaluated:

- Reduction in auto speed limit to 50 mph
- Increase in auto operating cost by 50%
- Establishment of auto-free zones in the central business district (CBD)

TABLE XXIII

1980 PRELIMINARY MODAL-SHIFT STRATEGY RESULTS -- ALL SHORT-HAUL SMSA-SMSA TRAVEL

Rail Improvement Measures

| | | | Rail Improvements | | | |
|---|---|---|---|---|---|---|
| | 1973 | 1980 Baseline | 50% Fare Reduction | 10% Time Reduction | $5 Dest. Transp. Discount | 50%Meals& Lodging Discount |
| Pass.-Miles ($10^9$) | 79.845 | 100.099 | 101.046 | 100.465 | 101.002 | 100.825 |
| Modal Shares: T/LS Air | .1574 | .2274 | .2254 | .2268 | .2254 | .2260 |
| Commuter Air | .0011 | .0026 | .0025 | .0026 | .0025 | .0026 |
| Rail & Metro | .0099 | .0121 | .0216 | .0152 | .0219 | .0187 |
| Bus | .0214 | .0285 | .0276 | .0281 | .0277 | .0278 |
| Auto | .8102 | .7293 | .7228 | .7273 | .7225 | .7249 |
| Total User Cost ($10^9$$) | 6.741 | 9.977 | 10.060 | 10.021 | 10.051 | 10.039 |
| Cost/Pass.-Mile ($/Mile) | .0844 | .0997 | .0996 | .0997 | .0995 | .0996 |
| Total User Time ($10^9$ Hrs) | 1.714 | 2.195 | 2.227 | 2.204 | 2.226 | 2.219 |
| Time/Pass.-Mile (Hrs/Mile) | .0215 | .0219 | .0220 | .0219 | .0220 | .0220 |
| Avg. Travel Speed (MPH) | 48.2 | 47.3 | 47.2 | 47.3 | 47.2 | 47.2 |
| Subsidy Req'd. ($10^9$$) | - | - | .0604 | 0 | .0786 | .0429 |
| Subsidy/Rail Pass. ($) | - | - | 4.69 | 0 | 5.00 | 3.73 |
| Total Energy ($10^{12}$ Btu) | 440.650 | 489.875 | 492.611 | 490.833 | 491.848 | 491.952 |
| Modal Shares: T/LS Air | .2847 | .3815 | .3795 | .3810 | .3797 | .3801 |
| Commuter Air | .0015 | .0036 | .0035 | .0035 | .0035 | .0035 |
| Rail & Metro | .0070 | .0085 | .0142 | .0102 | .0139 | .0123 |
| Bus | .0071 | .0089 | .0087 | .0088 | .0088 | .0088 |
| Auto | .6997 | .5975 | .5941 | .5965 | .5941 | .5953 |
| Energy Intensity ($10^3$ Btu/P. Mi) | 5.519 | 4.894 | 4.875 | 4.886 | 4.870 | 4.879 |
| (% Improvement) | - | - | 0.38% | 0.17% | 0.49% | 0.30% |
| Energy Saved ($10^{12}$ Btu): | | | | | | |
| Actual | - | - | -2.736 | -0.958 | -1.973 | -2.077 |
| (%) | - | - | -0.56% | -0.20% | -0.40% | -0.42% |
| Demand-Normalized | - | - | 1.881 | 0.830 | 2.424 | 1.465 |
| (%) | - | - | 0.38% | 0.17% | 0.49% | 0.30% |
| Subsidy Cost of Normalized Energy Saved ($/$10^6$ Btu) | - | - | 32.11 | 0 | 32.43 | 29.28 |

All Distances Straight-Line
All Costs in 1973 $

TABLE XXIV

EFFECTS OF BUS AND RAIL FARE REDUCTIONS IN THE NORTHEAST CORRIDOR

| | Northeast Corridor Only | | | All Short-Haul Travel | | |
|---|---|---|---|---|---|---|
| | 1980 Baseline | 50% Rail Fare Reduction | 50% Bus Fare Reduction | 1980 Baseline | 50% Rail Fare Reduction | 50% Bus Fare Reduction |
| City-Pairs | 108 | 108 | 108 | 5311 | 5311 | 5311 |
| Pass.-Miles ($10^9$) | 14.216 | 14.378 | 14.394 | 100.099 | 101.046 | 102.130 |
| Modal Shares: T/LS Air | .1669 | .1622 | .1612 | .2274 | .2254 | .2214 |
| Commuter | .0015 | .0014 | .0014 | .0026 | .0025 | .0025 |
| Rail & Metro | .0514 | .0760 | .0477 | .0121 | .0216 | .0112 |
| Bus | .0460 | .0436 | .0718 | .0285 | .0276 | .0512 |
| Auto | .7342 | .7168 | .7178 | .7293 | .7228 | .7138 |
| Avg. Trip Distance (Mi.) | 134 | 134 | 134 | 206 | 206 | 206 |
| Total Energy ($10^{12}$ BTU) | 70.413 | 70.604 | 70.264 | 489.875 | 492.611 | 491.758 |
| Energy Intensity ($10^3$ BTU/P.M.) | 4.9546 | 4.9106 | 4.8815 | 4.894 | 4.875 | 4.813 |
| % Improvement | - | 1.49% | 2.07% | - | 0.38% | 1.66% |
| Energy Saved ($10^{12}$ BTU): | | | | | | |
| Actual | - | -0.191 | 0.149 | - | -2.736 | -1.883 |
| % | - | -0.27% | 0.021% | - | -0.56% | -0.38% |
| Demand-Normalized | - | 1.046 | 1.457 | - | 1.891 | 8.132 |
| % | - | 1.49 % | 2.07 % | - | 0.38% | 1.66 % |

As indicated in Table XXV, a reduction in speed limit from 55 to 50 mph resulted in a drop in total demand of 5.6% and a shift from auto to other modes, mainly air. As a result of the shift to more costly modes, user costs/passenger-mile increase by 6.5%; despite the shift to air, however, overall travel speed declines because of the slower auto speeds. The decline in energy consumption of 6.07% is a combination of three effects: 1) the large decline in total demand, 2) improvement in automobile fuel economy from 20.0 mpg at 55 mph to 21.0 mpg at 50 mph, and 3) modal shifts. When the efficiency improvement and modal-shift effects are isolated by demand-normalization, the energy saving nearly disappears. The saving resulting from the lower speed limit (which would be 2.34% in the absence of demand and modal split changes) is nearly eliminated by shifts to air.

The second auto strategy is a 50% increase in direct operating cost from 5.4¢ to 8.1¢*/vehicle mile, as would result, for example, from a gasoline tax increase of 54¢/gallon. This strategy is similar to the Administration's proposed 5¢ per year gasoline tax included in the National Energy Plan forwarded to Congress on April 20, 1977. Again, demand declines and there is a modal shift from auto to air. Overall, average travel costs increase by 13.2%, but average travel time declines slightly due to the shift to a faster mode. The only energy-saving characteristic of this strategy is the demand reduction; when this effect is removed by normalization, the energy "saving" becomes negative, as indicated by the increased energy intensity. Even with the demand reduction and shifts from auto, federal gasoline tax receipts from short-haul travel alone increase from $93.7 million (4¢/gallon) to $1179.0 million (58¢ gallon).

The third auto strategy is the establishment of auto-free zones in the central business districts (CBD) of SMSAs having populations of one-million or more. This was simulated by adding 15 minutes and 50¢ to the time and cost of all auto trips having one end in a CBD, and double these amounts when both ends are in CBDs. This represents the use of mass transit in place of auto to travel between a remote parking lot and the ultimate origin or destination in the CBD. No additional parking charges were accounted for since auto travelers to/from CBDs probably already pay for parking. The impact of this strategy on the overall short-haul market is relatively small because only about 7% of all travel involves CBDs, and the penalties are modest. However, larger impacts can be seen when looking at specific situations. For example, in the case of travelers between Boston and New York who start and/or end their trips in a CBD, the modal split changes from 43% auto, 44% air, 13% bus and rail in the baseline, to 39% auto, 46% air, 15% bus and rail. Although almost 10% of the CBD auto travelers have changed modes, this represents less than 1% of the entire New York-Boston market. Furthermore, half of the diversions are to air, thereby negating any possible energy saving. The major impact of this strategy is probably on local urban travel, which is beyond the scope of this study.

*Only mileage-related costs (fuel, repairs, maintenance, tire wear) are included. Other costs (depreciation, insurance, taxes) are relatively fixed and would be incurred even if no intercity trips were made because automobiles are owned mainly for local travel.

TABLE XXV

1980 PRELIMINARY MODAL-SHIFT STRATEGY RESULTS -- ALL SHORT-HAUL SMSA-SMSA TRAVEL

Auto Penalty Measures

| | 1973 | 1980 Baseline | Auto Changes 50 MPH | 50% Oper. Cost Incr. | Auto-Free CBD's |
|---|---|---|---|---|---|
| Pass.-Miles ($10^9$) | 79.845 | 100.099 | 94.480 | 94.085 | 99.911 |
| Modal Shares: T/LS Air | .1574 | .2274 | .2619 | .2645 | .2289 |
| Commuter Air | .0011 | .0026 | .0032 | .0033 | .0027 |
| Rail & Metro | .0099 | .0121 | .0149 | .0158 | .0127 |
| Bus | .0214 | .0285 | .0366 | .0372 | .0290 |
| Auto | .8102 | .7293 | .6834 | .6793 | .7267 |
| Total User Cost ($10^9$\$) | 6.741 | 9.977 | 10.037 | 10.620 | 10.003 |
| Cost/Pass.-Mile (\$/Mile) | .0844 | .0997 | .1062 | .1129 | .1001 |
| Total User Time ($10^9$ Hrs) | 1.714 | 2.195 | 2.168 | 2.028 | 2.196 |
| Time/Pass.-Mile (Hrs/Mile) | .0215 | .0219 | .0229 | .0216 | .0220 |
| Avg. Travel Speed (MPH) | 48.2 | 47.3 | 45.4 | 48.5 | 47.2 |
| Additional User Charge ($10^9$\$) | - | - | 0 | 1.0788 | 0 |
| Per Auto Pass. (\$) | - | - | 0 | 3.15 | 0 |
| Total Energy ($10^{12}$ BTU) | 440.650 | 489.875 | 460.120 | 471.065 | 489.226 |
| Modal Shares: T/LS Air | .2847 | .3815 | .4413 | .4344 | .3841 |
| Commuter Air | .0015 | .0036 | .0042 | .0042 | .0036 |
| Rail & Metro | .0070 | .0085 | .0102 | .0105 | .0088 |
| Bus | .0071 | .0089 | .0115 | .0114 | .0091 |
| Auto | .6997 | .5975 | .5328 | .5394 | .5944 |
| Energy Intensity ($10^3$ BTU/P.Mile) | 5.519 | 4.894 | 4.870 | 5.007 | 4.897 |
| (% Improvement) | - | - | 0.49% | -2.31% | -0.06% |
| Energy Saved ($10^{12}$ BTU): | | | | | |
| Actual | - | - | 29.755 | 18.810 | 0.649 |
| (%) | - | - | 6.07% | 3.84% | 0.13% |
| Demand-Normalized | - | - | 2.390 | -11.301 | -0.272 |
| (%) | - | - | 0.49% | -2.31% | -0.06% |
| Add'l User Charge/Actual Energy Saved (\$/$10^6$ Btu) | - | - | 0 | 57.30 | 0 |

Note: All Costs in 1973 \$

While modal shift strategies which penalize auto travel can produce large energy savings, these are achieved largely through the suppression of demand. When considered in terms of energy intensity, the shifts to air induced by the auto penalties tend to negate these savings.

Strategies to Induce Modal Shifts from Air Travel

Three measures were investigated for inducing shifts away from air travel or increasing its energy effectiveness:

- Fare surcharges
- Changes in equipment and procedures
- Use of more energy-efficient vehicles in short-distance segments of long air trips

Results for the basic air measures appear in Table XXVI in the same format as in previous tables, again for just OMSA-SMSA travel. Additional air measures will be explained separately.

Fare Surcharges

In the first strategy, two types of surcharges on short-haul air fares were considered; these could be implemented as either a tax or as additional revenue for the carriers. The first type of surcharge (declining surcharge) has the form \$25.00-\$0.05 x distance (expressed in 1973 dollars) and was designed to have the largest impact on the shortest routes, where air energy intensity is highest. This surcharge results in a 100% fare increase on 100-mile routes, 30% at 300 miles, and disappears entirely at 500 miles. The average increase is 21.3%. The second type of surcharge (fixed) was set at \$8.00 (1973 dollars) before discounts, a little more than the average of the declining surcharge. It results in a 40% fare increase at 100 miles, 25% at 300 miles, and 15% at 500 miles, for an average of 23.8%. The fixed surcharge has the advantage of having a significant impact on longer short-haul air trips, which are still highly energy intensive relative to other modes, but introduces a discontinuity into the air fare structure.

The two surcharges have similar effects, although the fixed surcharge, despite causing a larger average fare increase than the declining surcharge, has a somewhat smaller impact. In both cases, significant numbers of air travelers are diverted to other modes, mainly auto. These diversions to slower modes cause a decline in the average travel speed; however, the diversion to less costly modes offsets the air fare surcharge, thereby resulting in little or no increase in the average cost of travel. The energy savings, both actual and normalized, are among the largest of the individual strategies investigated, with diversions from the most energy-intensive mode resulting in significant reductions in the overall energy intensity. The cost of these energy savings, in terms of additional user charges, is still very high relative to the cost of the petroleum saved.

TABLE XXVI

1980 PRELIMINARY MODAL-SHIFT STRATEGY RESULTS -- ALL SHORT-HAUL SMSA-SMSA TRAVEL

Air Penalty & Energy Reduction Measures

| | | | | | Measures to Reduce Air Energy Intensity | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Current Frequencies (70% Max. Load Factor) | |
| | | | Air Fare Surcharges | | | 70% Load | | |
| | 1973 | 1980 Baseline | Declining | Fixed | No Large Aircraft | Factor-All Routes (Baseline Aircraft) | Baseline Aircraft | No Large Aircraft |
| Pass.-Miles ($10^9$) | 79.845 | 100.099 | 96.916 | 97.157 | 100.121 | 99.872 | 99.986 | 100.021 |
| Modal Shares: T/LS Air | 0.1574 | 0.2274 | 0.1764 | 0.1741 | 0.2278 | 0.2231 | 0.2244 | 0.2252 |
| Commuter Air | 0.0011 | 0.0026 | 0.0035 | 0.0032 | 0.0026 | 0.0026 | 0.0027 | 0.0026 |
| Rail & Metro | 0.0099 | 0.0121 | 0.0140 | 0.0139 | 0.0121 | 0.0124 | 0.0122 | 0.0122 |
| Bus | 0.0214 | 0.0285 | 0.0328 | 0.0323 | 0.0285 | 0.0288 | 0.0287 | 0.0287 |
| Auto | 0.8102 | 0.7293 | 0.7733 | 0.7767 | 0.7290 | 0.7332 | 0.7320 | 0.7314 |
| Total User Cost ($10^9$$) | 6.741 | 9.977 | 9.659 | 9.706 | 9.982 | 9.919 | 9.945 | 9.953 |
| Cost/Pass.-Mile ($/Mile) | 0.0844 | 0.0997 | 0.0997 | 0.0999 | 0.0997 | 0.0993 | 0.0995 | 0.0995 |
| Total User Time ($10^9$ Hrs) | 1.714 | 2.195 | 2.195 | 2.208 | 2.195 | 2.203 | 2.202 | 2.200 |
| Time/Pass.-Mile (Hrs/Mile) | 0.0215 | 0.0219 | 0.0226 | 0.0227 | 0.0219 | 0.0221 | 0.0220 | 0.0220 |
| Avg. Travel Speed (mph) | 43.2 | 47.3 | 45.6 | 45.4 | 47.3 | 47.2 | 47.2 | 47.2 |
| Total New User Charge ($10^9$$) | - | - | 0.3710 | 0.4109 | 0 | 0 | 0 | 0 |
| Per Air Pass. ($) | - | - | 7.03 | 7.46 | 0 | 0 | 0 | 0 |
| Total Energy ($10^{12}$ Btu) | 440.650 | 489.875 | 451.285 | 454.043 | 480.451 | 463.352 | 471.243 | 465.654 |
| Modal Shares: T/LS Air | 0.2847 | 0.3815 | 0.3012 | 0.3035 | 0.3696 | 0.3433 | 0.3548 | 0.3476 |
| Commuter Air | 0.0015 | 0.0036 | 0.0049 | 0.0045 | 0.0036 | 0.0036 | 0.0038 | 0.0037 |
| Rail & Metro | 0.0070 | 0.0085 | 0.0101 | 0.0099 | 0.0087 | 0.0090 | 0.0089 | 0.0090 |
| Bus | 0.0071 | 0.0089 | 0.0108 | 0.0106 | 0.0091 | 0.0095 | 0.0094 | 0.0095 |
| Auto | 0.6997 | 0.5975 | 0.6730 | 0.6716 | 0.6090 | 0.6344 | 0.6232 | 0.6303 |
| Energy Intensity ($10^3$ Btu/P.Mi) | 5.519 | 4.894 | 4.656 | 4.673 | 4.799 | 4.639 | 4.713 | 4.656 |
| % Improvement | - | - | 4.85% | 4.51% | 1.95% | 5.20% | 3.69% | 4.87% |
| T/LS Line-Haul Energy Int. | 9.371 | 7.715 | 7.467 | 7.636 | 7.291 | 6.644 | 6.954 | 6.689 |
| % Improvement | - | - | 3.22% | 1.02% | 5.50% | 13.88% | 9.86% | 13.30% |
| Energy Saved ($10^{12}$ Btu): | | | | | | | | |
| Actual | - | - | 38.590 | 35.832 | 9.424 | 26.523 | 18.632 | 24.221 |
| (%) | - | - | 7.88% | 7.31% | 1.92% | 5.41% | 3.80% | 4.94% |
| Demand-Normalized | - | - | 23.769 | 22.083 | 9.530 | 25.470 | 18.099 | 22.858 |
| (%) | - | - | 4.85% | 4.51% | 1.95% | 5.20% | 3.69% | 4.87% |
| New User Charge/Energy Saved | | | | | | | | |
| Actual ($/$10^6$ Btu) | - | - | 9.61 | 11.46 | 0 | 0 | 0 | 0 |
| Normalized ($/$10^6$ Btu) | - | - | 15.61 | 18.61 | 0 | 0 | 0 | 0 |
| T/LS Air System Data: | | | | | | | | |
| Load Factor | 0.537 | 0.604 | 0.604 | 0.604 | 0.617 | 0.700 | 0.667 | 0.674 |
| Flights/Day | 7982 | 10798 | 9810 | 9920 | 10980 | 9240 | 9984 | 10220 |
| Seats/Flight | 96.3 | 98.2 | 97.6 | 97.5 | 94.5 | 98.1 | 98.0 | 94.5 |

All Distances Straight-Line
All Costs in 1973 $

Strategies to Reduce the Energy Intensity of Air Travel

The next four strategies were designed to reduce the energy intensity of air travel rather than to divert travelers from air. In the 1980 baseline, the load factor for each route is specified at from 0 to 12% above 1973 levels, corresponding to an increase in the average load factor from 54% to 60%. The aircraft mix is the same as in 1976, except that half the B-707/DC-8 and turboprop aircraft, which are being retired, are replaced by DC-10/L-1011 and DC-9-30/B-737-200 aircraft, respectively, on a one-for-two basis. Increases in seating densities on larger aircraft are also assumed, in line with current airline trends. The actual frequency on each route is set to match the demand, consistent with the specified load factor and capacity/flight.

The first air energy-intensity reduction strategy involves the replacement of large aircraft by smaller aircraft. Most of the dense routes are served in part by large aircraft (i.e., B-747, DC-10, L-1011, B-707, DC-8). Typically, the itinerary is a short hop to a large hub, followed by a long leg to a distant destination, such as Detroit-Chicago-Seattle or San Diego-Los Angeles-New York. The use of the large aircraft on the short leg is to provide same-plane service to the ultimate destination. Replacement by a smaller aircraft (i.e., DC-9-30 or B-737-200) connecting with the longer flight, while possibly involving unacceptable inconvenience to the passengers, would provide two benefits: a reduction in energy intensity per seat-mile and an increase in load factor. As shown in Table XXVI, a total energy saving of about 2% results from the 5.5% decline in air, line-haul, passenger-mile energy intensity. About 3.5% of this decline is due to equipment changes while the remaining 2% results from the load factor increase. (The small increase in total flights, which stimulates demand slightly, occurs because the increased load factors were not allowed to exceed 65%.)

The second strategy is enforcement of a 70% load factor on all routes, such as might occur in a fuel allocation situation. This value probably represents the maximum achievable average, considering time-of-day, day-of-week, and seasonal variations, and would undoubtedly cause some rejected demand during peak travel periods when load factors, even now, approach 100%. The strategy results in a nearly 14% reduction in air energy intensity and a saving of over 5% in total energy.

Since it may not be possible to achieve a high load factor on all routes because of scheduling, routing, and aircraft positioning considerations, an additional strategy was studied. In this strategy the current schedules, which already contain these considerations, were assumed to be maintained in 1980; frequencies were increased only to prevent load factors from exceeding 70%. The result is an overall load factor of 66.7%, achieving about 2/3 of the savings of the 70% load factor strategy.

Finally, the first and third energy reduction strategies were combined, with large aircraft replaced by smaller aircraft but frequencies remaining unchanged except where increases are needed to hold load factor at 70%. The result is 90% of the savings of the 70% load factor strategy, or about 5% of the total energy. About 3/4 of the air energy-intensity reduction of over 13% is due to the load factor increase, with the remainder resulting from the change to smaller aircraft. Note that the last three strategies discussed provide energy savings comparable to the air fare surcharge strategies with little cost to travelers but with inconvenience of some unquantified amount.

## Strategies Involving Connecting or Access Portions of a Trip

Three strategies involving mode substitution for portions of a long-haul air trip are as follows:

- Bus replacement of short-haul connecting air service
- Small-aircraft replacement of connecting air service
- Use of small airplanes rather than automobiles for airport access

Relative to the last of these, although Fig. 15 indicates that auto is less energy-intensive than commuter aircraft, the strategy involving this shift is concerned with long-distance airport access, a travel sector for which travel groups are smaller than for inter-city auto trips. The resulting auto load factor of 30.6% is much lower than the 45.6% used to calculate the auto energy intensity band in Fig. 15. When the lower load factor is used, the commuter and auto bands overlap enough to make auto-to-air shifts potentially attractive.

### Bus Replacement of Short-Haul Connecting Air Service

In the bus-replacement strategy, the idea is to substitute a fuel-efficient mode (bus) for a more fuel-intensive mode (short-haul air) on a short leg of longer air trips which are not presently flown direct from origin to destination. Since a modal change is involved in the proposed scheme, and since bus-connecting trips are likely to incur significant time penalties compared with short-haul air connections, there are impediments which must be taken into account to determine the practicality of this strategy. These questions are taken up later in the policy analysis. The probable reluctance of passengers to accept bus, rather than air connections, could well cause a change in travel path, thereby reducing the possible benefits of this strategy.

To determine how much fuel might be saved by bus connections, an analysis has been made of those representative city-pairs for which bus replacement might be viable. The study has been restricted to the shortest distance category (67-150 air miles) and to city-pairs in which one terminus is a major airport hub. These restrictions lead to consideration of categories represented by the eight city-pairs listed in Table XXVII.* Also indicated in Table XXVII are the bus and air distances and applicable one-way fares and block times for each mode.

* To ascertain the validity of this approach, the characteristics of all 20 short-distance categories were examined to determine what fraction of the city-pairs are candidates for connections; i.e., one terminus is an air hub. It was found that of the 597 city-pairs in these categories, 106 involve one hub, 5 involve two hubs, and 486 involve no hubs. In the eight categories selected here, 74% of the city-pairs are of the one-hub type. Overall, 91% of the city-pairs are properly represented in this respect by the 20 city-pairs representing these categories.

TABLE XXVII

BUS REPLACEMENT SERVICE SUMMARY

| | Albany-N.Y.C. | Bksfld.-L.A. | Ft. Wayne-Detroit | Huntsville-Atlanta | Kal./Bat. Crk.-Detroit | Mansfield-Cleveland | Milwaukee-Chicago | Richmond-Wash., DC | Total | Average |
|---|---|---|---|---|---|---|---|---|---|---|
| Distance, mi | | | | | | | | | | |
| Bus | 155 | 114 | 169 | 194 | 128 | 81 | 89 | 109 | | 130 |
| Air | 134 | 101 | 136 | 142 | 114 | 69 | 85 | 105 | | 110 |
| Block Time, hr (1) | | | | | | | | | | |
| Bus | 2.70 | 3.07 | 4.25 | 5.00 | 2.84 | 2.20 | 1.65 | 2.12 | | 2.98 |
| Air | 0.88 | 0.51 | 0.72 | 0.72 | 0.65 | 0.54 | 0.49 | 0.68 | | 0.65 |
| Difference | 1.82 | 2.56 | 3.53 | 4.28 | 2.19 | 1.66 | 1.17 | 1.44 | | 2.33 |
| Round Trip Fare, $ (1) | | | | | | | | | | |
| Bus Direct | 20.56 | 14.04 | 22.90 | 27.30 | 14.66 | 12.00 | 9.90 | 14.28 | | 16.96 |
| Air Direct | 66.00 | 50.00 | 56.00 | 78.00 | 64.00 | 52.00 | 46.00 | 50.00 | | 57.75 |
| Perceived Connecting | 6.00 | 6.20 | 5.10 | 2.40 | 12.70 | 12.00 | 1.40 | 4.95 | | 6.34 |
| Annual Demand, Round Trips (2) | | | | | | | | | | |
| Total Passengers ($10^3$) | 141.2 | 45.3 | 20.0 | 86.9 | 40.0 | 7.1 | 269.2 | 139.6 | 749.3 | 93.7 |
| Connecting Passengers ($10^3$) | 76.2 | 33.5 | 15.0 | 71.6 | 32.0 | 5.6 | 243.6 | 130.5 | 608.0 | 76.0 |
| Air Connecting P-M ($10^6$) | 10.21 | 3.38 | 2.04 | 10.17 | 3.65 | 0.39 | 20.71 | 13.70 | 64.25 | 8.03 |
| Bus Connecting P-M ($10^6$) | 11.81 (3) | 3.82 | 2.54 | 13.89 | 4.10 | 0.45 | 21.68 | 14.22 | 72.51 | 9.06 |
| % Shuttle Flights | 82.5 | 27.4 | 0 | 25.5 | 0 | 100.0 | 15.1 | 0 | | 35.5 |
| Energy Use, $10^9$ Btu/yr (4) | | | | | | | | | | |
| Air | 352.4 | 89.8 | 54.0 | 233.8 | 63.6 | 4.2 | 758.6 | 329.8 | 1896.2 | 237.0 |
| Bus | 55.2 | 9.0 | 5.9 | 32.5 | 9.6 | 1.1 | 50.7 | 33.3 | 197.3 | 24.7 |
| Energy Saving, $10^9$ Btu/yr | | | | | | | | | | |
| Rep. City-Pair, Ideal | 307.2 | 80.8 | 48.1 | 201.3 | 54.0 | 3.1 | 707.9 | 296.5 | 1689.9 | 212.4 |
| , Shuttle | 253.4 | 22.1 | 0 | 51.3 | 0 | 3.1 | 106.9 | 0 | 436.9 | 54.6 |
| Category, Ideal | 1048 | 81 | 632 | 4924 | 421 | 38 | 3688 | 8720 | 19552 | 2444 |
| , Shuttle | 864 | 22 | 0 | 1255 | 0 | 38 | 557 | 0 | 2736 | 342 |

(1) Based on OAG and Russell's Official Motor Coach Guide
(2) From CAB Table 12 of the O-D Survey for 1973, and 1973 Service Segment Data
(3) Bus passenger-miles exceed air passenger-miles because of circuity
(4) Includes traffic in both directions

As would be expected, the table shows that the bus holds a large advantage in direct fare and the airplane has a large time advantage. However, it is not equitable to compare direct fares since connecting air trips involving different carriers (the case under study) often feature joint fares and thru fares in which the short-haul segment is "subsidized" by the longer segment. For example, consider the joint air fare for connecting trips from Albany, N. Y. to various destinations with New York as the connecting point, and compare it with the direct fare from New York to each destination. The difference in each case is the "perceived" fare for the Albany-to-New York segment of the trip. Based on a recent issue of the OAG, the round-trip jet coach fares are, for example:

| To: | Baltimore | Charleston | Detroit | Los Angeles | Memphis | Miami |
|---|---|---|---|---|---|---|
| From: | | | | | | |
| Albany | $96 | $150 | $152 | $388 | $188 | $208 |
| New York | 64 | 140 | 122 | 388 | 184 | 202 |
| Difference | $32 | $ 10 | $ 30 | $ 0 | $ 4 | $ 6 |

The perceived air fare for the Albany-to-New York segment is thus a function of route. However, in every case it is significantly lower than the direct fare ($66) and one case it is zero*. If all possible connections through New York are considered, an average perceived air fare can be calculated for the Albany-to-New York segment. The individual contributions should be weighted to account for the fact that some destinations attract more passengers than others, and because connections through other cities also occur. These effects were determined by obtaining the number of O-D air passengers between Albany and each destination (CAB Table 12), and computing an "equivalent" frequency based on the number of nonstop, one-stop, and connecting flights in each case. The equivalent frequency was computed by the method of Ref. 67. Results for each of the nine representative city-pairs are summarized in Table XXVII.

It is apparent that the perceived connecting air fare is never more than the direct bus fare, and is generally much less. Therefore, it can be concluded that the bus replacement service could not save air passengers money, and would result in a fare penalty unless bus connecting service were subsidized to make up the difference.

An upper bound on potential fuel savings for the nine city-pair routes listed in Table XXVII can be determined by assuming that all connecting passengers on these routes are accommodated by the bus replacement service. This assumption is extremely

*Due to peculiarities in the rate structure, the perceived fare can actually be negative!

idealized, since a complete changeover would necessarily impact other routes and would be so disruptive to the present air system that the costs of a complete replacement would probably far outweigh the fuel saving achieved. If all the short-haul routes consisted of shuttle flights, the impact on the air system might not be unduly disruptive. However, as shown in Table XXVII the percentage of daily frequencies for which the OAG-listed itineraries involve only the two cities which make up the city-pair is significant for only two of the nine city-pairs (Albany-New York and Mansfield-Cleveland). Overall, fewer than one-third of the flights are of the shuttle type.

Energy use for air or bus was computed from the demand data given in Table XXVII. The number of connecting passengers on each route was determined by subtracting the O-D demand (Table 12 of the CAB O-D Survey) from the number of total on-line passengers in the CAB Service Segment Data. For air, the energy intensity on each route (Btu/ASM) is a weighted average of the intensities of the aircraft in use according to the frequency of each type.

Energy savings are calculated on two bases: 1) the "ideal" saving which would be achieved if all connecting passengers could be accommodated by bus, and 2) the saving on shuttle flights alone. Of the two, the latter is by far the more realistic. In extrapolating energy savings for each of the nine representative city-pairs to entire categories, the ratios of category to city-pair passenger-miles were used as multiplying factors. Since these passenger-mile figures include trips by all modes rather than just by air, the results are probably somewhat high. Nevertheless, the results as indicated in the last columns of Table XXVII show that a maximum of 19,522 x $10^9$ Btu/yr can be saved by replacing air-connecting services with buses, and that a more realistic figure is 2736 x $10^9$ Btu/yr.

Small-Aircraft Replacement of Connecting Air Service

A strategy for reducing fuel use on short-haul connecting air routes is to replace existing airplanes by smaller, more fuel-efficient aircraft. In general, this strategy implies not only a reduction in size, but also the use of propeller-driven airplanes to replace jets. In some cases, large propeller-driven airplanes (Convair CV-580, the Japanese NAMC YS-11) are replaced by smaller ones.

The analysis of this strategy differs in some important ways from the bus-replacement strategy discussed above. First, it is assumed that airplane replacements apply to entire flight itineraries rather than just the connecting route itself. Hence, the possibilities for fuel saving are enlarged, although the magnitudes of fuel savings are necessarily less because buses are universally less fuel-intensive than airplanes for short trips. A limitation of 300 miles was placed on the stage-length for which such replacements could be made. Therefore, only those itineraries for which the longest stage was under 300 miles were accepted as replaceable itineraries. It was also assumed that only in-production airplanes would be available as replacements, which limited the candidate airplanes to three models: Beech 99 (B-99), Shorts SD3-30, and deHavilland DHC-7. These airplanes have seating capacities of 15, 30, and 48 seats, respectively.

Passenger impacts are restricted to two considerations: 1) possible lowering of passenger appeal and comfort factors, and 2) increases in flight frequencies. These conditions are at least partially offsetting, but it is expected that passenger acceptance might not be enthusiastic.

Under the assumptions above, replacements were found to offer potential fuel savings in eleven city-pair categories, as represented by the city-pairs in Table XXVIII. The average distance of these routes is seen to be about 150 mi. Also, the fraction of flights which can be replaced is large because other than shuttle flights can be considered as viable candidates for replacement. The types of aircraft presently in use on each route are shown in Table XXVIII, along with the percentage of flights when more than one type is presently in use. Except for the Tulsa-Dallas route, only two- and three-engine airplanes comprise the replaceable group. These include two propeller-driven models (CV-580 and YS-11) and several jet types (BAC-111, B-737, DC-9, and B-727).

In considering the replacement of large aircraft by small ones, the question of frequency has two consequences. First, increased frequency has a favorable passenger impact in the sense of reducing the time penalty arising from discrepancies between desired and achievable departure and arrival times; and second, it increases required runway operation rates at hub airports and contributes to congestion delays which create penalties in trip time. The latter consequence has the effect of increasing fuel use, thereby reducing the postulated saving from aircraft replacements; consequently, large increases in frequency, which could accompany the use of very small aircraft to replace very large ones, should be avoided if it results in an increase in airport congestion and fuel use. Accordingly, it can be seen in Table XXVIII that the smallest airplane, the B-99, was not considered as a replacement candidate on routes with high existing frequencies such as Milwaukee-Chicago and Tulsa-Dallas.

The approach taken in analyzing the airplane replacement strategy has been as follows:

- The itineraries of all flights on the eleven representative city-pair routes in Table XXVIII were taken from the OAG.
- Replacement itineraries were identified and fuel consumed by presently operating aircraft was estimated.

TABLE XXVIII

SMALL-AIRCRAFT REPLACEMENT ON CONNECTING ROUTES

| City-Pair | Distance mi | Present Freq. Flt/Day | Replaceable Flights | | | | Potential Repl. A/C (3) |
|---|---|---|---|---|---|---|---|
| | | | Flights (1) % | Present Fuel Use Gal/wk | Present A/C (2) Type (%) | | |
| Albany - New York | 134 | 7.4 | 87.4 | 22,200 | CV5(100) | | B-99<br>SD3-30<br>DHC-7 |
| Albany - Philadelphia | 204 | 5.0 | 100.0 | 54,880 | B11(100) | | B-99<br>SD3-30<br>DHC-7 |
| Bakersfield - L.A. | 101 | 4.4 | 77.4 | 48,785 | 727 (45)<br>737 (55) | | B-99<br>SD3-30<br>DHC-7 |
| Huntsville - Atlanta | 142 | 4.8 | 100.0 | 79,990 | DC9 (58)<br>D9S (42) | | B-99<br>SD3-30<br>DHC-7 |
| Kalamazoo - Detroit | 114 | 6.1 | 100.0 | 57,345 | CV5(100) | | B-99<br>SD3-30<br>DHC-7 |
| Milwaukee - Chicago | 85 | 20.4 | 83.5 | 197,780 | CV5(79)<br>D9S(21) | | SD3-30<br>DHC-7 |
| Nashville - St. Louis | 255 | 3.7 | 36.5 | 46,180 | D9S(100) | | B-99<br>SD3-30<br>DHC-7 |
| Oshkosh - Chicago | 160 | 6.1 | 100.0 | 30,320 | CV5(84)<br>D9S(16 | | B-99<br>SD3-30<br>DHC-7 |
| Richmond - Wash., D.C. | 105 | 6.6 | 31.2 | 31,440 | Y11(100) | | B-99<br>DHC-7 |
| Spfld., Ill. - Chicago | 172 | 4.5 | 100.0 | 142,170 | DC9(19)<br>D9S(81) | | B-99<br>SD3-30<br>DHC-7 |
| Tulsa - Dallas | 245 | 12.8 | 32.0 | 121,180 | 707(12)<br>727(55)<br>727S(12)<br>D9S(21) | | B-99<br>SD3-30<br>DHC-7 |
| AVERAGE | 147 | 7.4 | 77.1 | 73,665 | | | |

(1) Replaceable flights are those for which the entire itinerary consists of stages under 300 mi.

(2) CAG abbreviations are used here:

DC9 -- DC-9-10,15
D9S -- DC-9-30
727 -- B-727-100
727S -- B-727-200
B11 -- BAC-111
737 -- B-737
CV5 -- CV-580
Y11 -- YS-11
707 -- B-707

Also:
B-99 -- Beech 99
SD3-30 -- Short SD3-30
DHC-7 -- deHavilland DHC-7

(3) Airplanes considered only where beneficial; i.e., for Milwaukee-Chicago present frequency so high that small airplane such as B-99 would not be practical; for Richmond-Washington, DHC-7 not enough more fuel-efficient than present airplane (YS-11). At other airports, all replacement aircraft can be considered, depending on increase in frequency permitted.

- Each of the three replacement airplanes was applied to these itineraries and fuel consumption was estimated for each route for each airplane. In this step, replacements were considered parametrically according to the number of flights per day required with each airplane.

- The savings in fuel by each airplane were compared and the maximum saving was sought by selecting the proper replacement on each route, at each frequency.

- The saving in fuel on each route was extrapolated to encompass all the city-pairs in the category.

- Fuel savings for all eleven categories were summed.

The results of this process are summarized in Fig. 16 where fuel saved is plotted against maximum allowable frequency, and in Tables XXIX and XXX which list fuel savings for both the discrete city-pairs and the categories they represent. If no increase in frequency is permitted over present levels, no replacements can be made and no fuel saved. If large frequency increases are allowed, increasing use of the smallest airplanes with the greatest fuel saving is possible. Implicit in these results then, is a trend toward B-99 replacements at the high-frequency end, and toward DHC-7 replacements at the low end. Table XXX and the upper curve in Fig. 16 show how much fuel is saved by replacing entire itineraries, as described. The fraction of that fuel saved on the connecting routes is indicated by Table XXIX and the lower curve in Fig. 16.

It is significant that the curves rise steeply for nominal frequency increases and then level off. The implication is that there is some hope of achieving appreciable savings without adding so many additional flights as to incur unacceptable congestion penalties. The magnitude of the congestion penalty was estimated as follows:

- The total number of additional daily flights in the entire U.S. domestic system was determined for the range of frequency levels in Fig. 16 by aggregating over all eleven categories represented.

- These frequencies were distributed over all major hubs, weighting the effect in each case by the fraction of enplanements which are connecting (e.g., more flights are added to Chicago than to New York).

- Using a delay correlation developed at UTRC, the additional minutes of delay per flight were estimated at each hub.

## FUEL SAVED BY AIRCRAFT REPLACEMENTS ON CONNECTING ROUTES

FOR ITINERARIES WITH STAGES UNDER 300 MI.

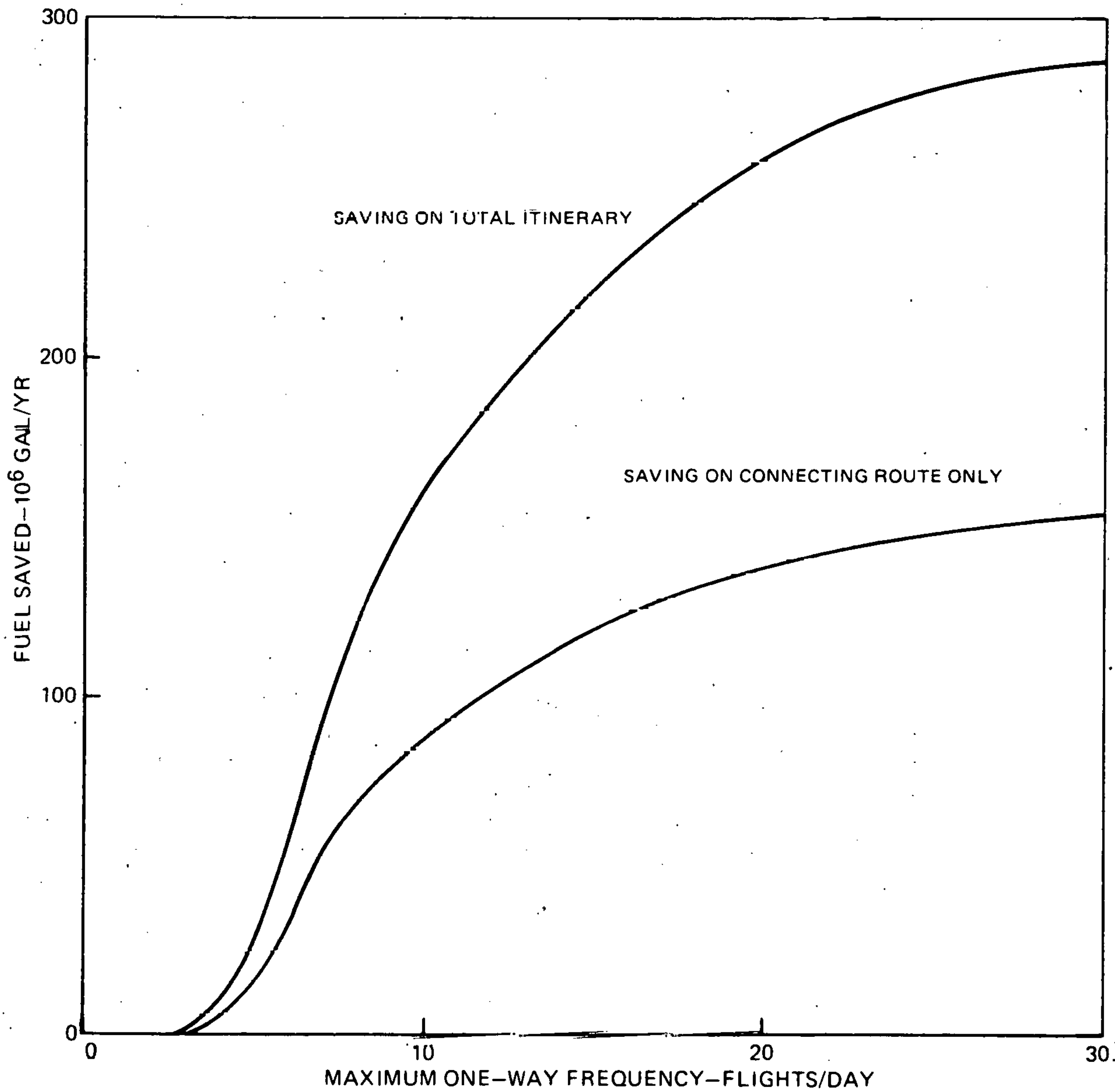


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TABLE XXIX

FUEL SAVED BY AIRCRAFT REPLACEMENTS

Connecting Route Only

$10^3$ Gal/Yr

| Maximum Frequency: | 5 | | 10 | | 15 | | 20 | | 30 | |
|---|---|---|---|---|---|---|---|---|---|---|
| City-Pair | Discrete City-Pair | Category | Discrete City-Pair | Category | Discrete City-Pair | Category | Discrete City-Pair | Category | Discrete City-Pair | Category |
| Albany - New York | 0 | 0 | 90 | 307 | 130 | 443 | 210 | 716 | 245 | 835 |
| Albany - Phildelphia | 0 | 0 | 750 | 38,535 | 905 | 46,500 | 905 | 46,500 | 1090 | 56,000 |
| Bakersfield - L. A. | 190 | 190 | 725 | 725 | 775 | 775 | 775 | 775 | 775 | 775 |
| Huntsville - Atlanta | 35 | 856 | 780 | 19,080 | 780 | 19,080 | 780 | 19,080 | 1025 | 25,070 |
| Kalamazoo - Detroit | 0 | 0 | 170 | 1,325 | 195 | 1,520 | 275 | 2,140 | 285 | 2,220 |
| Milwaukee - Chicago | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 600 | 3,125 |
| Nashville - St. Louis | 195 | 13,000 | 220 | 14,665 | 220 | 14,665 | 220 | 14,665 | 220 | 14,665 |
| Oshkosh - Chicago | 0 | 0 | 210 | 1,835 | 245 | 2,140 | 370 | 3,235 | 465 | 4,065 |
| Richmond - Wash., D.C. | 0 | 0 | 20 | 590 | 35 | 1,630 | 35 | 1,030 | 35 | 1,030 |
| Spfld., Ill. - Chicago | 85 | 435 | 890 | 4,555 | 1,360 | 6,965 | 1,360 | 6,965 | 1,745 | 8,935 |
| Tulsa - Dallas | 0 | 0 | 0 | 0 | 810 | 17,980 | 1,435 | 31,860 | 1,645 | 36,520 |
| TOTAL | 505 | 14,480 | 3,855 | 81,615 | 5,455 | 111,100 | 6,365 | 126,965 | 8,130 | 153,240 |

TABLE XXX

FUEL SAVED BY AIRCRAFT REPLACEMENTS

Total Itineraries

$10^3$ Gal/Yr

| Frequency | 5 | | 10 | | 15 | | 20 | | 30 | |
|---|---|---|---|---|---|---|---|---|---|---|
| City-Pair | City-Pair | Category | City-Pair | Category | City-Pair | Category | City-Pair | Category | City-Pair | Category |
| Albany - New York | 0 | 0 | 85 | 300 | 155 | 530 | 240 | 815 | 280 | 950 |
| Albany - Philadelphia | 0 | 0 | 893 | 45,880 | 1,030 | 52,870 | 1,055 | 54,260 | 1,315 | 67,515 |
| Bakersfield - L. A. | 260 | 260 | 1,290 | 1,290 | 1,380 | 1,380 | 1,380 | 1,380 | 1,380 | 1,380 |
| Huntsville - Atlanta | 50 | 1,223 | 1,560 | 38,160 | 1,800 | 44,030 | 1,800 | 44,030 | 2,050 | 50,145 |
| Kalamazoo - Detroit | 0 | 0 | 420 | 3,270 | 575 | 4,480 | 810 | 6,310 | 830 | 6,465 |
| Milwaukee - Chicago | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1,945 | 10,130 |
| Nashville - St. Louis | 370 | 24,665 | 690 | 46,000 | 836 | 55,730 | 835 | 55,730 | 835 | 55,730 |
| Oshkosh - Chicago | 0 | 0 | 813 | 7,105 | 974 | 8,515 | 1,160 | 10,130 | 1,245 | 10,880 |
| Richmond - Wash., D.C. | 0 | 0 | 128 | 3,765 | 190 | 5,530 | 190 | 5,530 | 190 | 5,530 |
| Spfld., Ill. - Chicago | 140 | 717 | 1,596 | 8,170 | 2,130 | 10,900 | 2,130 | 10,900 | 2,840 | 14,545 |
| Tulsa - Dallas | 0 | 0 | 0 | 0 | 1,430 | 31,745 | 2,530 | 56,145 | 2,830 | 62,800 |
| TOTAL | 820 | 26,865 | 7,475 | 153,940 | 10,500 | 215,710 | 12,130 | 245,230 | 15,740 | 286,070 |

- An average value for fuel consumption in terminal operations was developed (1930 gal/hr) by calculating a weighted average for airplanes presently in the fleet.
- This fuel consumption value was applied to the sum of all additional delay hours over the system.

Since the congestion fuel penalty rises with increasing frequency, a calculation of net fuel savings reaches a peak, as shown in Fig. 17. This curve is derived by subtracting the congestion-caused fuel increase in Table XXXI from the maximum fuel saving given in Table XXX at the corresponding flight frequency. Since the curve was found to peak at a frequency between 10 and 15 flights per day, the larger daily frequencies were not listed in Table XXXI. The maximum net saving of $120 \times 10^6$ gal/yr ($15.1 \times 10^{12}$ Btu/yr) occurs at an allowable frequency of between 10 and 15 one-way flights per day. The magnitude of this saving is respectable (1.5% of domestic airlines fuel use) and, by contrast with the bus replacement strategy, it is operationally feasible. That is, only equipment changes are required to achieve the saving. It is not clear that large-scale aircraft replacements could be effected quickly enough to make this strategy qualify as a contingency plan. However, the strategy does appear to be of sufficient interest to warrant consideration of a policy implementation analysis.

Use of Small Aircraft in Airport Access

The history of the cummuter airline industry shows that travel patterns of air passengers can be affected by the availability of air service linking small communities with large airports from which a wide range of destinations can be reached. Typically, in the absence of air commuter service, the access trips to neighboring hubs are made by private automobile. The introduction of commuter flights alters this access pattern by effecting a shift from auto to small aircraft, with a consequent change in fuel use. Therefore this effect can be considered as a possible strategy to achieve fuel savings. This strategy is different from the one in which small aircraft were used to replace large aircraft on connecting routes because in this case no air service presently exists. The strategies are alike in that they both involve air travelers to all destinations, and not just O-D trips on the short-haul segment over which the service is postulated.

The cities to be considered in this strategy are those presently without air access to a nearby hub from which good air connections can be made. The cities may be located within an SMSA, in which case they have been included in the city-pair categories without air service, or they may be outside SMSAs, in which case they have been neglected in the formation of the categories. Cities within SMSAs are generally in rather close proximity to an air hub, making access by airplane a less likely possibility than if a long access trip were required.

NET FUEL SAVED BY AIRCRAFT REPLACEMENTS ON CONNECTING ROUTES

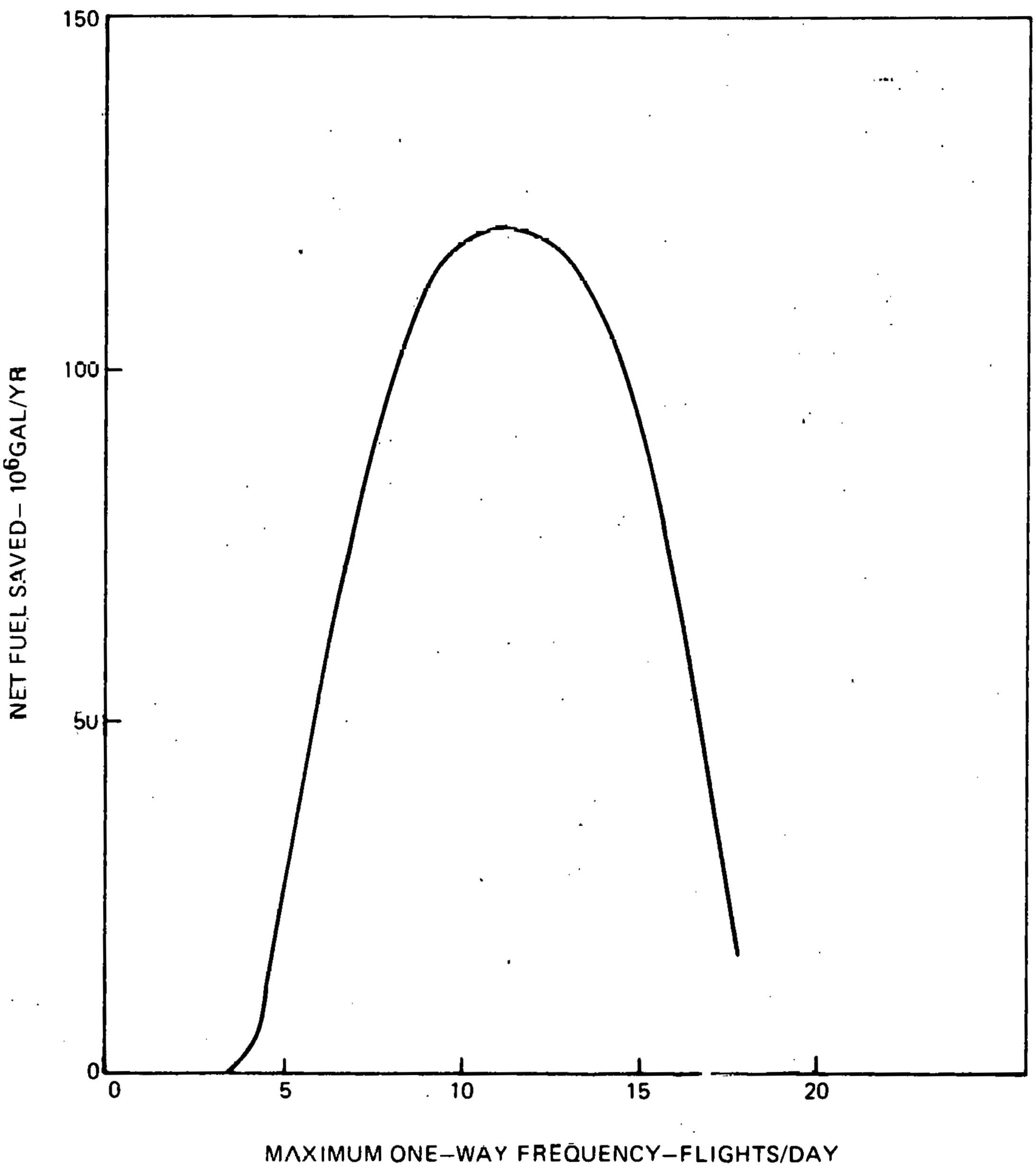


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TABLE XXXI

EFFECT OF DELAYS ON FUEL USE AT HUBS

| Major Hub City | 1980 Annual Operations ($10^3$) | % Increase in Operations | | | | Increase in Fuel Used, $10^6$ Gal/Yr | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Freq. = 7 | 10 | 13 | 15 | 7 | 10 | 13 | 15 |
| New York | 277 | 3.6 | 8.7 | 12.1 | 14.4 | 1.2 | 3.5 | 5.2 | 7.3 |
| Philadelphia | 181 | 11.0 | 27.6 | 38.2 | 45.3 | 0.1 | 0.4 | 0.7 | 1.4 |
| Wash. D. C. | 271 | 12.9 | 32.8 | 39.0 | 53.5 | 0.6 | 4.0 | 9.6 | 14.4 |
| Los Angeles | 633 | 3.8 | 9.5 | 13.1 | 15.5 | 3.3 | 10.4 | 15.9 | 21.6 |
| Chicago | 643 | 9.3 | 23.2 | 31.9 | 37.8 | 4.8 | 21.1 | 41.4 | 61.4 |
| Atlanta | 360 | 22.8 | 56.9 | 78.6 | 93.1 | 0.1 | 1.1 | 3.2 | 6.0 |
| Detroit | 221 | 13.6 | 33.5 | 46.5 | 55.2 | 0 | 0.2 | 0.5 | 0.8 |
| St. Louis | 177 | 28.2 | 70.6 | 97.4 | 115.3 | 0.1 | 1.8 | 5.7 | 12.0 |
| Dallas | 247 | 25.1 | 62.3 | 96.2 | 102.0 | 0 | 0.1 | 0.2 | 0.4 |
| | | | | | TOTAL | 10.2 | 42.6 | 82.4 | 125.3 |

A determination of the number of airport access trips which may be affected for a given city can be determined by considering the total number of air trips to all destinations, and then estimating the potential penetration of commuter-type air service in the access/egress segment of these trips. (It is assumed that all access is presently by private automobile.) Although trip data for small cities is rather scant, the National Travel Survey (NTS) provides a fairly good data base for determining the propensity for air travel by city size. Considering annual air trips to all destinations on a per-capita basis, Fig. 18 shows the effect of city size on air travel. The four categories of population are: 0 - 200,000; 200,000 - 500,000; 500,000 - 1,000,000; and over 1,000,000. The plotted points are the weighted averages in each category and the asymptote is for the largest size category. Although the average value for all cities is 0.66 round trips/person/year, the value at the lower end of the population range is only about 2/3 of this figure. For the cities of interest in this strategy, a value of 0.425 round trips/person/year was used.

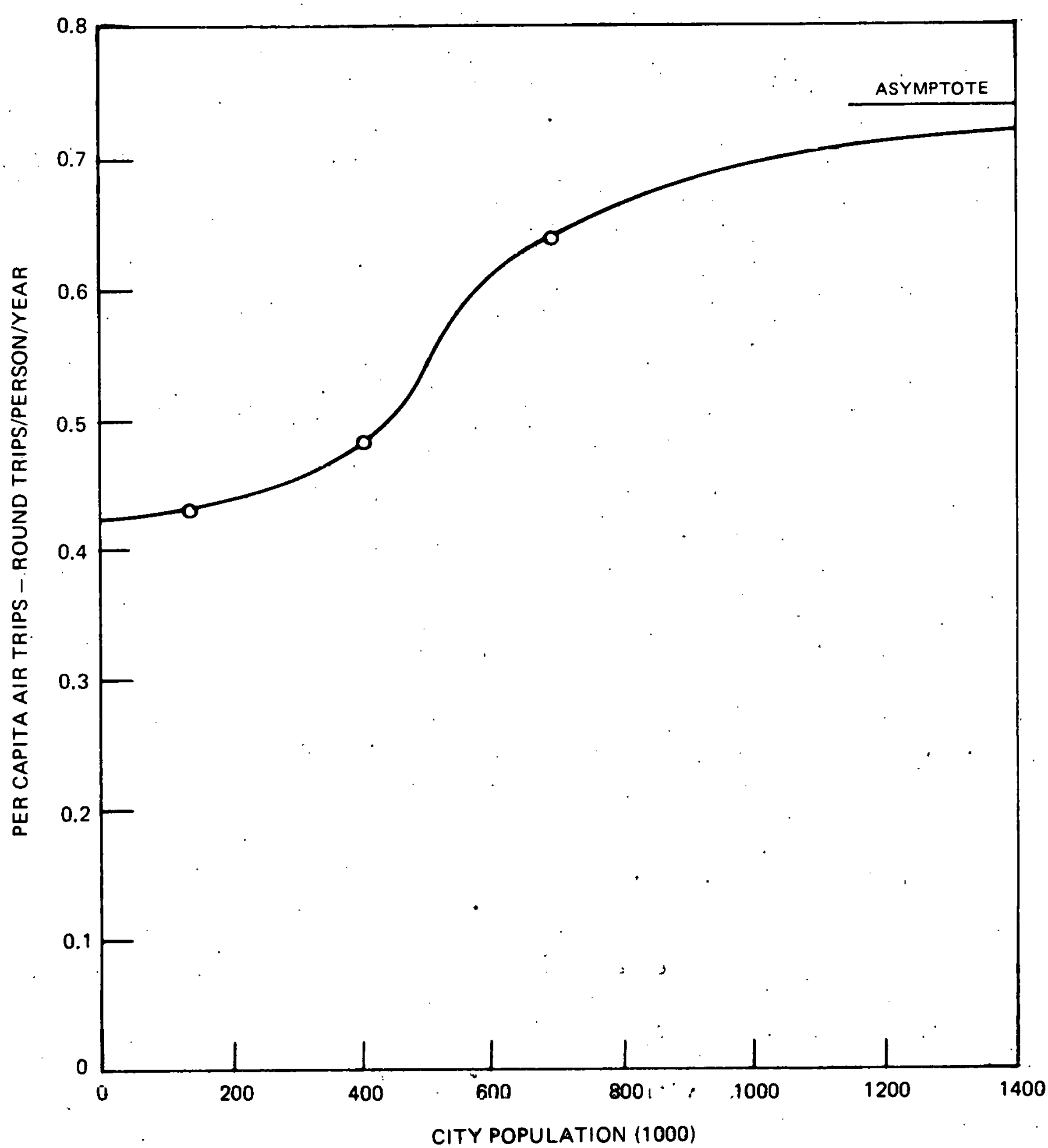
The penetration of commuter air service in short-haul markets can best be estimated by considering existing service from small cities to hubs. Tabulated CAB data for enplaned passengers in commuter markets are a starting point. These data must be corrected to remove O-D passengers (usually a small percentage, as indicated in the commuter airline survey performed in this study) and then divided by the estimated total air travel to all destinations from Fig. 18 to obtain the air share of access trips to the neighboring hub. Nine appropriate commuter markets were analyzed in this way and the results are presented in Fig. 19. Although there is considerable spread in these data, the trend with distance is evident. This correlation can be used in combination with Fig. 18 to determine the total number of air passenger trips shifted from auto to airplane access.

From the NTS, the typical air party size is 1.5; this will be the number of passenger-trips/vehicle trip used in calculating auto fuel usage. Since long distance access trips will consist mostly of highway driving, an auto energy efficiency of 18 mi/gal and a circuity of 20% were assumed. Airplane fuel consumption was based on use of the Beech 99 with a 60% load factor; i.e., nine passengers/vehicle. The resulting comparison of auto vs airplane energy use is shown in Fig. 20 in terms of annual per-capita energy expenditure vs distance from the origin city to the connecting hub. Given the population of the city for which air service is proposed and the distance to the nearest hub, Fig. 20 can be used to determine whether or not energy will be saved and what the magnitude of the saving (or loss) will be.

As indicated, only for access trips greater than about 110 miles can air service be justified on an energy basis. However, most trips are likely to be shorter than this. For example, 22 cities without air service were identified within SMSAs, but none of these was more than 70 miles from a connecting hub, and the average distance was only 33 miles. An additional 22 cities outside SMSAs, but with populations greater than 25,000, were also identified. On the average, these cities were 92 miles from the nearest hub, and only five of the 22 were distant enough for a hypothetical air service to save energy by attracting auto trips.

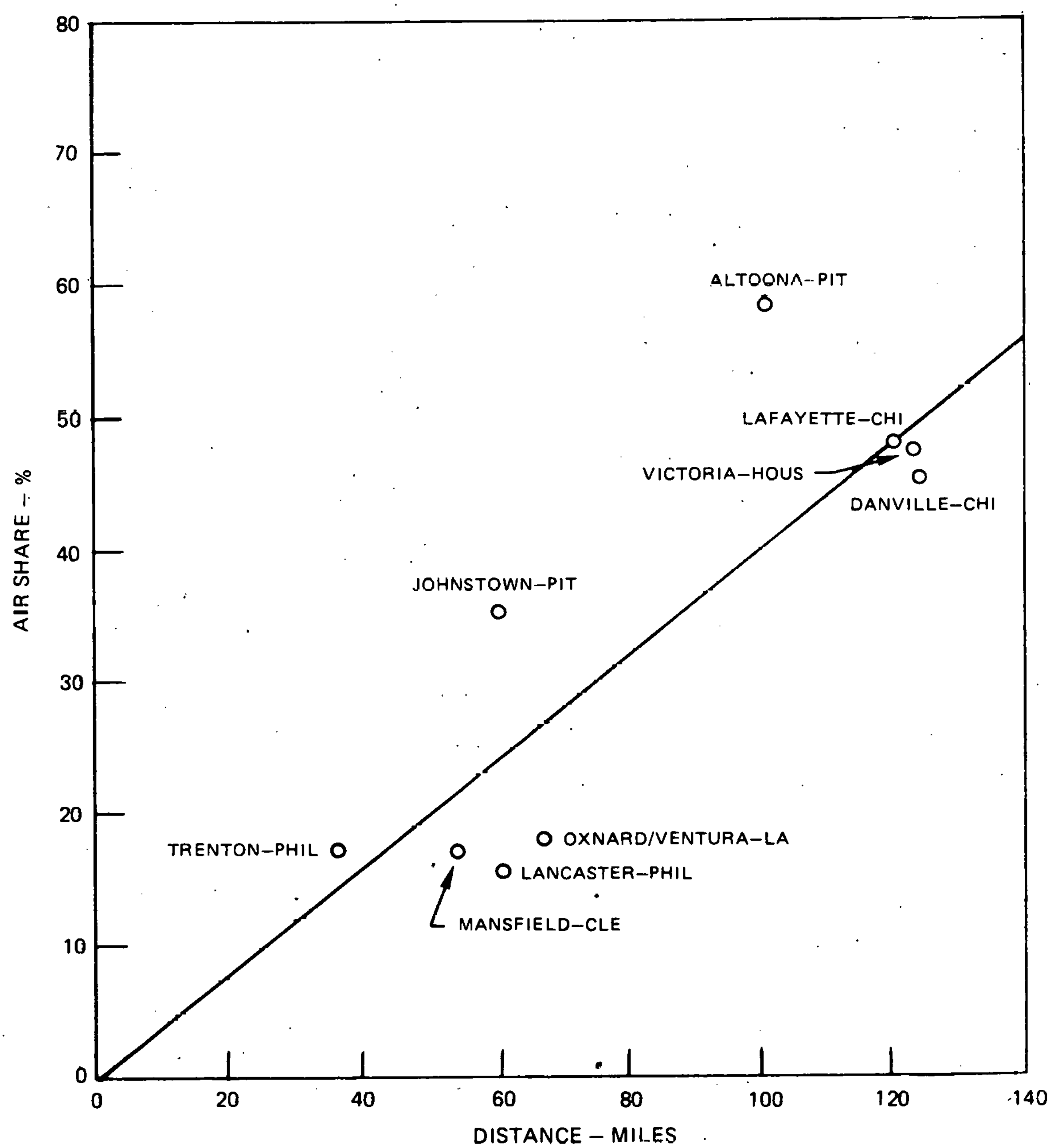
## EFFECT OF CITY SIZE ON PER CAPITA AIR TRIPS

SOURCE: NATIONAL TRAVEL SURVEY – 1972




76–12–44–2

## PENETRATION OF AIR COMMUTER INTO ACCESS MARKET

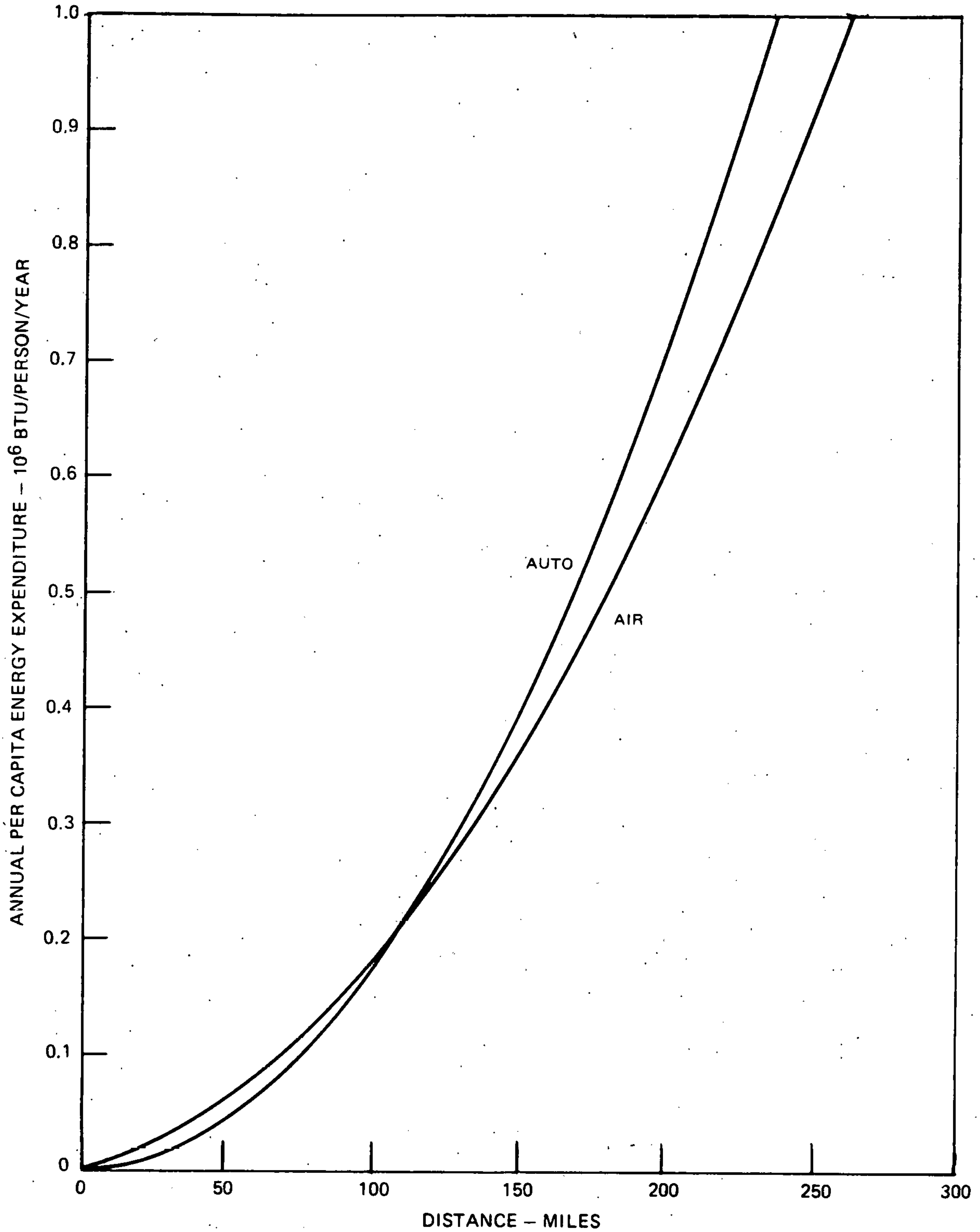



76–12–44–1

## ENERGY USED BY AIR PASSENGERS IN AIRPORT ACCESS

AIR COMMUTER VS AUTO

BASED ON ROUND TRIP TO/FROM NEAREST HUB




76–12–44–3

## Summary of Energy-Saving Results for Individual Strategies

The energy savings calculated for strategies imposed individually are summarized in Table XXXII. These results serve only as a preliminary screening, since they involve only total energy savings and do not reveal savings achieved through modal shift, per se. However, the results are given in terms of demand-normalized savings as well as absolute savings, so that the effects of demand suppression, where it occurs, can be factored into the selection of strategies for further analysis.

These results were used, as described below, to formulate combinations of individual strategies. However, in formulating the combination strategies, policy implications and implementation problems were also considered using information given in Table XXXIII which is discussed in detail in Appendix III. In consideration of both energy savings and implementation problems, as discussed below, individual strategies were selected for further study. These strategies are indicated in the last column of Table XXXII.

## Strategy Selection

The first step in formulating combination strategies was to eliminate those measures which have either poor potential for effecting an energy saving through modal shift or which would be difficult to implement. The energy-saving potential in Table XXXII shows both actual and demand-normalized savings for the individual strategies, and implementation problems are summarized in Table XXXIII. Demand-normalized energy savings are identified since demand suppression is generally a larger contributor to energy savings than modal shift effects, per se. Another effect which contributes to the indicated total energy savings is change in mode efficiency. This effect is also quantified in the analysis to provide a basis for isolating the actual savings resulting from modal shifts.

An obvious conclusion from Table XXXII is that the rail measures compare very poorly in either actual or normalized savings. Rail effects, as noted earlier, are largely confined to the Northeast corridor and the rail mode is already heavily subsidized by the Federal Government. Therefore the rail measures, which call for even more subsidization, can be dropped from consideration in the final strategies. The auto-free CBD proposal is also not very productive in saving energy compared to the other auto measures and can therefore safely be eliminated.

### Implementation Considerations

A preliminary study of the feasibility of implementing the energy-saving measures was made to further refine the list of candidates. It was decided that indirect subsidies such as the $5 destination transportation discount and the 50 percent discount on meal and lodging costs are not likely to be adopted. The major bus operators have offered auto rental discounts in the past without much success, and meal/lodging discounts of 10 to 15 percent are presently available; larger discounts would not be looked on favorably by the bus and hotel industries and are therefore unlikely in regular-route service.

TABLE XXXII

SUMMARY OF ENERGY SAVINGS FOR INDIVIDUAL STRATEGIES

| Strategy | Energy Savings Absolute % | Energy Savings Demand-Normalized % | Retain for Comb. Strat. |
|---|---|---|---|
| Surcharge on Short-Haul Air Fares | | | |
| . Declining | 7.88 | 4.70 | x |
| . Fixed | 7.31 | 4.38 | |
| Reduce Auto Speed to 50 mph | 6.07 | 0.46 | x |
| Force Short-Haul Air Load Factor to 70% | 5.41 | 5.19 | x |
| Replace Large A/C with Smaller A/C and Maintain Current Schedules | 4.94 | 4 66 | |
| Increase Auto Costs by 50% | 3.84 | -2.17 | x |
| Maintain Current Air Schedules | 3.80 | 3.69 | |
| Use Small A/C for Connecting Flights | 3.10 | 3.10 | |
| Replace Large A/C with Smaller A/C | 1.92 | 1.95 | |
| Legislate Auto-Free CBD's | 0.13 | -0.06 | |
| Reduce Bus Travel Time by 10% | -0.13 | 0.75 | x |
| Reduce Rail Travel Time by 10% | -0.20 | 0.17 | |
| Destination Transp. Discount of $5 for Bus Travelers | -0.33 | 1.20 | |
| Meals and Lodging Discount of 50% for Bus Travelers | -0.36 | 1.34 | |
| Bus Fare Reduction of 50% | -0.39 | 1.69 | x |
| Destination Transp. Discount of $5 for Rail Travelers | -0.40 | 0.50 | |
| Meals and Lodging Discount of 50% for Rail Travelers | -0.42 | 0.30 | |
| Train Fare Reduction of 50% | -0.56 | 0.39 | |

TABLE XXXIII

SUMMARY OF IMPLEMENTATION CONSIDERATIONS

| Strategy Policy Option | Implementation Considerations: Legislative, Political and Regulatory | Implementation Considerations: Operational and Economic | Feasibility Evaluation |
|---|---|---|---|
| Surcharge on Short-Haul Air Fares<br>--Declining<br>--Fixed | • Deregulation currently dominates legislative consideration of the airline industry<br>--Opposition from those seeking lower fares<br>--Danger of penalizing air travel during period of industry financial restructuring<br>• Difficulty of penalizing one mode to the advantage of others<br>--Identification in current law of promotion of air travel as goal of aviation policy | • Suppression of demand may further weaken the industry<br>--Possibility of rebate to carriers to prevent financial deterioration<br>• Declining surcharge is preferable to fixed<br>--Greater energy savings<br>--Lower cost<br>--Eliminate discontinuity | • Unlikely under normal conditions<br>• Possible during a crisis situation |
| Reduce Auto Speed to 50 mph<br>--Federal legislation | • Major opposition will come from the trucking industry<br>• Difficulty in imposing a limitation on mobility | • Enforcement problems may significantly undermine the strategy's impact<br>• Increased safety may yield some support | • Unlikely under normal conditions<br>• Possible during a crisis situation |
| Increase Efficiency of Air Travel - (70% Load Factor)<br>--Fuel Allocation | • Requires strong federal action | • Disruption of complex airline scheduling<br>• Loss of passenger convenience<br>• Reduction in airline employment<br>• Probable increase in breakeven load factor | • Unlikely under normal conditions<br>• Possible during crisis situation |
| --Maintain current Schedules | • Capacity agreements are illegal<br>• CAB does not have authority to control service frequency | • Capacity restraint results in more than proportional loss of market share<br>• Scheduling is the primary perogative of airline management | • Unlikely under normal conditions<br>• Unlikely during crisis situation |
| --Replace large aircraft with small aircraft and maintain current scheduling | • Same as above | Same as above | • Unlikely under normal conditions<br>• Unlikely during crisis situation |
| --Replace large aircraft with smaller aircraft | | • May not displace large aircraft due to scheduling and positioning requirements<br>• Large-scale replacement not possible in short-term | • Unlikely under normal conditions<br>• Unlikely during crisis situation |

TABLE XXXIII (Cont'd)

SUMMARY OF IMPLEMENTATION CONSIDERATIONS

| Strategy Policy Option | Implementation Considerations: Legislative, Political and Regulatory | Implementation Considerations: Operational and Economic | Feasibility Evaluation |
|---|---|---|---|
| Increase Auto Operating Costs by 50 percent | | | |
| --Increase gasoline tax \$.54 per gallon | • Strong pro-automobile lobby would oppose such a drastic increase<br>• Difficulty in imposing limitation on mobility | • Because of its regressive character, lower income groups would be more severely affected<br>• Industry and regional dependence on auto<br>Inflation and changing price elasticities will decrease the impact of a flat tax over time | • Unlikely under normal conditions<br>• Possible during crisis situation |
| --Charge tolls on roads | • Strong opposition will come from all levels of government as well as private groups | • Costs of collection will significantly reduce and may even eliminate any revenue | • Unlikely under normal conditions<br>• Unlikely during crisis situation |
| Replace equipment used on connecting flights with small aircraft | | | |
| --Mandatory adoption | • Momentum toward less regulation in the airline industry | • Requirements for aircraft positioning<br>• Demand peaking along a route<br>• Availability of smaller aircraft | • Unlikely under normal conditions<br>• Unlikely during crisis situation |
| --Voluntary adoption | | • Pilot pay scale biased toward larger planes<br>• Ability of airlines to attract capital for equipment purchases | • Unlikely under normal conditions<br>• Unlikely during crisis situation |
| --Deregulation | • Growing support in Congress<br>--Lower fares<br>--More efficient industry<br>--Better matching of equipment to markets | • Financial viability of industry: short versus long term | • Likely over the short term, but emergence of rationalized route system is a long term effect |
| Replace Automobile Use with small aircraft for accessing Hub airports | • Reluctance to foster dependence on uneconomic air travel | • Failure of commuter airlines to provide service indicates that it is uneconomic | • Unlikely under normal conditions<br>• Unlikely during crisis situation |
| Replace connecting flights with bus service | • Under the Administration's bill, airline deregulation may provide impetus to airline limousines<br>• Considerable expansion of (bus) route authority required<br>• CAB and communities affected would have to agree that bus is an adequate replacement | • Travel time penalty for passengers with no compensating fare inducement<br>• Initiation of new bus service is risky and expensive<br>• Only advantageous for airlines on routes operating unprofitably | • Unlikely under normal conditions<br>• Unlikely during crisis situation |

TABLE XXXIII (Cont'd)

SUMMARY OF IMPLEMENTATION CONSIDERATIONS

| Strategy Policy Option | Implementation Considerations: Legislative, Political and Regulatory | Implementation Considerations: Operational and Economic | Feasibility Evaluation |
|---|---|---|---|
| Auto Free CBD's | • National Parking Association members will oppose<br>• The number of institutions affected is enormous. In New York City alone approval would have to be obtained from at least 11 different agencies<br>• Support may be obtained from UMTA, which is currently investigating alternative locations for a demonstration project. Support may also come from EPA<br>• Leverage will have to come from urban sector | • Downtown merchants and other businesses are likely to object strongly. Experience in foreign countries has not, however, indicated that hardship will result<br>• Land required for outlying parking lots<br>• Transit mode into city must be available with good scheduled frequency | • Unlikely under normal conditions except as demonstration projects<br>• Unlikely during crisis situation |
| Reduce Bus Travel Time by 10 percent | | | |
| --Federal legislation allowing differential speed for trucks buses | • This was considered and rejected for safety reasons under the shortfall conditions of 1973-1974 | | • Unlikely under normal conditions<br>• Unlikely during crisis situation |
| -- Dedicated bus (and car-pool) lanes at city end points or on intercity routes | • The overall orientation of city, state, and even federal highway people remains in favor of maximization of vehicle (as opposed to passenger) throughput | • Bus lanes at city end-points will decrease travel time primarily during rush hour. The 10 percent decrease is not likely to be achieved | • Unlikely under normal conditions except in response to urban needs<br>• Unlikely during crisis situation |
| --Greater express bus service | • Growing recognition of bus industry may result in demonstration projects<br>• In some cases may require ICC approval to skip intermediate points | • On most routes express service will never catch on with sufficient load factor to provide even normalized energy savings<br>• On some high travel density routes express service, particularly during rush hours, could probably become self-sustaining. The seed money required to initiate the service, however, has prevented industry experimentation on most of these routes | • Publicly funded demonstration projects have a moderate likelihood of being initiated over the next five years<br>• Possible during crisis situation |
| Reduce Rail Travel time by 10 percent | | | |
| --Federal expenditure for track improvement | • No indication that potential energy savings could justify expenditures required<br>• Growing discontent with the exponential rate of growth of federal commitment to passenger rail .. | | • Unlikely except as already planned for next five years<br>• Unlikely during crisis situation |
| --Greater express service | • Route alternatives are limited because of the implied loss of service at intermediate points | • Load factors could not be maintained on the vast majority of routes<br>• Negligible potential for tightening schedules | • Unlikely except as already planned for next five years<br>• Unlikely during crisis situation |

TABLE XXXIII (Cont'd)

SUMMARY OF IMPLEMENTATION CONSIDERATIONS

| Strategy Policy Option | Implementation Considerations: Legislative, Political and Regulatory | Implementation Considerations: Operational and Economic | Feasibility Evaluation |
|---|---|---|---|
| Destination Cost Discount of $5 for Bus Users | | | |
| --Auto rental discounts | | • Greyhound has in the past provided this type of a discount in the Ameripass discount guide. A survey of passenger use of the discounts indicated that the car rental option was used least of all. They find that most of their patrons are picked up by relatives and/or take public transit | • Selected offerings will continue. Widespread use is unlikely under normal conditions<br>• Unlikely during crisis situation |
| --Taxi fare vouchers issued with ticket | | • This would probably require direct expenditure by the bus companies, and would not have the marketing advantage of providing greater consumer convenience<br>• Even with strong justification by way of increased sales (which is unlikely because of the characteristics of bus patrons) the need for seed money in other programs and the overall conservatism of the industry would militate against voluntary adoption of this program | • Unlikely under normal conditions<br>• Unlikely during crisis situation |
| --Federal subsidy of bus user destination costs | • As summarized below, there are significant restraints on federal subsidization, particularly through indirect methods | | • Unlikely under normal conditions<br>Unlikely during crisis situation |
| --Suburban terminals | • Growing support for federal assistance in construction and renovation of intermodal terminals<br>• The ICC has proposed Standards of Service for the bus industry which include terminal construction requirements. Industry contends that the Standards will bankrupt them | • Both Greyhound and Trailways have started program os suburban terminal construction. Costs per terminal range upward from about $100,000<br>• Terminal location may not yield a net saving in destination costs and will increase travel time | • Continuation of existing private program<br>• Increase in intermodal terminal construction is likely<br>• Unlikely during crisis situation |
| --Integrate urban and intercity transportation networks | • Funding would largely originate in UMTA. The urban as opposed to the intercity travel market would have the leverage | • Would yeild savings in areas where there is no such integration and for patrons who are not met by friends and relatives | • Increased integration is likely to occur in several cities over the next five years<br>• Unlikely during crisis situation |

TABLE XXXIII (Cont'd)

SUMMARY OF IMPLEMENTATION CONSIDERATIONS

| Strategy Policy Option | Implementation Considerations: Legislative, Political and Regulatory | Implementation Considerations: Operational and Economic | Feasibility Evaluation |
|---|---|---|---|
| Discount 50 percent on Meals and Lodging with Purchase of Bus Ticket | • Subsidization by the federal government of a discount program would likely run into the opposition of both the direct and indirect programs proposed under fare subsidies | • Greyhound currently offers discounts ranging up to 10 or 15 percent on lodging (Slumber Stop) and meals (Post House discount cards). Under this program you buy the meals and lodging minus the discount when you buy your ticket<br>• A 50 percent discount is viewed askance by both hoteliers and the bus industry. For lodging in particular guarantee of a room would be unlikely at a rate of 50 percent off | • Discounts of this magnitude are unlikely in regular route service<br>• Unlikely during crisis situation |
| Bus Fare Reduction of 50 percent | | | |
| --Prove rates are unjust and unreasonable | • Strong labor and management opposition<br>• Weak consumer position. Financial data is not in the public domain<br>• ICC would have to disallow certain costs<br>--equipment<br>--labor | • Operating costs for Class I carriers have increased 38.8 percent since 1970, while revenues have increased by only 31.3 percent<br>• In 1971 the average operating ratio for Class I carriers was 87.6 percent as compared with 90.6 percent in 1973 and 93.6 percent in 1975<br>• Route-by-route financial data, if they exist, are not public knowledge | • Unlikely under normal conditions<br>• Unlikely during crisis situation |
| --Indicate subsidies to passengers (income tax deductions or rebates) | • Strong legislative opposition can be expected on the basis of interference with freedom of choice<br>• Possibility of subsidizing mobility as opposed to fares | • Administrative cost<br>May not be perceived as a fare reduction by patrons<br>• Due to characteristically lower income patrons, this may imply a negative income tax | • Unlikely under normal conditions<br>• Unlikely during crisis situation |
| --Direct subsidization of fares | • Growing momentum in Congress and the Executive for private market solutions. This is compounded by the historic ability of the carriers to provide essential transportation services without public support<br>--Lessons of the past indicate that trying the balance inequities (e.g., Amtrak competition) through more subsidy tends to create further imbalance<br>--Inefficiencies are harbored by federal and state subsidy<br>--Potential for an initially modest spending program to grow at exponential rates | • Reservations of the bus companies include the operating requirements that may be imposed by accepting subsidy<br>• Administrative control may be virtually impossible within the existing regulatory framework<br>—Cross subsidization of routes, services, and geographic areas<br>--Over 900 carriers ranging in size from "Ma and Pa" to Greyhound Lines and serving over 15,000 cities | • Unlikely under normal conditions<br>• Possible during crisis situation |

TABLE XXXIII (Cont'd)

SUMMARY OF IMPLEMENTATION CONSIDERATIONS

<table>
<tr><th rowspan="2">Strategy Policy Option</th><th colspan="2">Implementation Considerations</th><th rowspan="2">Feasibility Evaluation</th></tr>
<tr><th>Legislative, Political and Regulatory</th><th>Operational and Economic</th></tr>
<tr><td>--Deregulation</td><td rowspan="2">• Motor carrier regulatory reform hinges on the trucking industry rather than the bus industry. The opposition is substantial. Even if airline reform paves the way over the next year, it will still be at least 2 to 3 years before motor carrier regulation is liberalized<br><br>• The Administration's bill does not preempt state control over exit. On this basis, industry says it will play havoc with the industry<br><br>• Without economic regulation, the barriers to entry are neglibile. The carriers, therefore, fear that numerous fly by night operations will discredit the whole industry</td><td>• Liberalized entry and exit would necessitate subsidization of certain rural routes in order to maintain service. The net result of increased competition, however, may be substantial fare reductions on other routes. Industry counters this latter assertion with a prediction of doom, stating that capacity will out run demand and carriers will face bankruptcy nationwide</td><td>• Moderately likely over next five years<br><br>• Unlikely during crisis situation</td></tr>
<tr><td>Destination Cost Discount of $5 for Rail Users</td><td rowspan="2">• Currently AMTRAK offers car rental discounts on selected routes (Florida Week of Wheels)<br><br>• AMTRAK marketing is based on identification of sensitive markets and instituting short term discount programs<br><br>• AMTRAK currently issues coupons for a 10 percent discount at certain hotels, tourist attractions, and restaurants on its western routes.</td><td>• Widespread use is unlikely under normal conditions<br><br>Unlikely during crisis situation</td></tr>
<tr><td>Discount of 50 percent on Meal and Lodging with Purchase of a Train Ticket</td><td></td><td>• Widespread use is unlikely under normal conditions<br><br>• Unlikely during crisis situation</td></tr>
<tr><td>Train Fare Reduction of 50 percent</td><td>• The federal government is already subsidizing AMTRAK fares and will be continuing to do so. There is no indication that energy savings could effectively justify greater operating subsidy</td><td></td><td>• Unlikely under normal conditions<br><br>• Unlikely during crisis situation</td></tr>
</table>

Of the two air fare surcharge measures, it appears that the fixed surcharge would produce an undesirable discontinuity in the airline fare schedule. The declining surcharge is equivalent to a 100 percent fare increase at 100 miles, 30 percent at 300 miles, and no increase at or above 500 miles; the average increase is 21.3 percent. It has a slightly larger impact than the fixed surcharge, despite being slightly smaller in size, because the declining surcharge concentrates its impact on the shortest routes, where modal shifts from air are easier and the potential energy savings of such shifts are greater. Consequently the fixed surcharge was dropped. Furthermore, it was decided that the two measures designed to replace large aircraft by smaller ones might further aggravate the airlines overcapacity problem if implemented on the scale necessary to achieve the illustrated energy savings. Accordingly, these methods were eliminated in favor of the more effective load factor and fare-increase strategies. Also, the constant-frequency strategies were dropped because they are similar to, but appear to save less energy than, the 70 percent load factor strategy.

Probable Impacts of Selected Strategies

Table XXXIV summarizes the major positive and negative impacts of implementing these six strategies during a severe energy shortfall. The table draws on the Task 5 results and the implementation considerations pointed out in Table XXXIII. The comparison indicates that both bus strategies are relatively undesirable from the point of view of federal expenditures, energy savings and efficiency, and administrative requirements. The auto strategies achieve greater energy savings, but at the sacrifice of energy efficiency. Moreover, the range of activities and groups adversely impacted by the strategies is large. The air strategies, while appearing to save more fuel than other strategies, would do so at a financial penalty to the air carriers and/or inconvenience and possibly excessive cost to the air traveler. A forced high load factor could adversely impact the long-haul air system by reducing the availability of connecting service provided by the short-haul sector.

TABLE XXXIV

SUMMARY OF IMPACTS ASSOCIATED WITH STRATEGY IMPLEMENTATION
(Effects noted are percentages of Baseline Conditions)

| Policy | Positive Impacts | Negative Impacts |
|---|---|---|
| Declining Surcharge on Short-Haul Air Fares | Energy savings of 7.88 percent<br>Energy efficiency improved by 4.70 percent<br>Federal revenues of $371 million | Passenger-miles of travel reduced by 3.10 percent<br>Average charge of $7.03 per air passenger<br>Reduced airline revenue<br>Travel time per passenger increased by 3.2 percent |
| Airline Fuel Allocation | Energy savings of 5.41 percent<br>Energy efficiency improved by 5.19 percent | Increased airline cost for fuel; rescheduling; re-training employees<br>Decreased service to passengers<br>Increased airline unemployment<br>Rise in break-even load factor<br>Penalizes long-haul air travel |
| Auto Speed Reduction | Energy savings of 6.07 percent<br>Energy efficiency improved by 0.46 percent<br>Increased highway safety | Passenger-miles of travel reduced by 5.6 percent<br>Reduced energy efficiency of truck and bus operations<br>Increased costs to trucking and bus operations<br>Reduced truck driver earnings<br>Increased delay in transport of passengers and property<br>Increased signing and enforcement costs<br>Travel time per passenger increased by 4.6 percent |
| Gasoline tax of $0.54 per gallon | Energy savings of 3.84 percent<br>Federal revenues of $1.0788 billion<br>Travel time per passenger decreased by 1.4 percent | Energy efficiency decreased by 2.31 percent<br>Passenger-miles of travel reduced by 6.0 percent<br>Average charge of $3.15 per auto passenger<br>Variation in incidence of tax by region, industry, and income group |
| Bus Fare Reduction | Energy efficiency improved by 1.69 percent<br>Passenger miles of travel increased by 2.08 percent<br>Average savings of $6.38 per bus passenger | Energy use increased by 0.38 percent<br>Subsidy of $153.8 million required<br>Travel time per passenger increased by 1.4 percent<br>Administrative requirements are likely to be high |
| Express Bus Service | Energy Efficiency improved by 0.75 percent<br>Passenger miles of travel increased by 0.87 percent | Energy use increased by 0.13 percent<br>Federal provision of seed money |

# EVALUATION OF COMBINATION STRATEGIES

Energy-saving measures considered in the preceding section were evaluated independently to determine their relative effectiveness in conserving energy. Combinations of these individual measures were then evaluated to determine their effectiveness in achieving energy savings specifically through the modal shift process together with information relative to their effects on travel demand and mode efficiency changes.

## Combination Strategies

A summary of the final strategies formulated by combinations of the remaining five measures, and their pertinent characteristics, is provided in Table XXXV. This table still refers to only the short-haul, SMSA-pairs; an expansion of results to all short-haul travel will be presented later. Altogether, fifteen combination strategies were composed from the two bus, two auto and one air measures listed at the top of the table. The combination strategies are divided into three groups. The first group consists of one or two changes in a single mode:

A - 50-mph auto speed and 50 percent increase in auto operating cost

B - 50 percent bus fare reduction and 10 percent reduction in bus time

C - 21 percent declining air fare surcharge

The second group (Strategies 1 to 6) consists of combinations of the auto (A) and bus (B) strategies, and the third group (Strategies 7 to 12) consists of these same combinations plus the air fare surcharge (C). Thus, Strategy 12 includes all of the selected individual strategies taken in combination. All of the results in Table XXXV are calculated with baseline air load factors.

Table XXXVI is similar to Table XXXV except that it includes the simulated effects of an arbitrary air load factor of 70 percent which, while not a modal-shift measure, was included in the calculations to show how the modal-shift savings might change if air load factors were to vary from their baseline value. An air load factor of 70 percent is assumed to be a limiting value which could not be achieved without disruptive effects on the entire air transport system; the effects of more realistic levels can be inferred, by interpolation, from the two sets of results given.

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TABLE XXXV

COMBINED MODAL-SHIFT STRATEGY RESULTS -- ALL SHORT-HAUL SMSA-SMSA INTERCITY TRAVEL

Baseline Load Factors

| | (1973) | 1980 Baseline | Single-Mode Strategies A | B | C | Auto and Bus Strategies 1 | 2 | 3 | 4 | 5 | 6 | Auto, Bus, and Air Fare Surcharge Strategies 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Strategies:** | | | | | | | | | | | | | | | | | |
| 50 MPH Auto Speed | | | X | | | X | X | | | X | X | X | X | | | X | X |
| 50% Auto Cost Increase | | | X | | | | | X | X | X | X | | | X | X | X | X |
| 50% Bus Fare Reduction | | | | X | | | X | | X | | X | | X | | X | | X |
| 10% Bus Time Reduction | | | | X | | (X)[1] | (X) | X | X | (X) | (X) | (X) | (X) | X | X | (X) | (X) |
| 21% Air Fare Surcharge | | | | | X | | | | | | | X | X | X | X | X | X |
| Pass.-Miles ($10^9$) | 79.845 | 100.099 | 89.496 | 103.392 | 96.916 | 94.480 | 96.610 | 94.969 | 97.457 | 89.496 | 91.679 | 91.262 | 93.433 | 91.769 | 94.292 | 86.266 | 88.461 |
| Modal Shares: T/LS Air | 0.1574 | 0.2274 | 0.2979 | 0.2168 | 0.1764 | 0.2619 | 0.2540 | 0.2613 | 0.2500 | 0.2979 | 0.2875 | 0.2044 | 0.1974 | 0.2025 | 0.1927 | 0.2331 | 0.2236 |
| Commuter Air | 0.0011 | 0.0026 | 0.0040 | 0.0024 | 0.0035 | 0.0032 | 0.0031 | 0.0032 | 0.0030 | 0.0040 | 0.0037 | 0.0043 | 0.0041 | 0.0043 | 0.0040 | 0.0054 | 0.0051 |
| Rail & Metro | 0.0099 | 0.0121 | 0.0193 | 0.0105 | 0.0140 | 0.0149 | 0.0134 | 0.0150 | 0.0131 | 0.0193 | 0.0170 | 0.0176 | 0.0156 | 0.0176 | 0.0151 | 0.0232 | 0.0202 |
| Bus | 0.0214 | 0.0285 | 0.0468 | 0.0690 | 0.0328 | 0.0366 | 0.0662 | 0.0487 | 0.0907 | 0.0468 | 0.0848 | 0.0428 | 0.0772 | 0.0578 | 0.1055 | 0.0557 | 0.0997 |
| Auto | 0.8102 | 0.7293 | 0.6320 | 0.7013 | 0.7733 | 0.6834 | 0.6633 | 0.6718 | 0.6432 | 0.6320 | 0.6070 | 0.7309 | 0.7057 | 0.7178 | 0.6826 | 0.6826 | 0.6514 |
| Total User Cost ($10^9$ $) | 6.741 | 9.977 | 10.6301 | 10.305 | 9.659 | 10.037 | 10.224 | 10.750 | 10.955 | 10.630 | 10.811 | 9.720 | 9.911 | 10.462 | 10.661 | 10.346 | 10.524 |
| Cost/Pass.-Mile | 0.0844 | 0.0997 | 0.1188 | 0.0997 | 0.0997 | 0.1062 | 0.1058 | 0.1132 | 0.1124 | 0.1188 | 0.1179 | 0.1065 | 0.1061 | 0.1140 | 0.1131 | 0.1200 | 0.1190 |
| Total User Time ($10^9$ Hrs) | 1.714 | 2.195 | 2.015 | 2.304 | 2.195 | 2.168 | 2.252 | 2.050 | 2.148 | 2.015 | 2.107 | 2.178 | 2.266 | 2.058 | 2.160 | 2.032 | 2.129 |
| Avg. Travel Speed (MPH) | 48.2 | 47.3 | 46.6 | 46.7 | 45.6 | 45.4 | 44.8 | 48.5 | 47.5 | 46.6 | 45.7 | 43.4 | 42.8 | 46.4 | 45.5 | 44.3 | 43.4 |
| Total Bus Subsidy ($10^9$ $) | - | - | - | 0.2109 | - | - | 0.1887 | - | 0.2620 | - | 0.2302 | - | 0.2138 | - | 0.2959 | - | 0.2621 |
| /Bus Traveler ($) | - | - | - | 6.50 | - | - | 6.57 | - | 6.54 | - | 6.59 | - | 6.58 | - | 6.57 | - | 6.60 |
| Total Auto Cost Increase ($10^9$ $) | - | - | 0.9469 | - | - | - | - | 1.0752 | 1.0571 | 0.9469 | 0.9326 | - | - | 1.1224 | 1.0976 | 0.9965 | 0.9767 |
| /Auto Traveler ($) | - | - | 3.05 | - | - | - | - | 3.14 | 3.13 | 3.05 | 3.04 | - | - | 3.23 | 3.22 | 3.15 | 3.14 |
| Total Air Surcharge ($10^9$ $) | - | - | - | - | 0.3710 | - | - | - | - | - | - | 0.4011 | 0.3947 | 0.3884 | 0.3780 | 0.4282 | 0.4173 |
| /Air Traveler ($) | - | - | - | - | 7.03 | - | - | - | - | - | - | 6.97 | 6.93 | 6.79 | 6.76 | 6.88 | 6.84 |
| Net Increase in Gov't. Receipts[2] ($10^9$ $) | - | - | 0.9469 | -0.2109 | 0.3710 | 0.0 | -0.1887 | 1.0752 | 0.7951 | 0.9469 | 0.7024 | 0.4011 | 0.1809 | 1.5108 | 1.1797 | 1.4246 | 1.1319 |
| Total Energy ($10^{12}$ Btu) | 440.650 | 489.875 | 446.631 | 490.488 | 451.285 | 460.120 | 460.660 | 470.979 | 468.722 | 446.631 | 445.509 | 417.812 | 417.817 | 427.782 | 425.016 | 400.384 | 398.640 |
| Energy Intensity ($10^3$ Btu/P.M.) | 5.519 | 4.894 | 4.991 | 4.744 | 4.656 | 4.870 | 4.768 | 4.959 | 4.810 | 4.991 | 4.859 | 4.578 | 4.472 | 4.662 | 4.507 | 4.643 | 4.506 |
| % Improvement | - | - | -1.97% | 3.06% | 4.85% | 0.49% | 2.57% | -1.34% | 1.72% | -1.97% | 0.70% | 6.45% | 8.62% | 4.75% | 7.90% | 5.12% | 7.92% |
| Energy Saved ($10^{12}$ Btu): | | | | | | | | | | | | | | | | | |
| Actual | - | - | 43.244 | -0.613 | 38.590 | 29.755 | 29.215 | 18.896 | 21.153 | 43.244 | 44.366 | 72.063 | 72.058 | 62.093 | 64.859 | 89.491 | 91.235 |
| % | - | - | 8.83% | -0.13% | 7.88% | 6.07% | 5.96% | 3.86% | 4.32% | 8.83% | 9.06% | 14.71% | 14.71% | 12.68% | 13.24% | 18.27% | 18.62% |
| Demand-Normalized | - | - | -9.670 | 15.009 | 23.769 | 2.390 | 12.579 | -6.545 | 8.446 | -9.670 | 3.449 | 31.606 | 42.249 | 23.252 | 38.684 | 25.013 | 38.790 |
| % | - | - | -1.97% | 3.06% | 4.85% | 0.49% | 2.57% | -1.34% | 1.72% | -1.97% | 0.70% | 6.45% | 8.62% | 4.75% | 7.90% | 5.12% | 7.92% |
| Emissions ($10^3$ Wtd Tons) | 212.628 | 160.210 | 134.544 | 163.680 | 161.066 | 146.521 | 148.778 | 146.443 | 148.817 | 134.544 | 136.540 | 147.529 | 149.560 | 147.389 | 149.437 | 135.601 | 137.387 |
| Wtd Tons/$10^6$ P.M. | 2.663 | 1.601 | 1.503 | 1.583 | 1.662 | 1.551 | 1.540 | 1.542 | 1.527 | 1.503 | 1.489 | 1.616 | 1.601 | 1.606 | 1.585 | 1.573 | 1.553 |

1. (X) indicates that potential bus time savings resulting from increased express bus service, for example, have been cancelled by slower speeds required by the 50-mph speed limit. Thus, baseline bus times were used.
2. "Net increase in Government receipts" assumes that bus fare reductions are achieved through subsidies, while auto cost increases and air fare surcharges are brought about through taxation.

All distances are in straight-line miles.

All costs are in 1973 dollars.

TABLE XXXVI

COMBINED MODAL-SHIFT STRATEGY RESULTS -- ALL SHORT-HAUL SMSA-SMSA INTERCITY TRAVEL

70% Air Load Factor

| | (1973) | 1980 Baseline | Single-Mode Strategies | | | Auto and Bus Strategies | | | | | | Auto, Bus, and Air Fare Surcharge Strategies | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | A | B | C | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Strategies: | | | | | | | | | | | | | | | | | |
| 50 MPH Auto Speed | | | X | | | X | X | | | X | X | X | X | | | X | X |
| 50% Auto Cost Increase | | | X | | | | | X | X | X | X | | | X | X | X | X |
| 50% Bus Fare Reduction | | | | X | | | X | | X | | X | | X | | X | | X |
| 10% Bus Time Reduction | | | | X | | (X)[1] | (X) | X | X | (X) | (X) | (X) | (X) | X | X | (X) | (X) |
| 21% Air Fare Surcharge | | | | | X | | | | | | | X | X | X | X | X | X |
| Energy Intensity ($10^3$ Btu/P.M.) | - | 4.639 | 4.628 | 4.478 | 4.469 | 4.551 | 4.459 | 4.640 | 4.505 | 4.628 | 4.523 | 4.346 | 4.248 | 4.431 | 4.289 | 4.379 | 4.259 |
| % Improvement | - | 5.20% | 5.43% | 3.50% | 8.68% | 7.01% | 8.89% | 5.19% | 7.95% | 5.43% | 7.50% | 11.20% | 13.20% | 9.46% | 12.36% | 10.52% | 12.97% |
| Energy Saved ($10^{12}$ Btu): | | | | | | | | | | | | | | | | | |
| Actual | - | 26.523 | 74.465 | 25.449 | 57.460 | 58.641 | 57.830 | 47.862 | 49.550 | 74.465 | 75.191 | 92.671 | 92.418 | 82.592 | 84.885 | 111.714 | 113.082 |
| % | - | 5.41% | 15.20% | 5.19% | 11.73% | 11.97% | 11.81% | 9.77% | 10.11% | 15.20% | 15.35% | 18.92% | 18.87% | 16.86% | 17.33% | 22.80% | 23.08% |
| Demand-Normalized | - | 25.470 | 26.617 | 41.632 | 42.533 | 34.324 | 43.534 | 25.816 | 38.929 | 26.617 | 37.127 | 54.845 | 64.654 | 46.336 | 60.550 | 51.541 | 63.553 |
| % | - | 5.20% | 5.43% | 3.50% | 8.68% | 7.01% | 8.89% | 5.19% | 7.95% | 5.43% | 7.58% | 11.20% | 13.20% | 9.46% | 12.36% | 10.52% | 12.97% |
| Emissions ($10^3$ Wtd Tons) | - | 158.379 | 132.384 | 161.861 | 159.772 | 144.526 | 146.802 | 144.243 | 146.859 | 132.384 | 134.410 | 146.112 | 148.170 | 145.990 | 148.072 | 134.086 | 135.899 |
| Wtd Tons/$10^6$ P.M. | - | 1.582 | 1.479 | 1.566 | 1.649 | 1.530 | 1.520 | 1.521 | 1.507 | 1.479 | 1.466 | 1.601 | 1.586 | 1.591 | 1.570 | 1.555 | 1.536 |

1. (X) indicates that potential bus time savings resulting from increased express bus service, for example, have been cancelled by slower speeds required by the 50-mph speed limit. Thus, baseline bus times were used.
2. "Net increase in Government receipts" assumes that bus fare reductions are achieved through subsidies, while auto cost increases and air fare surcharges are brought about through taxation.

All distances are in straight-line miles.

All costs are in 1973 dollars.

While Tables XXXV and XXXVI summarize much of the basic quantitative data derived from applying the model described earlier, the most pertinent data -- energy savings -- have been highlighted in Table XXXVII which separates the contributions of the following three mechanisms by which energy savings are produced by the implementation of the strategies examined:

- Energy savings through suppression of demand
- Energy savings through mode efficiency improvements
- Energy savings through modal shifts

Because energy savings based on demand suppression and mode efficiency improvements can also be achieved by measures other than modal shift, the modal-shift effect, as presented in Table XXXVII, is the most pertinent of the three with respect to the objectives of the present study.

For those strategies which result in the greatest total savings (Strategies 11' and 12'), the demand-suppression effect is dominant (44-54%) and the mode efficiency effect is responsible for much of the remainder (32-33%). The savings achieved by modal shift, per se, are small (13-24% of total savings and only 3-5% of the baseline energy). Where the modal-shift savings are a major part of the total (Strategies C, 2, 10, B') the total savings are not nearly as large (5-13% of the baseline energy).

All of the above results are based on travel among only the SMSA-SMSA pairs in the 67-500 mile distance category. Since this is only a part of the short-haul travel in the U.S., these results must be expanded into the entire short-haul sector in order to more fully evaluate the strategies considered. This expansion, and the final quantitative results of the study, are presented in the following section.

## Additional Travel Sectors

In its most comprehensive definition, short-haul, intercity travel consists of all trips between population centers which are less than 500 miles apart. For very short distances the definition of an "intercity trip" becomes obscure since the generally accepted categories of trip purpose are not descriptive of all such trips, and criteria such as an overnight stay at destination are often not met. Therefore it is convenient to set both upper and lower bounds on travel distance, as in the preceding analysis of SMSA-to-SMSA travel, between 67 and 500 miles. However, trips involving population centers below the SMSA level should also be considered. Furthermore, intercity trips under 67 miles should not be neglected entirely. The method by which these additional intercity trips were analyzed is described below.

TABLE XXXVII

COMPONENTS OF ENERGY SAVINGS IN THE SHORT-HAUL
SMSA - SMSA INTERCITY SECTOR

| Strategy | Total Energy Savings $10^{12}$ Btu | Energy Savings Due to: Demand Suppression $10^{12}$ Btu | Reduced Auto Speed $10^{12}$ Btu | Increased Air Eff. $10^{12}$ Btu | Modal Shift $10^{12}$ Btu | Modal Shift Savings: % Total | % Baseline |
|---|---|---|---|---|---|---|---|
| Baseline | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| A | 43.24 | 52.92 | 11.09 | 0 | -20.76 | -48.01 | -4.24 |
| B | -0.61 | -15.62 | 0 | 0 | 15.01 | --- | --- |
| C | 38.59 | 14.82 | 0 | 0 | 23.77 | 61.60 | 4.85 |
| 1 | 29.76 | 27.37 | 12.66 | 0 | -10.27 | -34.50 | -2.10 |
| 2 | 29.22 | 16.64 | 12.56 | 0 | 19.49 | 66.72 | 3.98 |
| 3 | 18.90 | 25.44 | 0 | 0 | -6.54 | -34.63 | -1.34 |
| 4 | 21.15 | 12.71 | 0 | 0 | 8.45 | 39.92 | 1.72 |
| 5 | 43.24 | 52.92 | 11.09 | 0 | -20.76 | -48.01 | -4.24 |
| 6 | 44.37 | 40.91 | 10.91 | 0 | -7.45 | -16.80 | -1.52 |
| 7 | 72.06 | 40.46 | 13.07 | 0 | 18.53 | 25.72 | 3.78 |
| 8 | 72.06 | 29.81 | 12.92 | 0 | 29.32 | 40.70 | 5.99 |
| 9 | 62.09 | 38.83 | 0 | 0 | 23.26 | 37.46 | 4.75 |
| 10 | 64.86 | 26.17 | 0 | 0 | 38.69 | 59.65 | 7.90 |
| 11 | 89.49 | 64.23 | 11.54 | 0 | 13.72 | 15.33 | 2.80 |
| 12 | 91.24 | 52.44 | 11.29 | 0 | 27.50 | 30.14 | 5.61 |
| Baseline ' | 25.52 | 0 | 0 | 28.11 | -2.59 | -10.17 | 0 |
| A' | 75.69 | 49.07 | 11.09 | 32.99 | -17.46 | -23.07 | -3.56 |
| B' | 26.89 | -14.75 | 0 | 27.67 | 13.96 | 51.92 | 2.85 |
| C' | 56.76 | 14.22 | 0 | 21.29 | 21.24 | 37.43 | 4.34 |
| 1' | 59.90 | 25.57 | 12.66 | 30.58 | -8.91 | -14.88 | -1.82 |
| 2' | 59.09 | 15.56 | 12.56 | 30.33 | 0 | 0 | 0 |
| 3' | 49.22 | 23.80 | 0 | 30.65 | -5.23 | -10.63 | -1.07 |
| 4' | 50.83 | 11.90 | 0 | 30.11 | 8.82 | 17.36 | 1.80 |
| 5' | 75.69 | 49.07 | 11.09 | 32.99 | -17.46 | -23.07 | -3.56 |
| 6' | 75.21 | 38.08 | 10.91 | 32.60 | -6.38 | -8.48 | -1.30 |
| 7' | 93.25 | 38.41 | 13.07 | 23.26 | 18.52 | 19.86 | 3.78 |
| 8' | 92.97 | 28.32 | 12.92 | 22.99 | 28.74 | 30.92 | 5.87 |
| 9' | 83.25 | 36.91 | 0 | 23.17 | 23.17 | 27.83 | 4.73 |
| 10' | 85.46 | 24.91 | 0 | 22.65 | 37.91 | 44.36 | 7.74 |
| 11' | 112.12 | 60.58 | 11.54 | 25.12 | 14.88 | 13.27 | 3.04 |
| 12' | 113.12 | 49.57 | 11.29 | 24.70 | 27.56 | 24.36 | 5.63 |

The National Travel Survey, which was used as a basic data source in this study, included all intercity trips between 67 and 500 miles; it was not limited to SMSA-to-SMSA trips. In addition, data for bus, rail and air intercity trips for all distances (not bounded by upper or lower limits on trip length) are available from NAMBO, AMTRAK and CAB sources. Thus, it is possible to estimate the number of short-haul intercity trips not included in the SMSA-to-SMSA analysis summarized in Tables XXXV and XXXVI by piecing together data from various sources. The primary "gap" in making such an estimate is the uncertainty in the amount of auto travel which can be categorized as intercity.

Table XXXVIII includes a series of 1973 modal comparisons, with each successive comparison based on an increasingly comprehensive portion of the travel market. The first comparison repeats the 1973 data from the SMSA-to-SMSA analysis, and includes demand and energy data for both short-haul (under 500 mi) and total intercity travel. The second comparison enlarges the market to include trips between SMSAs and non-SMSAs, but the lower bound of 67 miles still applies. Both of these comparisons are based on the UTRC demand and modal split models, which incorporate NTS, CAB and intrastate demand data. Energy calculations were made by applying appropriate energy intensities to each modal demand. It is seen that short-haul energy more than doubles in this more inclusive market.

The market is further expanded in the third comparison to include all intercity trips between 0 and 500 miles. Some of these data were obtained directly from sources, and the remaining figures (in parentheses) were estimated as described further on. Here, the total short-haul energy is more than four times that in the SMSA-SMSA market due, mostly, to the dominance of auto travel for trips under 67 miles.

Finally, in the last comparison, a breakdown of transportation energy use in all public and private categories (except military and agriculture) is given in order to show intercity travel in its proper perspective relative to other vehicular uses of energy.

In order to fill out the data in the third part of Table XXVIII it was convenient to divide intercity travel into three sectors: 1) SMSA-to-SMSA trips above 67 mi; 2) intercity trips (including non-SMSAs) above 67 mi; and 3) intercity trips under 67 mi. The first sector is identical to the first listing in the table and has been analyzed in great detail in this study. The second sector is the difference between the first two sets of data in Table XXXVIII, and the third is the difference between the second and third sets. Since the first two sets of data are complete from in-hand sources, two of the three desired sectors are completely defined. The third set was initially incomplete (numbers in parentheses) for all auto travel and for short-haul public-mode trips. However, since the only difference between the second and third data sets is the addition of 0-67 mi trips, all of which are short-haul, the short-haul column for the public modes can be estimated with confidence by assuming the differences are the same for short-haul as for all distances. Therefore only auto trips were unknown at this point.

TABLE XXXVIII

MODAL COMPARISONS OF TRANSPORTATION DEMAND AND ENERGY
1973 Data

| Source | Coverage | Mode | Demand - $10^9$ Pass-Mi | | Energy - $10^{12}$ Btu | |
|---|---|---|---|---|---|---|
| | | | Short-Haul | All Distances | Short-Haul | All Distances |
| UTRC[1] | SMSA-SMSA above 67 mi | Auto | 64.691 | 111.153 | 317.57 | 477.96 |
| | | Bus | 1.709 | 2.911 | 2.31 | 3.93 |
| | | Rail | 0.790 | 2.846 | 2.40 | 8.65 |
| | | Air | 12.655 | 97.421 | 118.37 | 855.65 |
| | | TOTAL | 79.845 | 214.331 | 440.65 | 1346.19 |
| UTRC[1] | Intercity above 67 mi | Auto | 180.150 | 274.100 | 843.89 | 1178.63 |
| | | Bus | 2.878 | 5.370 | 4.11 | 7.25 |
| | | Rail | 0.970 | 3.654 | 3.06 | 11.10 |
| | | Air | 18.332 | 132.451 | 174.07 | 1163.32 |
| | | TOTAL | 202.330 | 415.575 | 1025.13 | 2360.30 |
| CAB SNTS[3] SAUS[4] | All Intercity All Distances | Auto | (380.773)[6] | (474.723) | (1828.03) | (2041.31) |
| | | Bus | (9.100) | 11.592 | (17.73) | 15.66 |
| | | Rail | (1.520) | 4.204 | (5.34) | 12.78 |
| | | Air | 18.337 | 132.456 | (174.16) | 1163.36 |
| | | TOTAL | (409.730) | (622.98) | (2010.26) | (3233.11) |
| SNTS ES[5] | All Transportation[2] All Distances | Auto | | 1882.21 | | 9080.48 |
| | | Bus | | 50.50 | | 106.13 |
| | | Rail | | 7.74 | | 542.45 |
| | | Air | | 196.84 | | 1446.66 |
| | | Truck | | - | | 3808.46 |
| | | Other | | 4.00 | | 777.19 |
| | | TOTAL | | 2141.29 | | 15,761.37 |

(1) Based on CAB, NTS, Intrastate data
(2) Includes Freight, International and Urban Travel
(3) Summary of National Transportation Statistics
(4) Statistical Abstract of the U.S.
(5) Energy Statistics (Supplement to SNTS)
(6) Parentheses indicate estimated data

The best way to estimate short-distance auto demand is to estimate modal shares. Using the three distance categories by which SMSA-to-SMSA travel was analyzed earlier, modal shares were plotted against distance, in Fig. 21, to determine trends which might be extrapolated (dashed portions) to short range. As shown, the trends for auto and air are quite consistent, auto decreasing steadily with distance and air increasing. Bus and rail shares are always small, but are greatest for the shortest distance category analyzed (67-150 mi), which has an average trip length of 104 miles.

It is known from CAB and intrastate data that air demand below 50 mi is almost negligible. Therefore the air share at the 35-mi average trip in the 0-67 mi distance category is essentially zero. Furthermore, the other public-mode shares ought to approach zero as distance becomes very small, and the auto trend in Fig. 21 appears to support this contention very well, reaching almost a 97% share at 35 mi. The total bus and rail share is therefore only 3%. The curve extrapolations show that the rail portion was assumed to be low, primarily because many of the city-pairs in this sector will not have rail service, whereas bus service is widely available, even for non-SMSA cities.

A final summary of the demand and energy breakdowns among the three short-haul intercity travel sectors appears in Table XXXIX. In this listing, and in all subsequent tabulations, the commuter and trunk/local service air categories are consolidated into a single air mode designation because the commuters' primary market is in providing access to hubs for long air trips rather than in origin-destination travel. Also, the effects of shifts to commuters from the larger carriers was not significant in SMSA-to-SMSA travel, where possible fuel savings would have originated. The table shows that SMSA-to-SMSA travel accounts for only about 21% of demand and energy in short-haul intercity travel. In terms of possibilities for modal shifts, however, this first sector is important because travel choices are not as overwhelmingly dominated by auto as in sectors II and III. Shifts away from air, for example, can be effective only in Sectors I and II where the air share is large enough to allow a measurable impact. Therefore the only modal shift which is of interest in Sector III is auto to bus. The fact that about half of the demand and energy use is concentrated in this sector is of great significance in the ultimate effectiveness of modal shift strategies. In particular, the combined auto penalty and bus improvement strategies will grow in importance relative to the Sector I results in Tables XXXV and XXXVI.

The impacts of modal shift strategies in Sectors II and III were determined by analogy with the closest corresponding city-pair categories in the detailed SMSA-to-SMSA analysis described earlier under Task 1. In that analysis, SMSA-pairs were categorized by distance and by demand density. Therefore, it is appropriate to determine modal shift impacts in Sector II by analogy with the lowest-density SMSA-pairs, and in Sector III by analogy with the shortest-distance SMSA-pairs. The validity of this approach is illustrated by the following comparison of 1973 modal shares in these city-pair groups:

## DISTRIBUTION OF MODAL SHARES BY DISTANCE

SUMMARIZES AVERAGE CHARACTERISTICS OF SMSA–PAIRS IN EACH DISTANCE CATEGORY

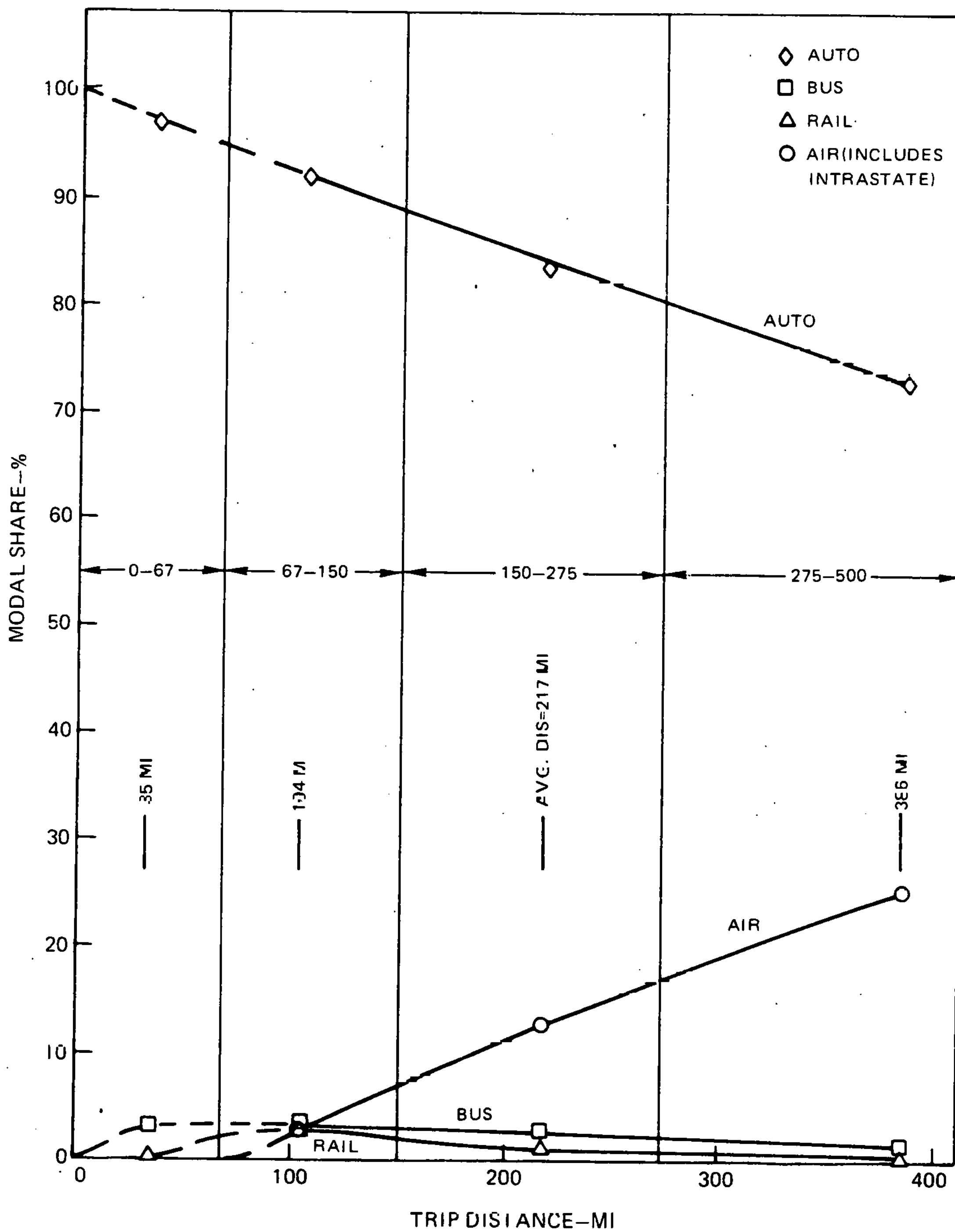


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TABLE XXXIX

Short-Haul Intercity Travel Sectors
1973 Data

| Sector Coverage | Mode | Demand $10^9$ pass-mi | Modal Share % | Energy $10^{12}$ Btu |
|---|---|---|---|---|
| I. SMSA-to-SMSA 67-500 mi | Air | 12.655 | 15.9 | 118.37 |
| | Rail | 0.790 | 1.0 | 2.40 |
| | Bus | 1.709 | 2.1 | 2.31 |
| | Auto | 64.691 | 81.0 | 317.57 |
| | Total | 79.845 | 100.0 | 440.65 |
| II. Other Intercity 67-500 mi | Air | 5.677 | 4.6 | 55.70 |
| | Rail | 0.180 | 0.0 | 0.66 |
| | Bus | 1.169 | 0.1 | 1.80 |
| | Auto | 115.459 | 94.3 | 526.32 |
| | Total | 122.485 | 100.0 | 622.02 |
| III. Intercity 0-67 mi | Air | 0.005 | 0.0 | 0.09 |
| | Rail | 0.550 | 0.3 | 2.28 |
| | Bus | 6.222 | 3.0 | 13.62 |
| | Auto | 200.623 | 96.7 | 969.14 |
| | Total | 207.400 | 100.0 | 985.13 |
| Total Intercity 0-500 mi | Air | 18.337 | 4.5 | 174.16 |
| | Rail | 1.520 | 0.4 | 5.34 |
| | Bus | 9.100 | 2.2 | 17.73 |
| | Auto | 380.773 | 92.9 | 1813.03 |
| | Total | 409.730 | 100.0 | 2010.26 |

MODAL SHARES - %

| Mode | Sector I | Low Density SMSA-pairs | Low Density Sector II | Short Distance SMSA-pairs | Short Distance Sector III |
|---|---|---|---|---|---|
| Air | 15.9 | 6.1 | 4.6 | 2.6 | 0 |
| Rail | 1.0 | 0.1 | 0.1 | 2.6 | 0.3 |
| Bus | 2.1 | 1.7 | 1.0 | 2.9 | 3.0 |
| Auto | 81.0 | 92.1 | 94.3 | 91.9 | 96.7 |

It can be seen that modal shares of the low-density SMSA-pair group correspond well with the Sector II shares, and that modal shares of the short-distance SMSA-pair group correspond well with the Sector III shares. In both cases, shares are significantly different from those in Sector I. These data suggest that the redistribution of modal shares which occurs when a modal shift strategy is implemented can be computed for Sector II from the redistribution which occurs in the low-density SMSA-pair group. Similarly, Sector III shifts can be obtained from the short-distance SMSA-pair group. Specifically, percentage changes in demand for each mode were determined from the appropriate SMSA-pair group and applied to baseline modal demands in Sectors II and III. In this way, effects on total demand as well as modal shares could be correctly simulated. The resulting shares for each of the combined modal shift strategies described earlier are given in Table XL for each of the three sectors; at the bottom of this table are the fractions of total passenger-miles in each sector. Regardless of strategy, it can be seen that the percentages of demand in the three sectors are about 20%, 30%, and 50%.

TABLE XL

STRATEGY MODAL SHARE DISTRIBUTIONS BY SHORT-HAUL TRAVEL SECTOR

| | (1973) | 1980 Baseline | Single Mode Strategies A | B | C | Auto and Bus Strategies 1 | 2 | 3 | 4 | 5 | 6 | Auto, Bus, and Air Fare Surcharge Strategies 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Strategies: | | | | | | | | | | | | | | | | | |
| 50 MPH Auto Speed | | | X | | | X | X | | | X | X | X | X | | | X | X |
| 50% Auto Cost Increase | | | X | | | | | X | X | X | X | | | X | X | X | X |
| 50% Bus Fare Reduction | | | | X | | | X | | X | | X | | X | | X | | X |
| 10% Bus Time Reduction | | | | X | | (X)[1] | (X) | X | X | (X) | (X) | (X) | (X) | X | X | (X) | (X) |
| 21% Air Fare Surcharge | | | | | X | | | | | | | X | X | X | X | X | X |
| **Sector I** | | | | | | | | | | | | | | | | | |
| Pass.-Miles ($10^9$) | 79.845 | 100.099 | 89.496 | 103.392 | 96.916 | 94.480 | 96.610 | 94.969 | 97.457 | 89.496 | 91.679 | 91.262 | 93.433 | 91.769 | 94.292 | 86.226 | 88.461 |
| Share: Air | 0.1585 | 0.2300 | 0.3019 | 0.2192 | 0.1799 | 0.2651 | 0.2571 | 0.2645 | 0.2530 | 0.3019 | 0.2912 | 0.2087 | 0.2015 | 0.2068 | 0.1967 | 0.2375 | 0.2287 |
| Rail | 0.0099 | 0.0121 | 0.0193 | 0.0105 | 0.0140 | 0.0149 | 0.0134 | 0.0150 | 0.0131 | 0.0193 | 0.0170 | 0.0176 | 0.0156 | 0.0176 | 0.0151 | 0.0232 | 0.0202 |
| Bus | 0.0214 | 0.0285 | 0.0468 | 0.0690 | 0.0328 | 0.0366 | 0.0662 | 0.0487 | 0.0907 | 0.0468 | 0.0848 | 0.0428 | 0.0772 | 0.0578 | 0.1055 | 0.0557 | 0.0997 |
| Auto | 0.8102 | 0.7293 | 0.6320 | 0.7013 | 0.7733 | 0.6834 | 0.6633 | 0.6718 | 0.6432 | 0.6320 | 0.6070 | 0.7309 | 0.7057 | 0.7178 | 0.6826 | 0.6826 | 0.6514 |
| **Sector II** | | | | | | | | | | | | | | | | | |
| Pass.-Miles ($10^9$) | 122.485 | 146.623 | 123.147 | 148.699 | 145.178 | 133.966 | 135.154 | 134.274 | 135.230 | 123.147 | 123.977 | 132.516 | 133.621 | 132.777 | 133.634 | 121.698 | 122.427 |
| Share: Air | 0.0463 | 0.0882 | 0.1301 | 0.0841 | 0.0701 | 0.1079 | 0.1049 | 0.1082 | 0.1033 | 0.1301 | 0.1261 | 0.0860 | 0.0831 | 0.0853 | 0.0814 | 0.1042 | 0.1003 |
| Rail | 0.0015 | 0.0027 | 0.0067 | 0.0020 | 0.0030 | 0.0045 | 0.0037 | 0.0041 | 0.0032 | 0.0067 | 0.0056 | 0.0049 | 0.0040 | 0.0046 | 0.0036 | 0.0075 | 0.0061 |
| Bus | 0.0095 | 0.0189 | 0.0401 | 0.0507 | 0.0199 | 0.0287 | 0.0543 | 0.0371 | 0.0701 | 0.0401 | 0.0724 | 0.0303 | 0.0572 | 0.0395 | 0.0738 | 0.0425 | 0.0765 |
| Auto | 0.9425 | 0.8902 | 0.8231 | 0.8632 | 0.9070 | 0.8589 | 0.8371 | 0.8506 | 0.8234 | 0.8231 | 0.7959 | 0.8788 | 0.8557 | 0.8706 | 0.8412 | 0.8458 | 0.8171 |
| **Sector III** | | | | | | | | | | | | | | | | | |
| Pass.-Miles ($10^9$) | 207.400 | 259.426 | 225.362 | 266.777 | 259.426 | 242.945 | 247.720 | 241.820 | 247.333 | 225.362 | 230.502 | 242.945 | 247.720 | 241.820 | 247.333 | 225.362 | 230.502 |
| Share: Air | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Rail | 0.0027 | 0.0032 | 0.0048 | 0.0029 | 0.0032 | 0.0038 | 0.0035 | 0.0039 | 0.0035 | 0.0048 | 0.0043 | 0.0038 | 0.0035 | 0.0039 | 0.0035 | 0.0048 | 0.0043 |
| Bus | 0.0300 | 0.0336 | 0.0431 | 0.0596 | 0.0336 | 0.0388 | 0.0574 | 0.0504 | 0.0775 | 0.0481 | 0.0738 | 0.0388 | 0.0574 | 0.0504 | 0.0775 | 0.0481 | 0.0738 |
| Auto | 0.9673 | 0.9632 | 0.9471 | 0.9375 | 0.9632 | 0.9574 | 0.9391 | 0.9457 | 0.9190 | 0.9471 | 0.9219 | 0.9574 | 0.9391 | 0.9457 | 0.9190 | 0.9471 | 0.9219 |
| **Share of Pass.-Miles** | | | | | | | | | | | | | | | | | |
| Sector I | 0.1949 | 0.1978 | 0.2043 | 0.1993 | 0.1932 | 0.2004 | 0.2015 | 0.2016 | 0.2030 | 0.2043 | 0.2055 | 0.1955 | 0.1968 | 0.1968 | 0.1984 | 0.1990 | 0.2004 |
| Sector II | 0.2989 | 0.2897 | 0.2812 | 0.2866 | 0.2895 | 0.2842 | 0.2819 | 0.2850 | 0.2817 | 0.2812 | 0.2779 | 0.2839 | 0.2814 | 0.2847 | 0.2812 | 0.2809 | 0.2774 |
| Sector III | 0.5062 | 0.5125 | 0.5145 | 0.5141 | 0.5173 | 0.5154 | 0.5156 | 0.5134 | 0.5153 | 0.5145 | 0.5166 | 0.5206 | 0.5218 | 0.5185 | 0.5204 | 0.5201 | 0.5222 |

Note 1: (X) indicates that potential bus time savings resulting from increased express bus service, for example, have been cancelled by slower speeds required by 50-mph speed limit.

Expanded Statistics for Combination Strategies

Final comparisons of the combination strategies are provided in Tables XLI and XLII for baseline and 70 percent load factors. These tables are analogous to Tables XXXV and XXXVI, but encompass all short-haul intercity trips, whereas the earlier tables included only SMSA-to-SMSA trips above 67 miles (Sector I). Similarly, Table XLIII provides a summary of the energy savings as they are achieved by the three mechanisms effected by the strategies considered. As before, it is to this breakdown that attention should be directed in order to appreciate the energy savings achievable through modal shift.

Again, it is clear that the dominant element in energy savings is the suppression of demand except in those anomolous cases where the total energy saving is negative or small (Strategies B, C, and B' and C'). Where a 50-mph auto speed limit is enforced, or where an artificially high air load factor is imposed, the mode efficiency improvements combine with the demand-suppression effect to overshadow fuel savings attributable to modal shift. For the case resulting in the maximum total energy saving (Strategy 11'), the modal shift contribution is 10% of the total and 2.11% of the baseline energy. For the case resulting in the maximum saving due to modal shift, per se, (Case 10'), its contribution is 34% of the total and 3.85% of the baseline energy. Even in this case, demand suppression accounts for 51% of the total saving, the remainder (15%) being the result of the enforcement of arbitrarily high air load factors.

While these are the pertinent results with respect to the potential of modal shift as a means of conserving energy, it is informative to examine details of the effects of the various strategies. For this purpose, it is useful to refer to Tables XLI and XLII which contain the detailed results.

The effects of modal shift strategies on total demand vary from a small induced demand in Strategy B (2.5%) to a substantial suppression of 14.4% in Strategy 11; in general, demand is suppressed because auto is the dominant mode (almost 90% in the baseline case) and most of the strategies involve an auto penalty. Modal shares also vary significantly, the extremes for each mode occurring either in Strategies A and C where auto and air are penalized selectively, or in Strategies 6 and 12 where combinations of auto and air penalties with bus improvements create large shifts. Thus, air share varies between a low of 5.51% in C to a high of 9.83% in A; bus varies between a low of 2.95% in C to a high of 7.97% in 12; and auto varies between a low of 82.21% in 6 to a high of 91.02% in C. Even though no rail improvements were incorporated in the combination strategies, rail shares also vary between a low of 0.41% in B to a high of 0.92% in 11.

TABLE XLI

COMBINED MODAL SHIFT STRATEGY RESULTS - ALL SHORT-HAUL INTERCITY TRAVEL

Baseline Load Factors

| | (1973) | 1980 Baseline | Single-Mode Strategies | | | Auto and Bus Strategies | | | | | | Auto, Bus, and Air Fare Surcharge Strategies | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | A | B | C | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Strategies | | | | | | | | | | | | | | | | | |
| 50 MPH Auto Speed | | | X | | | X | X | | | X | X | X | X | | | X | X |
| 50% Auto Cost Increase | | | X | | | | | X | X | X | X | | | X | X | X | X |
| 50% Bus Fare Reduction | | | | X | | | X | | X | | X | | X | | X | | X |
| 10% Bus Time Reduction | | | | X | | (X)[1] | (X) | X | X | (X) | (X) | (X) | (X) | X | X | (X) | (X) |
| 21% Air Fare Surcharge | | | | | X | | | | | | | X | X | X | X | X | X |
| Pass.-Miles ($10^9$) | 409.730 | 506.148 | 438.005 | 518.868 | 501.520 | 471.391 | 479.484 | 471.063 | 480.020 | 438.005 | 446.158 | 466.723 | 474.774 | 466.366 | 475.259 | 433.286 | 441.390 |
| Modal Shares: Air | 0.0448 | 0.0710 | 0.0983 | 0.0678 | 0.0551 | 0.0838 | 0.0814 | 0.0842 | 0.0805 | 0.0983 | 0.0949 | 0.0652 | 0.0631 | 0.0650 | 0.0619 | 0.0768 | 0.0737 |
| Rail & Metro | 0.0037 | 0.0048 | 0.0083 | 0.0041 | 0.0052 | 0.0062 | 0.0055 | 0.0062 | 0.0054 | 0.0083 | 0.0073 | 0.0068 | 0.0060 | 0.0068 | 0.0058 | 0.0092 | 0.0080 |
| Bus | 0.0222 | 0.0283 | 0.0456 | 0.0589 | 0.0295 | 0.0355 | 0.0583 | 0.0463 | 0.0781 | 0.0456 | 0.0757 | 0.0372 | 0.0613 | 0.0487 | 0.0820 | 0.0480 | 0.0797 |
| Auto | 0.9293 | 0.8959 | 0.8478 | 0.8692 | 0.9102 | 0.8745 | 0.8548 | 0.8633 | 0.8360 | 0.8478 | 0.8221 | 0.8908 | 0.8696 | 0.8795 | 0.8503 | 0.8660 | 0.8386 |
| Total User Cost ($10^9$ \$) | 30.5950 | 43.1268 | 45.1236 | 44.5462 | 42.6520 | 42.4272 | 43.2307 | 46.6248 | 47.5198 | 45.1236 | 45.9540 | 41.9537 | 42.7503 | 46.1856 | 47.0653 | 44.7078 | 45.5160 |
| Total User Time ($10^9$ Hrs) | 9.5872 | 12.3749 | 11.3491 | 12.7992 | 12.3698 | 12.2639 | 12.5912 | 11.4830 | 11.8539 | 11.3491 | 11.7082 | 12.2775 | 12.6076 | 11.4932 | 11.8640 | 11.3738 | 11.7365 |
| Total Bus Subsidy ($10^9$ \$) | - | - | - | 0.8920 | - | - | 0.8129 | - | 1.0985 | - | 0.9863 | - | 0.8466 | - | 1.1436 | - | 1.0292 |
| Total Auto Cost Increase ($10^9$ \$) | - | - | 6.2397 | - | - | - | - | 6.8594 | 6.7678 | 6.2397 | 6.1663 | - | - | 6.9371 | 6.8332 | 6.3218 | 6.2396 |
| Total Air Surcharge ($10^9$ \$) | - | - | - | - | 0.5419 | - | - | - | - | - | - | 0.5833 | 0.5768 | 0.5651 | 0.5531 | 0.6210 | 0.6089 |
| Net Increase in Gov't Receipts ($10^9$ \$) | - | - | 6.2397 | -0.8920 | 0.5419 | - | -0.8129 | 6.8594 | 5.6693 | 6.2397 | 5.1800 | 0.5833 | -0.2698 | 7.5022 | 6.2427 | 6.9428 | 5.8193 |
| Total Energy ($10^{12}$ Btu) | 2010.261 | 2163.403 | 1823.233 | 2168.745 | 2106.118 | 1951.651 | 1955.712 | 2007.040 | 2000.981 | 1823.233 | 1821.504 | 1888.539 | 1891.443 | 1942.152 | 1935.469 | 1754.322 | 1751.235 |
| Energy Intensity ($10^3$ Btu/PM) | 4.906 | 4.274 | 4.163 | 4.180 | 4.199 | 4.140 | 4.079 | 4.261 | 4.169 | 4.163 | 4.083 | 4.046 | 3.984 | 4.164 | 4.072 | 4.049 | 3.968 |
| % Improvement | - | - | 2.61 | 2.21 | 1.75 | 3.14 | 4.57 | 0.32 | 2.47 | 2.61 | 4.48 | 5.33 | 6.79 | 2.57 | 4.72 | 5.27 | 7.18 |
| Energy Saved ($10^{12}$ Btu) | | | | | | | | | | | | | | | | | |
| Actual | - | - | 340.170 | -5.342 | 57.285 | 211.752 | 207.691 | 156.363 | 162.422 | 340.170 | 341.899 | 274.854 | 271.960 | 221.251 | 227.934 | 409.081 | 412.168 |
| % | - | - | 15.72 | -0.25 | 2.65 | 9.79 | 9.60 | 7.23 | 7.51 | 15.72 | 15.80 | 12.71 | 12.57 | 10.23 | 10.54 | 18.91 | 19.05 |
| Demand-Normalized | - | - | 56.519 | 47.825 | 37.850 | 67.851 | 98.934 | 6.878 | 53.506 | 56.519 | 96.981 | 115.335 | 146.970 | 55.581 | 102.140 | 114.072 | 155.238 |
| % | - | - | 2.61 | 2.21 | 1.75 | 3.14 | 4.57 | 0.32 | 2.47 | 2.61 | 4.48 | 5.33 | 6.79 | 2.57 | 4.72 | 5.27 | 7.18 |

[1](X) indicates that potential bus time savings resulting from increased express bus service, for example, have been cancelled by slower speeds required by the 50 mph speed limit. Thus, baseline bus times were used.

All distances are in straight-line miles.

All costs are in 1973 dollars.

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TABLE XLII

COMBINED MODAL SHIFT STRATEGY RESULTS - ALL SHORT-HAUL INTERCITY TRAVEL

70% Air Load Factor

| | (1973) | 1980 Baseline | Single Mode Strategies | | | Auto and Bus Strategies | | | | | | Auto, Bus, and Air Fare Surcharge Strategies | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | A' | B' | C' | 1' | 2' | 3' | 4' | 5' | 6' | 7' | 8' | 9' | 10' | 11' | 12' |
| Strategies | | | | | | | | | | | | | | | | | |
| 50 MPH Auto Speed | | | X | | | X | X | | | X | X | X | X | | | X | X |
| 50% Auto Cost Increase | | | X | | | | | X | X | X | X | | | X | X | X | X |
| 50% Bus Fare Reduction | | | | X | | | X | | X | | X | | X | | X | | X |
| 10% Bus Time Reduction | | | | X | | (X)[1] | (X) | X | X | (X) | (X) | (X) | (X) | X | X | (X) | (X) |
| 21% Air Fare Surcharge | | | | | X | | | | | | | X | X | X | X | X | X |
| Pass.-Miles ($10^9$) | 409.730 | 506.148 | 438.005 | 518.368 | 501.520 | 471.391 | 479.488 | 471.063 | 480.020 | 433.005 | 446.158 | 466.723 | 474.774 | 466.366 | 475.259 | 433.286 | 441.390 |
| Modal Shares: Air | 0.0443 | 0.0710 | 0.0983 | 0.0678 | 0.0551 | 0.0838 | 0.0814 | 0.0842 | 0.0805 | 0.0983 | 0.0949 | 0.0652 | 0.0631 | 0.0650 | 0.0619 | 0.0768 | 0.0737 |
| Rail & Metro | 0.0037 | 0.0048 | 0.0083 | 0.0041 | 0.0052 | 0.0062 | 0.0055 | 0.0062 | 0.0054 | 0.0083 | 0.0073 | 0.0068 | 0.0060 | 0.0068 | 0.0058 | 0.0092 | 0.0080 |
| Bus | 0.0222 | 0.0283 | 0.0456 | 0.0589 | 0.0295 | 0.0355 | 0.0583 | 0.0463 | 0.0781 | 0.0456 | 0.0757 | 0.0372 | 0.0613 | 0.0487 | 0.0820 | 0.0480 | 0.0797 |
| Auto | 0.9293 | 0.8959 | 0.8478 | 0.8692 | 0.9102 | 0.8745 | 0.8548 | 0.8633 | 0.8360 | 0.8478 | 0.8221 | 0.8908 | 0.8696 | 0.8795 | 0.8503 | 0.8660 | 0.8386 |
| Total Energy ($10^{12}$ Btu) | 2010.26[illegible] | 2119.512 | 1770.519 | 2125.874 | 2073.711 | 1903.372 | 1908.072 | 1958.560 | 1953.821 | 1770.519 | 1769.684 | 1852.790 | 1856.303 | 1906.580 | 1900.951 | 1715.223 | 1713.023 |
| Energy Intensity ($10^3$ Btu/PM) | - | 4.188 | 4.042 | 4.097 | 4.135 | 4.038 | 3.979 | 4.158 | 4.070 | 4.042 | 3.966 | 3.970 | 3.910 | 4.088 | 4.00 | 3.959 | 3.881 |
| % Improvement | | 2.03 | 5.43 | 4.14 | 3.26 | 5.53 | 6.90 | 2.73 | 4.77 | 5.43 | 7.20 | 7.12 | 8.53 | 4.35 | 6.42 | 7.38 | 9.20 |
| Energy Saved ($10^{12}$ Btu) | | | | | | | | | | | | | | | | | |
| Actual | - | 43.891 | 392.884 | 37.529 | 89.592 | 260.031 | 255.331 | 204.843 | 209.582 | 392.884 | 393.719 | 310.613 | 307.100 | 256.823 | 262.452 | 448.180 | 450.380 |
| % | - | 2.02 | 18.16 | 1.73 | 4.15 | 12.02 | 11.80 | 9.47 | 9.69 | 18.16 | 18.20 | 14.36 | 14.20 | 11.87 | 12.13 | 20.72 | 20.82 |
| Demand Normalized | - | 43.891 | 117.434 | 89.645 | 70.556 | 119.690 | 149.240 | 58.969 | 103.233 | 117.434 | 155.769 | 154.104 | 184.432 | 94.188 | 138.902 | 159.746 | 199.056 |
| % | - | 2.03 | 5.43 | 4.14 | 3.26 | 5.53 | 6.90 | 2.73 | 4.77 | 5.43 | 7.20 | 7.12 | 8.53 | 4.35 | 6.42 | 7.38 | 9.20 |

[1] (X) indicates that potential bus time savings resulting from increased express bus service, for example, have been cancelled by slower speeds required by the 50 mph speed limit.

All distances are in straight-line miles.

All costs are in 1973 dollars.

TABLE XLIII

ANNUAL 1980 ENERGY SAVINGS DUE TO SUPPRESSION OF DEMAND, MODE EFFICIENCY IMPROVEMENTS AND MODAL SHIFT

| Strategy | Energy $10^{12}$ Btu | Demand $10^{9}$ p-m | Energy Savings Due to: Suppressed Demand $10^{12}$ Btu | Reduced Auto Speed $10^{12}$ Btu | Increased Air. Effic. $10^{12}$ Btu | Modal Shift $10^{12}$ Btu | Total Energy Savings $10^{12}$ Btu | Modal Shift Savings: % Total | % Baseline |
|---|---|---|---|---|---|---|---|---|---|
| Baseline | 2163.41 | 506.15 | 0 | 0 | 0 | 0 | 0 | - | 0 |
| A | 1823.23 | 438.01 | 283.63 | 72.78 | 0 | -16.24 | 340.17 | -4.78 | -0.75 |
| B | 2168.75 | 518.87 | -53.19 | 0 | 0 | 46.87 | -6.32 | - | 2.17 |
| C | 2106.12 | 501.52 | 19.44 | 0 | 0 | 37.84 | 57.28 | 66.06 | 1.75 |
| 1 | 1951.65 | 471.39 | 143.91 | 80.80 | 0 | -12.96 | 211.75 | -6.12 | -0.60 |
| 2 | 1955.71 | 479.49 | 108.74 | 80.33 | 0 | 18.62 | 207.69 | 8.97 | 0.86 |
| 3 | 2007.04 | 471.06 | 149.51 | 0 | 0 | 6.85 | 156.36 | 4.38 | 0.32 |
| 4 | 2000.98 | 480.02 | 109.78 | 0 | 0 | 36.9 | 146.68 | 25.16 | 1.71 |
| 5 | 1823.23 | 438.01 | 283.63 | 72.78 | 0 | -16.24 | 340.17 | -4.77 | -0.75 |
| 6 | 1821.50 | 446.16 | 245.97 | 72.61 | 0 | 15.51 | 334.09 | 4.64 | 0.72 |
| 7 | 1888.54 | 466.72 | 159.55 | 81.49 | 0 | 33.82 | 274.86 | 12.30 | 1.56 |
| 8 | 1891.44 | 474.77 | 125.02 | 80.92 | 0 | 66.02 | 271.96 | 24.28 | 3.05 |
| 9 | 1942.15 | 466.37 | 165.66 | 0 | 0 | 55.59 | 221.25 | 25.13 | 2.57 |
| 10 | 1935.47 | 475.26 | 127.02 | 0 | 0 | 82.03 | 209.05 | 39.23 | 3.79 |
| 11 | 1754.32 | 433.29 | 295.00 | 73.54 | 0 | 40.54 | 409.08 | 9.91 | 1.87 |
| 12 | 1751.24 | 441.39 | 258.53 | 73.55 | 0 | 69.27 | 401.35 | 17.26 | 3.20 |
| Baseline' | 2119.51 | 506.15 | 0 | 0 | 43.88 | 0 | 43.88 | 0 | 0 |
| A' | 1770.52 | 438.01 | 275.43 | 72.78 | 52.57 | -7.91 | 392.88 | -2.01 | -0.37 |
| B' | 2125.87 | 518.87 | -52.14 | 0 | 42.95 | 45.75 | 36.56 | 125.10 | 2.11 |
| C' | 2073.71 | 501.52 | 19.14 | 0 | 51.32 | 19.22 | 89.69 | 21.43 | 0.89 |
| 1' | 1903.37 | 471.39 | 140.35 | 80.80 | 48.23 | -9.35 | 260.03 | -3.60 | -0.43 |
| 2' | 1908.07 | 479.49 | 106.09 | 80.33 | 47.66 | 21.25 | 255.33 | 8.32 | 0.98 |
| 3' | 1958.56 | 471.06 | 145.90 | 0 | 48.43 | 10.51 | 204.84 | 5.13 | 0.49 |
| 4' | 1953.82 | 480.02 | 107.21 | 0 | 47.18 | 39.45 | 193.84 | 20.35 | 1.82 |
| 5' | 1770.52 | 438.01 | 275.43 | 72.78 | 52.57 | -7.91 | 392.88 | -2.01 | -0.37 |
| 6' | 1769.68 | 446.16 | 238.99 | 72.61 | 51.70 | 22.60 | 385.91 | 5.86 | 1.04 |
| 7' | 1852.79 | 466.72 | 156.53 | 81.49 | 37.16 | 35.44 | 310.61 | 11.41 | 1.64 |
| 8' | 1856.30 | 474.77 | 122.69 | 80.92 | 36.59 | 66.91 | 307.10 | 21.79 | 3.09 |
| 9' | 1906.58 | 466.37 | 162.62 | 0 | 37.01 | 57.18 | 256.82 | 22.26 | 2.64 |
| 10' | 1900.95 | 475.26 | 124.76 | 0 | 35.92 | 83.19 | 243.87 | 34.11 | 3.85 |
| 11' | 1715.22 | 433.29 | 288.42 | 73.54 | 40.63 | 45.57 | 448.18 | 10.17 | 2.11 |
| 12' | 1713.02 | 441.39 | 252.89 | 73.55 | 39.72 | 73.41 | 439.57 | 16.70 | 3.39 |

Differing mode characteristics (speed, cost, etc) result in changes in the parameters listed in Tables XLI and XLII as trips are shifted among the modes. Of special importance are the energy parameters which appear at the bottom of each table. Qualitatively, these results are not different from those noted earlier for Sector I; the most effective strategies in saving energy are those which combine the most penalties and improvements, and increasing air load factor to 70% always produces an additional saving. Quantitatively, however, there are some significant differences between these results and those summarized in Tables XXXV and XXXVI.

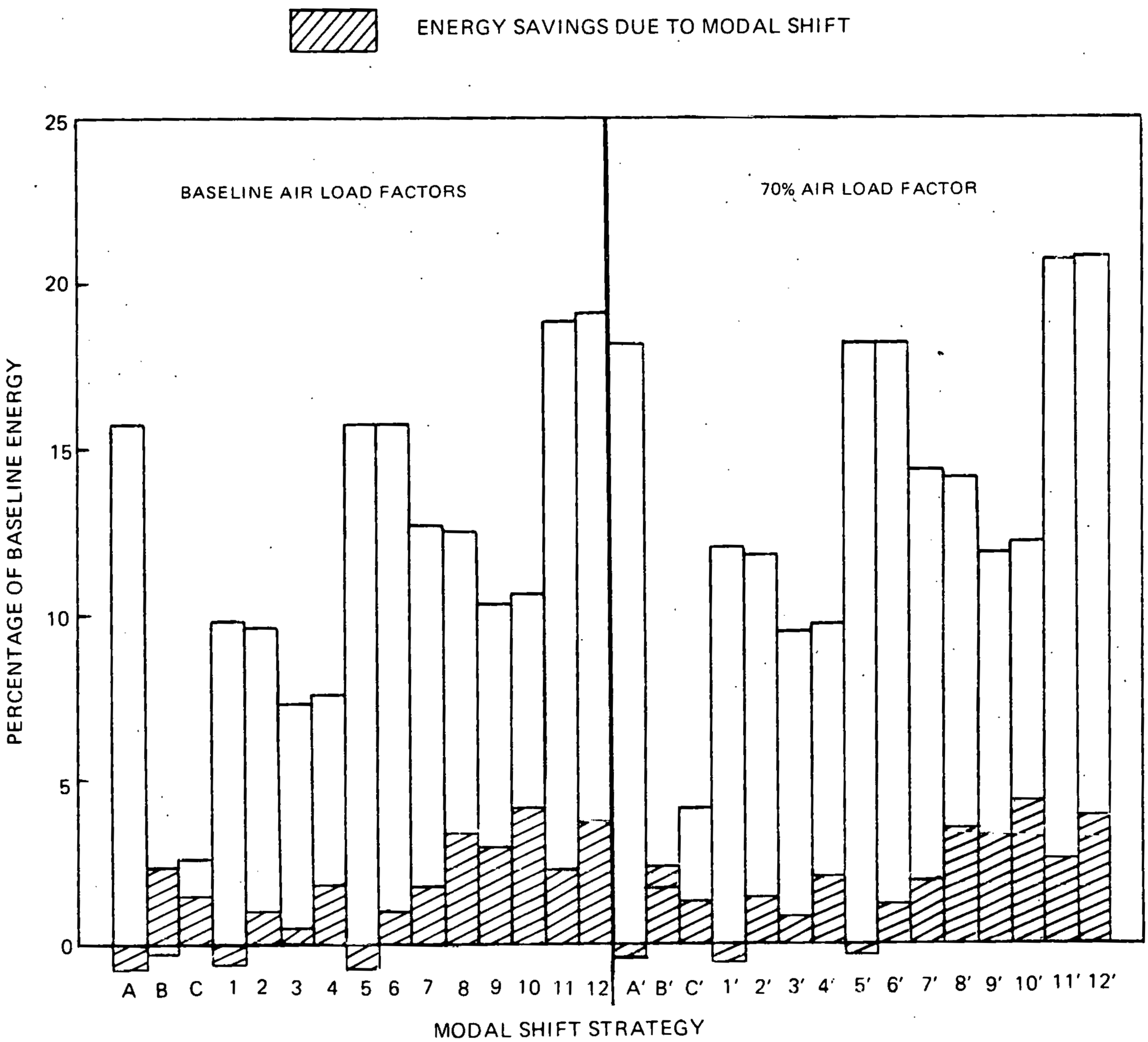
All strategies now result in improved energy intensity, but strategies which penalize air are not as effective because the air share is only about one-third of the Sector I value. Conversely, auto penalty strategies are considerably more effective because a large number of shifts to bus occur in Sectors II and III where air does not compete as favorably with bus as in Sector I. These intensity improvements translate into similar improvements in energy saved, both actual and demand-normalized. In addition, the larger passenger-mile base in Tables XLI and XLII results in much greater energy savings than in Sector I alone. The greatest gain in energy saved occurs in Strategies A and 1-6. Those strategies in which the air surcharge is imposed also gain, but not in percentage increase over the baseline, except when both auto penalties are included (11 and 12).

A pictorial comparison of actual energy saved by each strategy appears in Fig. 22. This chart shows that Strategies A, 5, 6, 11 and 12, all of which incorporate both auto penalties (50 mph speed limit and 50% auto operating cost increase), achieve large savings. Strategy 6, which adds the bus fare reduction to the auto penalties, increases energy saved only slightly because of induced demand. The margin between Strategies 5 and 6 and Strategies 11 and 12 is the additional energy effect of the air surcharge.

That portion of the total energy saving which can be attributed to the modal shift effect is shown in Fig. 22 by shaded bars, again emphasizing the small savings achievable through this expedient, relative to the savings attributable to demand suppression and increased mode efficiency.

## ENERGY SAVINGS BY COMBINED MODAL–SHIFT STRATEGIES

PERCENTAGE OF BASELINE ENERGY - 2163.4 x $10^{12}$ BTU

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## Benefit/Cost Considerations

As an adjunct to the strategy evaluations, which have thus far centered on fuel use in a quantitative way and on various feasibility considerations in a semi-quantitative way, a benefit/cost analysis was performed to provide some insight into the positive and negative impacts of strategies designed to emphasize fuel savings. This analysis was based on the UTRC procedure described in Ref. 67, and include only parameters for which numerical values could be established with reasonable confidence. Most of these parameters have been incorporated in prior tabulations describing the various strategies. They include:

- Demand for short-haul, intercity travel ($10^9$ \$)
- Total user time ($10^9$ hrs)
- Required subsidies ($10^9$ \$)
- Number of fatalities
- Total energy ($10^{12}$ Btu)
- Total emissions ($10^3$ wtd. tons).

Calculated values for these parameters are presented in Table XLIV for all combination strategies investigated.

While the benefit/cost analysis provided some perspective to the analyst, in that the energy savings associated with the respective strategies tended to be neutralized by other considerations, the results of the analysis did not prove to be conclusive. That is, no more definitive comparison of alternative strategies could be gained through the benefit/cost analysis than was already provided on the basis of energy considerations alone. Furthermore, the benefit/cost technique is abstract and utilizes judgmental factors which are not universally accepted by the technical or business community. In consideration of these factors, the benefit/cost analysis is not further discussed within the main body of the text. For those readers who may nevertheless be interested in the approach, the analytical process is presented in Appendix IV.

TABLE XLIV

COMBINED MODAL SHIFT STRATEGY BENEFITS & COSTS - ALL SHORT-HAUL INTERCITY TRAVEL

| | 1980 Baseline | Single Mode Strategies | | | Auto and Bus Strategies | | | | | | Auto, Bus, and Air Fare Surcharge Strategies | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | A | B | C | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Strategies: | | | | | | | | | | | | | | | | |
| 50 mph Auto Speed | | X | | | X | X | | | X | X | X | X | | | X | X |
| 50% Auto Cost Increase | | X | | | | | X | X | X | X | | | X | X | X | X |
| 50% Bus Fare Reduction | | | X | | | X | | X | | X | | X | | X | | X |
| 10% Bus Time Reduction | | | X | | (X)[1] | (X) | X | X | (X) | (X) | (X) | (X) | X | X | (X) | (X) |
| 21% Air Fare Surcharge | | | | X | | | | | | | X | X | X | X | X | X |
| Pass.-Miles ($10^9$) | 506.148 | 438.005 | 518.863 | 501.520 | 471.391 | 479.484 | 471.063 | 480.020 | 438.005 | 446.158 | 466.723 | 474.774 | 466.366 | 475.259 | 433.286 | 441.390 |
| Total User Cost ($10^9$ $) | 43.1268 | 45.1236 | 44.5462 | 42.6520 | 42.4272 | 43.2307 | 46.6248 | 47.5198 | 45.1236 | 45.9540 | 41.9537 | 42.7503 | 46.1856 | 47.0653 | 44.7078 | 45.5160 |
| Total User Time ($10^9$ Hrs) | 12.3749 | 11.3491 | 12.7992 | 12.3698 | 12.2639 | 12.5912 | 11.4830 | 11.8539 | 11.3491 | 11.7082 | 12.2775 | 12.6076 | 11.4932 | 11.8640 | 11.3738 | 11.7365 |
| Subsidies ($10^9$ $) | 0.4000 | 0.4000 | 1.2920 | 0.4000 | 0.4000 | 1.2129 | 0.4000 | 1.4985 | 0.4000 | 1.3863 | 0.4000 | 1.2466 | 0.4000 | 1.5436 | 0.4000 | 1.4292 |
| Fatalities | 8480 | 6422 | 8465 | 8529 | 7132 | 7120 | 7602 | 7543 | 6422 | 6385 | 7178 | 7159 | 7652 | 7583 | 6471 | 6425 |
| **Baseline Air Load Factor** | | | | | | | | | | | | | | | | |
| Total Energy ($10^{12}$ Btu) | 2163.403 | 1823.233 | 2168.745 | 2106.118 | 1951.651 | 1955.712 | 2007.040 | 2000.981 | 1823.233 | 1821.504 | 1888.539 | 1891.443 | 1942.152 | 1935.469 | 1754.322 | 1751.235 |
| Emissions ($10^3$ Wtd. Tons) | 888.794 | 747.179 | 901.008 | 890.421 | 816.631 | 824.845 | 810.284 | 817.733 | 747.179 | 753.392 | 818.548 | 826.323 | 812.049 | 818.863 | 748.447 | 755.031 |
| **70% Air Load Factor** | | A' | B' | C' | 1' | 2' | 3' | 4' | 5' | 6' | 7' | 8' | 9' | 10' | 11' | 12' |
| Total Energy ($10^{12}$ Btu) | 2119.512 | 1770.519 | 2125.874 | 2073.711 | 1903.372 | 1908.072 | 1958.560 | 1953.821 | 1770.519 | 1769.684 | 1852.790 | 1856.303 | 1906.580 | 1900.951 | 1715.223 | 1713.023 |
| Emissions ($10^3$ Wtd. Tons) | 885.714 | 743.465 | 897.997 | 888.172 | 813.237 | 821.492 | 806.867 | 814.417 | 743.465 | 749.743 | 816.081 | 823.898 | 809.500 | 816.484 | 745.749 | 752.397 |

[1](X) indicates that potential bus time savings resulting from increased express bus service, for example, have been cancelled by slower speeds required by the 50 mph speed limit. Thus, baseline bus times were used.

All distances are in straight-line miles.

All costs are in 1973 dollars.



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# POLICY ANALYSIS OF COMBINATION STRATEGIES

The preceding analysis showed how the most likely individual strategies were alternately combined with each other in order to test the potential for even greater energy savings. In evaluating these combination strategies from a policy perspective, primary attention was given to overlapping or synergistic effects. Matrices were developed, based on the analysis of individual strategies and related policies, so as to illuminate such effects. As necessary, the analytical procedure applied to the individual strategies was repeated. Summaries were then developed for the combined strategies.

## Policy Analysis

Combination of the individual air, bus, and auto strategies does not impose additional restraints on implementation. It does, however, suggest that certain restraints may be amplified. In particular, further analysis is required to determine the capability of the intercity bus industry to accommodate the passenger-miles projected under the combination strategies. Analysis is also required to determine whether the energy savings achieved warrant the politically difficult step of imposing combined penalties on air and automobile travel. These two issues are discussed below.

### Diversion of Passengers to Bus

In the absence of strategy implementation, the 1980 (baseline) bus passenger-miles in short-haul markets were estimated to equal 14.3 billion. Implementation of the combination strategies would result in increases in bus passenger-miles ranging from 17 percent to 172 percent. Ten of the twenty-four strategies (considering baseline and 70 percent load factor as separate sets) generate increases in passenger-miles of over 100 percent, and eight of these increases are over 133 percent. The magnitude of these diversions to bus suggests the potential for severe operational restraints on implementation.

Evidence presented by the bus industry during 1973 Congressional Hearings* indicates that an increase of 110% over current regular route (interstate) and 51% over current regular-route and charter (inter- and intra-state) passenger-miles could be achieved within one year. It was also noted that further increased were possible but would

*Statement by Charles Webb, National Association of Motor Bus Owners, in Hearing before the Subcommittee on Transportation of the Committee on Public Works, United States Senate. 93rd Congress, first session. December 11, 1973. (Hereafter referred to as Hearings.)

require more time, further fleet augmentation, greater crowding and somewhat less convenience in schedules. In view of this information, and assuming that bus share increases in non-SMSA and short distance markets are the same as for SMSA-to-SMSA travel, it is expected that the ridership increases projected for these strategies could be accommodated over the short term. Advanced planning of schedules and bus and driver utilization would certainly be required in order to apply these strategies as contingency measures.

The implication of these industry projections is that 1973 bus capacity might be increased 51 percent from 25.6 to 38.6 billion passenger-miles, for the entire industry, and 110 percent from 15.5 to 32.6 billion passenger miles for the interstate segment. These gains would result from increased vehicle utilization in terms of bus miles per bus, increased loadings (passenger-miles per bus mile), some diversion of bus miles from charter service to regular-route service, and the expected annual production of 2650 buses. However, as previously stated, the Class I intercity bus figures are more appropriate in the definition of short-haul intercity travel adopted in this study. Therefore, comparable figures for 1950 would be a 110% increase, from 14.3 to 30.1 billion passenger miles.*

Conditions in the industry are somewhat better now than in 1973. Passenger-miles in Class I regular route service increased to 16.3 billion in 1975 and the number of buses in 1975 has increased by about 500 since 1973.** Consequently, the interstate regular-route segment appears to be in a considerably better position to meet its 110 percent goal.

The capability of the industry to accommodate the dramatic increases in passenger-miles resulting from the combination strategies hinges on the extent of any demand surges in the long-haul market. If the industry could effect a 110 percent increase in passenger-miles, on a contingency basis, then as many as 30.1 billion passenger-miles would be available. However, the combination strategy (Strategy 10) which causes the greatest diversion to bus would require 39 billion passenger-miles.

The advantages of bus travel in short-haul, as compared to long-haul, markets make it reasonable to assume that diversions to bus in long-haul markets will be substantially less than in short-haul markets. As a result, increases greater than 110 percent could perhaps be added to the short-haul routes on a contingency basis. Therefore, it is conceivable that the industry could accommodate increases in short-haul passenger miles without major scheduling and service problems.

* from Table XLI: 2.83% of 506.15 passenger-miles = 14.3 billion passenger-miles.

**National Association of Motor Bus Owners, One Half Century of Service to America, 1976, p.23. (Route miles served increased by 200, while passenger loadings remained about the same.

Diversion of Passengers to Rail

Currently, the available seat-miles in the entire AMTRAK system are estimated at around 3.3 billion (Ref. 64). In the Corporation's five-year plan, an increase of 17.9 percent in available seat-miles is projected (Ref. 65). This represents nearly 3.9 billion seat-miles in 1980 and is very close to the largest projected diversion in Table XL (Strategy 11). While system-wide, the seat-mile projections may exceed the total short-haul requirements of the strategies, individual routes may still be unable to accommodate passenger surges in an energy-crisis situation. The Corporation has, however, indicated that in a crisis situation it would operate schedules which would otherwise be commercially impractical and increase the seating density in its new equipment. A standby plan has been arranged with the seat manufacturer to effect this latter option. Therefore, it appears that projected rail diversions can be accommodated.

Combined Penalties on Air and Auto Travel

The penalties on air and auto travel suppress short-haul passenger demand in all the combination strategies. As compared with the baseline, passenger-miles are reduced from 5 percent to 14 percent depending on the strategy. In the face of a severe energy shortfall, some such limitation on mobility will have to be endured. However, the degree of acceptability of these limitations on mobility must be related to compensating features including, but not limited to, saving energy. An attempt was made to examine such compensating features in the benefit/cost analysis discussed earlier. Unfortunately, the benefit/cost analysis was not capable of revealing a definitive choice among strategies even though some reordering of strategies, from that based on energy savings alone, is indicated in that analysis. In broad terms, a judgment must be made as to whether or not demand suppression is an acceptable energy-saving measure. This study was not addressed to that question, since its objective was to examine energy savings achievable through the modal shift effect, per se.

## Summary of Policy Analysis for Combination Strategies

Table XLV summarizes the positive and negative impacts of implementing each of the combination strategies. The nonquantified impacts included in Table XLV for the individual strategies have not been reiterated. Instead, this summary is aimed at delineation of those effects predictable from the Task 5 analysis. Included in the summary are impacts on: passenger-miles traveled; user costs and time; direct federal revenues and expenditures; energy savings per passenger-mile suppressed; and gross revenues or losses to the public modes. All revenues and losses are calculated on the basis of average revenue per passenger-mile in the mode affected. As such the estimates are rough and should be viewed in terms of order-of-magnitude.

Two general conclusions can be drawn from the summary of impacts. First, when federal expenditures are required for direct subsidy of bus fares and/or for institution of express bus service, the resulting revenue gains to the bus carriers can at least partially offset the requirements for federal monies. Secondly, twelve of the strategies result in significant reductions in the gross revenues of the air carriers. Based on the analysis in the previous section, it is likely that costs will decrease less than proportionally relative to the revenue reductions. Particularly when fuel allocation is included in the combination strategies, the airlines would face a loss in revenue if load factors did not increase enough to compensate for reduced frequencies.

A major result of the policy analysis, both of individual strategies and of selected combinations, is that most of the hypothesized energy-conservation measures could be implemented under what might be regarded as energy crisis conditions, though the term cannot be precisely defined. Exceptions are the institution of express bus services to reduce bus trip time, which will probably occur regardless of energy conditions, and reductions in bus fares through government subsidy, which is possible under normal energy conditions, though far more likely in a crisis. The remaining measures -- 50 mph auto speed limit, 50% increase in auto operating costs, 21% air fare surcharge, and 70% air load factor -- will most likely meet with considerable opposition from both consumer groups and political quarters. Similar measures, but at less stringent levels, would have even less of an energy impact than those examined herein.

(Text continues on p. 134)

TABLE XLV

SUMMARY OF IMPACTS FOR COMBINATION STRATEGIES

| Strategies | Positive Impacts | Negative Impacts |
|---|---|---|
| 12 Auto Speed Reduction<br>Auto Cost Increase<br>Bus Fare Reduction<br>Bus Time Reduction<br>Air Fare Surcharge<br><br>12' With Fuel Allocation | • Federal revenues of $6.85 billion from auto and air penalties. Bus fare subsidy is $1.03 billion, plus seed money for express service.<br><br>• Without fuel allocation, energy savings of $6.4 \times 10^3$ Btu per passenger-mile of suppressed demand<br><br>• With fuel allocation, savings of $7.0 \times 10^3$ Btu per passenger-mile of suppressed demand<br><br>• Bus passenger-miles increased by 145 percent. At an average fare per passenger-mile, bus revenues will increase by 1.2 billion.<br><br>• Rail passenger-miles increased by 45 percent. Revenues will increase by $65 million. | • Short-haul passenger-miles of travel reduced by 13 percent<br><br>• Average cost per passenger-mile increased by 21 percent<br><br>• Average travel time per passenger-mile increased by 9 percent<br><br>• Airline passenger-miles decreased by 9 percent At the average fare per passenger-mile this represents loss in revenue of $347 million. |
| 11 Auto Speed Reduction<br>Auto Cost Increase<br>Bus Time Reduction<br>Air Fare Surcharge<br><br>11' With Fuel Allocation | • Federal revenues of $6.94 billion from air and auto penalties.<br><br>• Without fuel allocation, energy savings of $5.6 \times 10^3$ Btu per passenger-mile of suppressed demand<br><br>• With fuel allocation, energy savings of $6.2 \times 10^3$ Btu per passenger-mile of suppressed demand<br><br>• Bus passenger-miles increased by 45 percent, resulting in increased revenues of $375 million<br><br>• Rail passenger-miles increased by 64 percent, resulting in increased revenues of $92 million | • Short-haul passenger-miles suppressed by 14 percent<br><br>• Average cost per passenger-mile increased by 21 percent<br><br>• Average travel time per passenger-mile increased by 7 percent<br><br>• Airline passenger-miles decreased by 7 percent. At the average fare per passenger-mile this represents a loss in revenue of $271 million. |

TABLE XLV (Cont'd)

SUMMARY OF IMPACTS FOR COMBINATION STRATEGIES (Cont.)

| Strategies | Positive Impacts | Negative Impacts |
|---|---|---|
| 8 Auto Speed Reduction<br>Bus Fare Reduction<br>Bus Time Reduction<br>Air Fare Surcharge<br><br>8' With Fuel Allocation | . Federal revenues of $577 million, less expenditures for bus fare reductions ($847 million) and for express bus service start-up costs<br><br>. Without fuel allocation, energy savings of $8.7 \times 10^3$ Btu per passenger-mile suppressed<br><br>. With fuel allocation, savings of $9.8 \times 10^3$ Btu per passenger-mile suppressed<br><br>. Bus passenger-miles increased by 103 percent. Bus revenues will increase by $857 million<br><br>. Rail passenger-miles increased by 17%. Revenues will increase by $25 million | . Short-haul passenger miles suppressed by 6 percent<br><br>. Average cost per passenger-mile increased by 6 percent<br><br>. Airline passenger-miles decreased by 17 percent. At the average fare per passenger-mile, this represents a loss in revenue of $609 million<br><br>. Average travel time per passenger-mile increased by 9 percent |
| 10 Auto Cost Increase<br>Bus Fare Reduction<br>Bus Time Reduction<br>Air Fare Surcharge<br><br>10' With Fuel Allocation | . Federal revenues of $7.4 billion, less expenditures for bus fare reductions ($1.14 billion) and for express bus service start-up costs<br><br>. Without fuel allocation, energy savings of $7.4 \times 10^3$ Btu per passenger-mile suppressed<br><br>. With fuel allocation, savings of $8.5 \times 10^3$ Btu per passenger-mile suppressed<br><br>. Bus passenger-miles increased from 172 percent. Revenues will increase by $1.4 billion<br><br>. Rail passenger-miles increased by 13 percent. Revenues will increase by $19 million | . Short-haul passenger miles suppressed by 6 percent<br><br>. Average cost per passenger-mile increased by 16 percent<br><br>. Average travel time per passenger-mile increased by 2 percent<br><br>. Airline passenger miles decreased by 18 percent. At the average fare per passenger-mile, this represents a loss in revenue of $664 million |

TABLE XLV (Cont'd)

SUMMARY OF IMPACTS FOR COMBINATION STRATEGIES (Cont.)

| Strategies | Positive Impacts | Negative Impacts |
|---|---|---|
| 9 Auto Cost Increase<br>Bus Time Reduction<br>Air Fare Surcharge<br><br>9' With Fuel Allocation | . Federal revenues of $7.5 billion, less expenditures for express bus service start-up<br>. Without fuel allocation, energy savings of $5.6 \times 10^3$ Btu per passenger-mile suppressed<br>. With fuel allocation, savings of $6.5 \times 10^3$ Btu per passenger-mile suppressed<br>. Bus passenger-miles increased by 59 percent, resulting in increased revenues of $487 million<br>. Rail passenger-miles increased by 31 percent, resulting in increased revenues of $44 million | . Short-haul passenger-miles suppressed by 8 percent<br>. Average cost per passenger-mile increased by 16 percent<br>. Average travel time per passenger-mile increased by 1 percent<br>. Airline passenger-miles decreased by 16 percent. At the average fare per passenger-mile, this represents a loss in revenue of $573 million. |
| 6 Auto Speed Reduction<br>Auto Cost Increase<br>Bus Fare Reduction<br>Bus Time Reduction<br><br>6' With Fuel Allocation | . Federal revenues of $6.2 billion, less expenditures for reduced bus fares ($986 million) and for express bus service start-up costs<br>. Without fuel allocation, energy savings of $5.7 \times 10^3$ Btu per passenger-mile suppressed<br>. With fuel allocation, savings of $6.6 \times 10^3$ Btu per passenger-mi mile suppressed<br>. Bus passenger-miles increased by 136 percent. Revenues will increase by $1.12 billion.<br>. Rail passenger-miles increased by 34 percent. Revenues will increase by $49 million.<br>. Airline passenger-miles increased by 18 percent, resulting in increased revenues of $653 million | Short-haul passenger-miles suppressed by 12 percent<br>. Average cost per passenger-mile increased by 21 percent<br>. Average travel time per passenger-mile increased by 7 percent |

TABLE XLV (Cont'd)

SUMMARY OF IMPACTS FOR COMBINATION STRATEGIES (Cont.)

| Strategies | Positive Impacts | Negative Impacts |
|---|---|---|
| 5 Auto Speed Reduction<br>Auto Cost Increase<br>Bus Time Reduction<br><br>5' With Fuel Allocation | . Federal revenues of $6.2 billion, less expenditures for express bus service start-up costs<br><br>. Without fuel allocation, energy savings of 5 x $10^3$ Btu per passenger-mile suppressed<br><br>. With fuel allocation, savings of 5.8 x $10^3$ Btu per passenger-mile suppressed<br><br>. Bus passenger-miles increased by 39 percent, resulting in increased revenues of $328 million<br><br>. Rail passenger-miles increased by 50 percent, resulting in increased revenues of $71 million<br><br>. Airline passenger-miles increased by 20 percent, resulting in increased revenues of $725 million | . Short-haul passenger miles suppressed by 13 percent<br><br>. Average cost per passenger-mile increased 21 percent<br><br>. Average travel time per passenger-mile increased 6 percent |
| 7 Auto Speed Reduction<br>Bus Time Reduction<br>Air Fare Surcharge<br><br>7' With Fuel Allocation | . Federal revenues of $583.3 million, less expenditures for express bus service start-up costs<br><br>. Without fuel allocation, energy savings of 7.0 x $10^3$ Btu per passenger-mile suppressed<br><br>. With fuel allocation, savings of 7.9 x $10^3$ Btu per passenger-mile suppressed<br><br>. Bus passenger-miles increased by 21 percent, resulting in increased revenues of $176 million<br><br>. Rail passenger-miles increased by 31 percent, resulting in increased revenues of $44 million | . Short-haul passenger miles suppressed by 8 percent<br><br>. Average cost per passenger-mile increased by 5 percent<br><br>. Average Travel time per passenger-mile increased by 8 percent<br><br>. Airline passenger-miles decreased by 15 percent. At the average fare per passenger-mile this represents a loss in revenue of $561 million. |

TABLE XLV (Cont'd)

SUMMARY OF IMPACTS FOR COMBINATION STRATEGIES (Cont.)

| Strategies | Positive Impacts | Negative Impacts |
|---|---|---|
| 1 Auto Speed Reduction<br>Bus Time Reduction<br><br>1' With Fuel Allocation | . Without fuel allocation, energy savings of $6.1 \times 10^3$ Btu per passenger-mile suppressed<br>. With fuel allocation, savings of $7.5 \times 10^3$ Btu per passenger-mile suppressed<br>. Bus passenger-miles increased 17 percent, resulting in increased revenues of $140 million<br>. Rail passenger-miles increased 20 percent, resulting in increased revenues of $29 million<br>. Airline passenger-miles increased 10 percent, resulting in increased revenues of $363 million | . Federal expenditures for express bus service start-up costs<br>. Short-haul passenger-miles suppressed by 7 percent<br>. Average cost per passenger-mile increased 6 percent<br>. Average travel time per passenger-mile increased 6 percent |
| 2 Auto Speed Reduction<br>Bus Fare Reduction<br>Bus Time Reduction<br><br>2' With Fuel Allocation | . Without fuel allocation, energy savings of $7.8 \times 10^3$ Btu per passenger-mile suppressed<br>. With fuel allocation, savings of $9.6 \times 10^3$ Btu per passenger-mile suppressed<br>• Bus passenger-miles increased 95 percent. Bus revenues will increase by $791 million<br>• Rail passenger-miles increased by 9 percent. Revenues will increase by $12 million<br>• Bus subsidy of $813 million<br>• Airline passenger-miles increased by 9 percent, resulting in increased revenues of $315 million | . Federal expenditures for reduced bus fares ($161 Million) and for express bus service start-up costs<br>. Short-haul passenger-miles suppressed by 5 percent<br>. Average cost per passenger-mile increased 6 percent<br>. Average travel time per passenger-mile increased 7 percent |

TABLE XLV (Cont'd)

SUMMARY OF IMPACTS FOR COMBINATION STRATEGIES (Cont.)

| Strategies | Positive Impacts | Negative Impacts |
|---|---|---|
| 4 Auto Cost Increase<br>Bus Fare Reduction<br>Bus Time Reduction<br><br>4' With Fuel Allocation | . Federal revenues of $6.8 billion, less expenditures for reduced bus fares ($1.1 billion) and for express bus service start-up costs<br><br>. Without fuel allocation, energy savings of 6.2 x $10^3$ Btu per passenger-mile suppressed<br><br>. With fuel allocation, savings of 8.0 x $10^3$ Btu per passenger-mile suppressed<br><br>. Bus passenger-miles increased 162 percent. Revenues will increase by $1.34 billion<br><br>. Rail passenger-miles increased by 7 percent. Revenues will increase by $10 million<br><br>. Airline passenger-miles increased by 8 percent, resulting in increased revenues of $276 million | . Short-haul passenger miles suppressed by 5 percent<br><br>. Average cost per passenger-mile increased by 16 percent<br><br>. Average travel time per passenger-mile increased 1 percent |
| 3 Auto Cost Increase<br>Bus Time Reduction<br><br>3' With Fuel Allocation | . Federal revenues of $6.9 billion, less expenditures for express bus service start-up costs<br><br>. Without fuel allocation, energy savings of 4.5 x $10^3$ Btu per passenger-mile suppressed<br><br>. With fuel allocation, savings of 6.0 x $10^3$ Btu per passenger-mile suppressed<br><br>. Average travel time per passenger-mile decreased by 1 percent<br><br>. Bus passenger-miles increased by 52 percent, resulting in increased revenues of $434 million<br><br>. Rail passenger-miles increased by 20 percent, resulting in increased revenues of $29 million<br><br>. Airline passenger-miles increased by 10 percent, resulting in increased revenues of $380 million | . Short-haul passenger-miles suppressed by 7 percent<br><br>. Average cost per passenger-mile increased by 16 percent |

## CONCLUDING REMARKS

A summary of the maximum energy savings which might result from implementation of the two most severe combinations of individual strategies examined in the study is given in Table XLVI. The impact of these strategies on total passenger miles is also presented to provide perspective in the concurrent shifts and changes in travel demand.

The maximum modal shift energy saving for the most severe combination of measures (Strategy 11') is approximately $83 \times 10^{12}$ Btu/Yr, or 3.8% of the short-haul fuel consumption, 0.44% of all fuel consumption in transportation, and 0.23% of total U. S. petroleum use. (No individual strategy would provide an energy saving greater than $43 \times 10^{12}$ Btu/Yr.) A concurrent reduction in overall annual travel demand of approximately 31 billion passenger miles would result from implementation of this combination of strategies. The additional imposition of a 50-mph speed limit on all highway travel (Strategy 12') would reduce travel demand by an additional 34 billion passenger miles. However, the addition of this measure would reduce the energy savings attributable to modal shift to approximately $73 \times 10^{12}$ Btu/Yr and would actually cause a shift from autos and buses to air and rail modes. The suppression of overall travel demand by the extent indicated in the table would have a severe impact on the overall economy.

The maximum potential savings resulting from modal shifts are small relative to the savings which might be realized from other actions which can be pursued by the Government or industry, or from strategies other than modal shift inducements which might be implemented to accommodate future crisis situations.

Because of the small savings indicated by the study, and the inconclusiveness of the cost/benefit analysis, there appears to be little justification for recommending a deliberate modal shift approach. Implementation of the most effective combination of strategies is not believed to be politically acceptable, especially in light of the small potential benefits. Strategies incorporating either a fewer number of the measures enumerated in the table, individual measures, or other, less severe measures would result in even less energy savings.

Notwithstanding the fact that energy savings from modal shifts per se are small in light of the severity of strategies to effect such savings, an assessment of the relative practicality of implementing the individual measures selected for the combination strategies was performed to highlight potential problems in areas of controversy. Table XLVII summarizes the major factors and problems considered in this assessment.

TABLE XLVI

IMPACTS OF MOST SEVERE MODAL SHIFT STRATEGIES

Short-Haul Passenger Miles ($10^9$)

| Mode | Baseline Data | | Combination Modal Shift Strategy | | | |
|---|---|---|---|---|---|---|
| | | | 10'<br>50% auto cost increase<br>50% bus fare reduction<br>10% bus time reduction<br>21% air fare surcharge<br>70% air load factor | | 12'<br>50 mph speed limit<br>50% auto cost increase<br>50% bus fare reduction<br>10% bus time reduction<br>21% air fare surcharge<br>70% air load factor | |
| | 1973 | Baseline 1980 | With Strategy 10' | Change from Baseline | With Strategy 12' | Change from Baseline |
| Auto | 380.8 | 453.5 | 404.1 | -49.4 | 370.2 | -83.3 |
| Air | 18.4 | 35.9 | 29.4 | - 6.5 | 32.5 | - 3.4 |
| Bus | 9.1 | 14.3 | 39.0 | 24.7 | 35.2 | 20.9 |
| Rail | 1.5 | 2.4 | 2.8 | 0.4 | 3.5 | 1.1 |
| Total | 409.8 | 506.1 | 475.3 | -30.8 | 441.4 | -64.7 |

Short-Haul Energy Consumption ($10^{12}$ Btu)

| | 1973 | Baseline 1980 | With Strategy 10' | Change from Baseline | With Strategy 12' | Change from Baseline |
|---|---|---|---|---|---|---|
| Total Consumption | 2010 | 2163 | 1920 | -243 | 1724 | -439 |
| Cause of Energy Reduction: | | | | | | |
| Demand Suppression | | | | -124 | | -253 |
| Improved Mode Efficiency | | | | - 36 | | -113 |
| Modal Shift | | | | - 83 | | - 73 |

TABLE XLVII

SUMMARY OF IMPLEMENTATION CONSIDERATIONS

| Strategy Policy Option | Implementation Considerations: Legislative, Political and Regulatory | Implementation Considerations: Operational and Economic |
|---|---|---|
| Surcharge on Short-Haul Air Fares<br>--Declining<br>--Fixed | • Deregulation currently dominates legislative consideration of the airline industry<br>--Opposition from those seeking lower fares<br>--Danger of penalizing air travel during period of industry financial restructuring<br>• Difficulty of penalizing one mode to the advantage of others<br>--Identification in current law of promotion of air travel as goal of aviation policy | • Suppression of demand may further weaken the industry<br>--Possibility of rebate to carriers to prevent financial deterioration<br>• Declining surcharge is preferable to fixed<br>--Greater energy savings<br>--Lower cost<br>--Eliminate discontinuity |
| Reduce Auto Speed to 50 mph<br>--Federal legislation | • Major opposition will come from the trucking industry<br>• Difficulty in imposing a limitation on mobility | • Enforcement problems may significantly undermine the strategy's impact<br>• Increased safety may yield some support |
| Increase Efficiency of Air Travel - (70% Load Factor)<br>--Fuel Allocation | • Requires strong federal action | • Disruption of complex airline scheduling<br>• Loss of passenger convenience<br>• Reduction in airline employment<br>• Probable increase in breakeven load factor |
| Increase Auto Operating Costs by 50%<br>--Increase gasoline tax \$.54 per gallon | • Strong pro-automobile lobby would oppose such a drastic increase<br>• Difficulty in imposing limitation on mobility | • Because of its regressive character, lower income groups would be more severely affected<br>• Industry and regional dependence on auto<br>• Inflation and changing price elasticities will decrease the impact of a flat tax over time |

TABLE XLVII (Cont'd)

SUMMARY OF IMPLEMENTATION CONSIDERATIONS
(cont.)

| Strategy Policy Option | Implementation Considerations: Legislative, Political and Regulatory | Implementation Considerations: Operational and Economical |
|---|---|---|
| Reduce Bus Travel Time by 10% | | |
| --Federal legislation allowing differential speed for trucks and buses | • This was considered and rejected for safety reasons under the shortfall conditions of 1973-1974 | |
| --Dedicated bus (and car-pool) lanes at city end-points or on intercity routes | • The overall orientation of city, state, and even federal highway people remains in favor of maximization of vehicle (as opposed to passenger) throughput | • Bus lanes at city end-points will decrease travel time primarily during rush hour. The 10% decrease is not likely to be achieved |
| --Greater express bus service | • Growing recognition of bus industry may result in demonstration projects<br>• In some cases, may require ICC approval to skip intermediate points | • On most routes express service will never catch on with sufficient load factor to provide even normalized energy savings<br>• On some high travel density routes express service could probably become self-sustaining |
| Bus Fare Reduction of 50% | | |
| --Indirect subsidies to passengers (income tax deductions or rebates) | • Strong legislative opposition can be expected on the basis of interference with freedom of choice<br>• Possibility of subsidizing mobility as opposed to fares | • Administrative Cost<br>• May not be perceived as a fare reduction by patrons<br>• Due to characteristically lower-income patrons, this may imply a negative income tax |
| --Direct subsidization of fares | • Growing momentum in Congress and the Executive for private market solutions. This is compounded by the historic ability of the carriers to provide essential transportation services without public support.<br>--Lessons of the past indicate that trying to balance inequities (e.g., Amtrak competition) through more subsidity tends to create further imbalance<br>--Potential for an initially modest spending program to grow at exponential rates<br>--Industry concern that subsidization of fares may be linked to regulatory changes (such as increased reporting requirements, and so forth) | • Reservations of the bus companies include the operating requirements that may be imposed by accepting subsidy<br>• Administrative control may be virtually impossible within the existing regulatory framework<br>--Cross subsidization of routes, services, and geographic areas<br>--Over 900 carriers ranging in size from "Ma and Pa" to Greyhound Lines and serving over 15,000 cities<br>--Inefficiencies are harbored by federal and state subsidy |

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# APPENDIX I

## DESCRIPTION OF SIMULATION PROGRAM

The culmination of the methodology tasks was the programming of a computer model by which the effects of modal shift strategies could be simulated. The basic elements of this model are the intercity demand and modal split models developed at UTRC (Ref. 3). Using data from Tasks 3 and 4 above, adaptations to the models were made to accurately reflect traveler characteristics and energy intensities of intercity travel at distances in the 6-500 mile range. The simulation program was then applied to the 48 city-pairs identified in Task 1 as representative of the various categories of short-haul travel. Appropriate data descriptive of origin-destination trips by each mode on each of these 48 routes came from Task 2. In order to give a full account of the functional operation of this simulation program, an example is provided here for a single city-pair, Detroit to Ft. Wayne. As shown in Table IV, this city-pair represents a category consisting of seven city-pairs in the shortest distance range (67-150 miles), without rail service, and comprising 0.54% of all short-haul intercity pass.-miles.

Since Detroit is a major SMSA, it was divided into four zones in order to represent the access/egress portions of trips, wherease Ft. Wayne could be adequately described by a single zone. As depicted in Fig. A-1, the Detroit zones were defined on the basis of political boundaries. The first zone was the central business district (CBD), as defined in the 1970 census, and the second zone included the remaining area within the city limits. The other zones, which were determined by county lines, extend to the boundaries of the SMSA west and north of the city, each incorporating two of the four counties in the SMSA.

In Fig. A-1, circled numbers denote the population centroids of each zone, and the locations of public-mode terminals are indicated by the letters R for rail and B for bus, and by the word air for airports. Although auto trips do not involve access/egress segments in the conventional sense, cordon points were established to separate local from intercity portions. Two such cordon points were defined for Detroit, one through which trips to the West would flwo (to Kalamazoo/Battle Creek, Chicago and Ft. Wayne), and one through which trips to the South would flow (to Cleveland). Also shown on Fig. A-1 are the major highways which link the zone centroids to the terminals and cordon points most likely to be used in each case.

Total demand for intercity trips is computed in the UTRC model (see Ref. 3) using population and disutility as basic determinants, together with the diluting of travel propensity according to the number of alternative destinations and their relative attractions. In the case of Detroit-Ft. Wayne trips, each of the four Detroit zones accounts for a different percentage of the total demand. This allocation of trips was made independently for business and personal travelers depending on teh distributions of residence, employment, and hotel/motel accommodations in each zone, as described in Task 2 of the main text.

R77-912553-10

# Zone Breakdown for Detroit SMSA

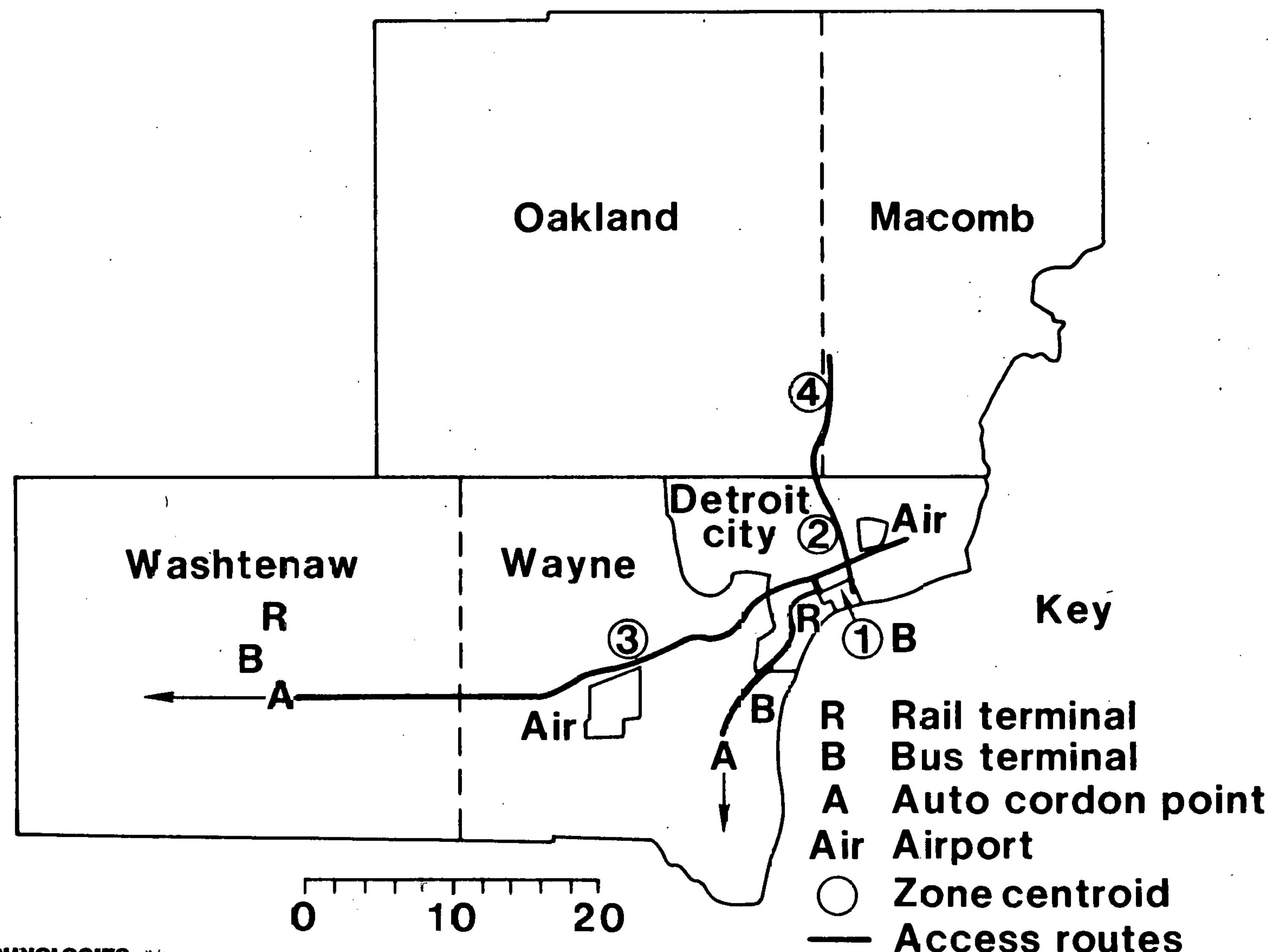


FIG. A-1

Measurements were made on the Detroit SMSA map to determine the access distances from zone centroids to terminals and cordon points. Furthermore, appropriate speeds were applied to the urban, surburban, and highway segments of these access trips to compute access times. Thus, the time, cost, and energy expended on access/egress portions of all trips could be determined. These calculations were based on the assumption that all access is by automobile. Although this assumption appears to make access/egress trips energy-intensive compared to the use of bus or rail transit, a large fraction of air access trips are made by auto and taxi, and access to rail and bus terminals is often by auto dropoff which is equivalent to two auto trips.

The complete computation for Detroit-Ft. Wayne trips involves four zone-pairs and five terminal-pairs (see Table X) to complete trips by bus, auto, T/LS air and commuter air. (There is no rail service between these cities.) A partial summary, based primarily on a single zone-pair, is provided in Tables A-I and A-II to illustrate the process of analyzing city-pairs zone by zone, summing the results of these calculations to complete the city-pair analysis; and then expanding this result to account for all seven city-pairs in the category represented by this specially chosen city-pair.

Table A-I is a summary of pertinent distance, time, and cost characteristics for travel between Detroit, Zone 3 and Ft. Wayne, Zone 1. It illustrates that Detroit-Ft. Wayne calculations were disaggregated by: zone-pair, direction of travel, mode of travel, trip purpose (business and personal), terminal-pair, and access/egress and line-haul segments. The final column indicates the disutility of travel, which is the basis on which the UTRC modal-split model allocates passengers among the competing modes. Results of this modal-split calculation are shown in Table A-II for the illustrative zone and for the entire city-pair. In this case, auto dominates the market and differences in modal share and business/personal share between the zone and the entire city-pair are small.

In the next part of the calculation, energy use is computed to the same degree of disaggregation indicated earlier. A final summary is provided in Table A-II which presents results for the entire city-pair by mode of travel and for the access/egress and line-haul segments. Based on the totals in the final three columns of this table, it is seen that auto travel accounts for almost 97% of the energy but only 92% of the demand. The second largest share is for T/LS air, which accounts for 2% of the demand and more than 6.5% of the energy.

The final step is to expand the city-pair energy use figures in Table A-II to the full seven city-pair category. The scaling parameter used to make this expansion is the ratio of Detroit-Ft. Wayne pass.-miles to category pass.-mile. In this case, the scaling factor is 4.55.

Thus, it can be seen that the simulation program described here is amenable to evaluation of modal-shift strategies which attempt to save energy by altering the passenger appeal of the competing modes. Typically, variations are made in the parameters which make up the time and cost figures in Table A-I. These changes produce a a differential effect on disutility which results in a redistribution of demand among the modes. If the shift is away from energy-intensive modes and toward energy-efficient modes, a favorable change in energy efficiency occurs.

TABLE A-I

MODE TRAVEL CHARACTERISTICS

Detroit Zone 3 - Ft. Wayne Zone 1

| Mode | Term. Pair | Distance (mi) | | Dir.[1] | Trip Purpose | Freq. | Time (hr) | | | | Cost ($/Pass) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Acc./Egr. | Line-haul | | | | Acc./Egr.[2] | Block | Wait | Total | Acc./Egr.[2] | Fare[3] | Dest. Trans. | M&L | Total | Disutility |
| T/LS Air | 1-1 | 6/9 | 128 | i-j | bus | 2.6 | 0.55/0.61 | 0.55 | 1.86 | 3.57 | 1.57/1.21 | 21.65 | 15.15 | 2.55 | 42.13 | 76.95 |
| | | | | | per | | | | | | | 19.40 | 8.17 | 1.79 | 32.14 | 43.52 |
| | | | | j-i | bus | | | | | | | | 7.71 | 2.48 | 34.63 | 63.21 |
| | | | | | per | | | | | | | | 5.23 | 1.75 | 29.16 | 37.98 |
| Comm. Air | 1-1 | 6/9 | 128 | i-j | bus | 2.0 | 0.55/0.61 | 0.67 | 2.30 | 4.13 | 1.57/1.21 | 22.54 | 15.15 | 3.48 | 43.95 | 84.23 |
| | | | | | per | | | | | | | 22.54 | 8.17 | 2.67 | 36.16 | 49.32 |
| | | | | j-i | bus | | | | | | | | 7.71 | 3.41 | 36.44 | 69.50 |
| | | | | | per | | | | | | | | 5.23 | 2.63 | 33.18 | 43.37 |
| Bus | 6-2 | 11/7 | 159 | i-j | bus | 3.0 | 0.49/0.45 | 3.90 | 1.66 | 6.50 | 1.98/1.11 | 8.71 | 15.15 | 9.20 | 36.15 | 99.60 |
| | | | | | per | | | | | | | 8.71 | 8.17 | 7.05 | 27.03 | 47.76 |
| | | | | j-i | bus | | | | | | | | 7.71 | 9.03 | 28.54 | 80.61 |
| | | | | | per | | | | | | | | 5.23 | 6.95 | 23.99 | 40.04 |
| Auto | 8-3 | 16/5 | 169 | i-j | bus | - | 0.32/0.10 | 3.00 | - | 3.42 | 0.46/0.14 | 6.42 | - | 7.81 | 14.83 | 48.22 |
| | | | | | per | | | | | | | 2.34 | | 5.98 | 8.92 | 19.84 |
| | | | | j-i | bus | | | | | | | 5.92 | | 7.66 | 14.18 | 41.59 |
| | | | | | per | | | | | | | 2.17 | | 5.90 | 8.67 | 17.12 |

1 i = Detroit j = Ft. Wayne
2 Public mode access based on auto
3 Auto fare = (operating cost + tolls)/party size

TABLE A-II

SUMMARY OF DETROIT - FT. WAYNE TRAVEL AND ENERGY CHARACTERISTICS

| Mode | Detroit Zone 3 - Ft. Wayne Zone 1 | | | Total Detroit - Ft. Wayne | | |
|---|---|---|---|---|---|---|
| | Round-Trip Demand $10^3$ Pass/Yr | Travel Share % | Bus/Per Split % | Round-Trip Demand $10^3$ Pass/Yr | Travel Share % | Bus/Per Split % |
| T/LS Air | 3.4 | 2.4 | 83/17 | 8.9 | 2.0 | 84/16 |
| Comm Air | 1.2 | 0.9 | 93/7 | 3.3 | 0.7 | 94/6 |
| Bus | 0.3 | 0.2 | 49/51 | 2.6 | 0.6 | 53/47 |
| Auto | 135.5 | 96.5 | 25/75 | 440.4 | 96.8 | 25/75 |
| TOTAL | 140.4 | 100.0 | 17/73 | 455.2 | 100.0 | 27/73 |

| Mode | Access | | | Line Haul | | | Total | | |
|---|---|---|---|---|---|---|---|---|---|
| | Party Size | Distance (mi) | Energy ($10^3$ Btu/Pass) | Load Factor % | Distance (mi) | Energy ($10^3$ Btu/Pass) | Energy ($10^9$ Btu) | Energy Share % | Demand Share % Pass-mi |
| T/LS Air | 1.2 | 28.7 | 165 | 47.2 | 128 | 2031 | 39.1 | 6.55 | 1.96 |
| Comm Air | 1.2 | 28.8 | 174 | 37.4 | 128 | 1072 | 8.2 | 1.37 | 0.72 |
| Bus | 1.5 | 17.6 | 90 | 46.0 | 169 | 198 | 1.5 | 0.25 | 0.57 |
| Auto | 1.8 | 27.1 | 107 | 35.9 | 148 | 515 | 548.2 | 91.83 | 96.76 |
| TOTAL | | | | | | | 597.0 | 100.00 | 100.00 |

# APPENDIX II

## SURVEY OF COMMUTER AIRLINES

Since commuter air service was treated as a separate mode in this study, operations of commuter airlines were analyzed to determine whether there may exist fundamental reasons why modal shifts to commuter carriers are not feasible on a large scale. A survey of commuter carriers was conducted to ascertain the nature of commuter operations on the 13 representative city-pair routes which have commuter service. A total of 16 different carriers serve these routes, and contacts or on-site interviews were made with all but one carrier. The questions asked concerned equipment in use, load factor, block fuel, operating cost, and the split between origin-destination and connecting passengers; fare, frequency, and block time information are available in the OAG. Other general subjects explored included the impact of joint fare agreements, lack of OAG connection listings, fuel effects of IFR/VFR operations, and amount of freight carried on passenger flights.

The data obtained from the commuter carriers, as summarized in Table A-III, are somewhat disappointing in that most of the commuter carriers surveyed were unwilling to release certain data they considered proprietary; e.g., operating costs and load factors, and data from carriers who responded are not entirely consistent. As far as the nature of commuter airline service is concerned, as reflected in the information in Table A-III, it appears that the intent of most operators is to provide one or more of the following:

- Connecting service from small cities to hubs
- Alternative airport service in higher-density markets
- Frequent nonstop service by use of small aircraft

Despite the longevity of the major commuter carriers, the industry is characterized by a high turnover rate. Table A-III indicates numerous instances where carriers have moved into and out of the 13 city-pair markets during the 1973-1976 period. There are also examples of carriers becoming identified as intrastate, or joining the Allegheny Commuter System for particular routes. In addition, some carriers are listed as providing passenger service when, in fact, their primary business is in freight.

With respect to fuel utilization, the data in Table A-III are somewhat conservative compared with the fuel data derived for commuter-type aircraft in Task 3 of this study. However, it appears that the difference has to do with the fact that the block fuel information supplied by the carriers are planning data, whereas the CAB data upon which the Task 3 trends were established are based on actual fuel consumed. It is felt that the CAB-derived data are the more appropriate source for this study since trunk and local service CAB data were used to derive the block fuel trends for larger airplanes.

Two questions which have implications for expanded commuter operations are the OAG policy concerning connections listings involving commuter airline flights and joint fare agreements with trunk and local service carriers. As the result of a recent decision, commuter connections will be listed in the OAG beginning with the issue of December 1, 1976. The listing will be separate from the connections listing of the certificated carriers, just as the listing of direct commuter flights is presently separate from that of certificated carriers. And while the commuters will continue to press for fully integrated listings, the fact that connections involving commuters can be readily constructed under the new OAG format means that what might formerly have been an impediment to expanded commuter service will no longer exist.

The limitation on commuter involvement in joint fare agreements has been a potential impediment to wider use of commuter services. However, if the CAB acts favorably on their petition to make joint fare agreements mandatory for all carriers in all markets rather than just for certificated carriers, this impediment will be removed. The commuters surveyed generally agree that past joint fare agreements, made under the discretionary policy now in effect, have had a very positive impact on their growth in connecting markets. Therefore, if, replacement services are postulated as a strategy to save fuel, such fuel savings would be promoted by broadening mandatory joint fare agreements to include commuters.

With respect to passenger attitudes toward commuters, the results of two surveys were obtained and reviewed. The first survey was performed by an anonymous agency which solicited opinions from passengers deplaning from commuter flights. About 500 passengers were surveyed, many of whom volunteered additional comments beyond the questions asked of them. Although the survey results are not entirely conclusive, a generally favorable passenger response was obtained. In particular, if commuter airlines provide the most convenient public service (or the only air service), travelers are inclined to use it. Many passengers have used the service before, indicating that they either prefer it or are not reluctant to fly in the small aircraft commonly used by the carriers.

The second survey (Ref. 66) provided a confirmation of these results as well as some additional demographic data. It indicated that the percentage of business travelers on commuter carriers (∿ 80 percent) is considerably higher than for domestic air travel in general (∿ 50 percent) and that seating comfort is a significant factor affecting passenger attitudes on small aircraft. However, as in the first survey, it was concluded that passengers indicate no reluctance to utilize commuter-type service, which in turn suggests that expanded commuter operations would not be restricted by lack of passenger acceptance.

TABLE A-III

COMMUTER AIRLINE DATA

| | City Pair: | NEW YORK - PHILADELPHIA | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Airline | Altair Airlines | | | | | | Downtown Airlines (2) | Seaplane Shuttle | Cumberland Airlines (3) | Business A/C Corp (3) | | Island Air (2) | | Allegh. Comm (Ransome) |
| | Year: | 1973 (1) | | | 1976 (1) | | | 1973 | 1976 | 1976 | 1976 | | 1976 | | 1976 |
| | Airport (4) | HPN | ISP | BDR | HPN | ISP | BDR | - | Wall St.-34 St Penn's Landing | EWR | ISP | BDR | JFK | FMN | EWR |
| Air Distance, mi | | 115 | 129 | 142 | 115 | 129 | 142 | 77 | [illegible] | 80 | 129 | 142 | 43 | 100 | 80 |
| Equipment in Use | | | B99 | | B99 | B99/N262 | N262 | Aztec | DHC6 | Aztec | Ce310 | Baron | DC3 | | N262A |
| Available seats | | | NR | | | NR | 0 | NR | 19 | 2 | 5 | 6 | - | | 27 |
| Frequency - nonstop | | 2 | 4 | 0 | 1.5 | 3 | 0 | 8 | 0 | 1 | 0 | 0 | - | | 6 |
| one stop | | 0 | 0 | 2.5 | 0.5 | 0 | 2. | 0 | 6 | 0 | 2 | 2 | - | | 0 |
| One-Way Fare, $ | | 23.00 | 25.00 | 27.00 | 31.00 | 33.00 | 34.00 | 27.00 | 15 | 15 | 29.00 | 30.00 | - | | 28.00 |
| , $/pass-mi | | 0.256 | 0.217 | 0.225 | 0.344 | 0.287 | 0.283 | 0.351 | 0.135 | 0.176 | 0.252 | 0.250 | - | | 0.373 |
| Annual Passengers Carried (5) | | 6,078 | 9,564 | 5,225 | | NR | | 4,236 | NR | NR | NR | | - | | 22,593 |
| % O&D | | | NR | | | NR | | 100 | 100 | 100 | NR | | - | | <20 |
| % Connecting | | | NR | | | NR | | 0 | 0 | 0 | NR | | - | | >80 |
| Average Load Factor % | | | NR | | | NR | | NR | NR | NR | NR | | - | | NR |
| Operating Cost - Total, $/hr | | | NR | | | NR | | NR | NR | NR | NR | | - | | 307 |
| Direct, $/hr | | | NR | | | NR | | NR | NR | NR | NR | | - | | NR |
| Fuel Usage, gal/flight | | | NR | | | NR | | NR | 75 | NR | NR | | - | | 84 |
| seat-mi/gal | | | NR | | | NR | | NR | 1.35 | NR | NR | | - | | 24.1 |

NR: No response from carrier
(1) Data from OAG editions: 8/1/73 and 5/15/76
(2) Service discontinued
(3) Primarily freight
(4) Airport indicated only if different from major city airport
(5) Demand data applies to 1975 rather than 1976

TABLE A-III (Cont'd)

COMMUTER AIRLINE DATA

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | City Pair: | PHILA. - HARRISBURG | | WASHINGTON - BINGHAMTON | | | CLEVELAND - DETROIT | | CLEVELAND - MANSFIELD | | CHICAGO - APPLETON | | CHICAGO - DETROIT | | |
| | Airline: | Altair Airlines | | Commuter Airlines | | Colgan Airways | Wright Airlines(7) | | Allegh. Comm. (GCS-Fischer) | | Air Wisconsin | | Hub Airlines | Skystream(2) Airlines | Air Wisconsin |
| | Year: | 1973 | 1976 | 1973 | 1976 | 1976 | 1973 | 1976 | 1973 | 1976 | 1973 | 1976 | 1973 | 1976 | 1976 |
| | Airport:(4) | | | | | IAD | BKL-DET | | | | | | CGX-DET | CGX-DET | |
| Air Distance, mi | | 85 | | 228 | | 228 | 93 | | 69 | | 160 | | 225 | 225 | 238 |
| Equipment in Use | | B99/ Queen 80 | B99 N262 | Metro | | B99 | Convair 600 | | Heron | | Metro | Metro | B99 | B99 | Metro |
| Available seats | | NR | NR | 19 | | 12 | 40 | | 16 | | 19 | | NR | NR | 19 |
| Frequency - nonstop | | 4 | 3.5 | 3 | 4 | 2 | 8 | 6 | 7 | 7 | 8.5 | 9.5 | 4 | 2 | 0 |
| one stop | | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 2 | 7(6) |
| One-Way Fare, $ | | 19.00 | 25.00 | 36.00 | 50.00 | 56.00 | 22.00 | 25.63 | 15.00 | 26.00 | 28.00 | 35.00 | 30.00 | 39.00 | 39.00 |
| $/pass-mi | | 0.224 | 0.294 | 0.158 | 0.219 | 0.246 | 0.237 | 0.276 | 0.217 | 0.377 | 0.175 | 0.219 | 0.133 | 0.173 | 0.164 |
| Annual Passengers Carried(5) | | 11,455 | NR | 21813 | NR | 4,320 | 48,820 | NR | 14,287 | 27,000 | 52,434 | NR | 9,553 | NR | NR |
| % O&D | | NR | | NR | | 100 | 100 | | 5 | | 20 | | 100 | 100 | NR |
| % Connecting | | NR | | NR | | 0 | 0 | | 95 | | 80 | | 0 | 0 | NR |
| Average Load Factor % | | NR | | -55 | | 62 | 52 | | NR | >60 | -55 | | NR | NR | NR |
| Operating Cost - Total, $/hr | | NR | | NR | | 207 | NR | | NR | NR | NR | | NR | NR | NR |
| Direct, $/hr | | NR | | NR | | 160 | NR | | NR | 110 | NR | | NR | NR | NR |
| Fuel Usage, gal/flight | | NR | | 67 | | 84 | 145 | | 30 | | NR | 65 | NR | NR | 135 |
| seat-mi/gal | | NR | | 64.7 | | 32.6 | 25.7 | | 36.8 | | NR | 46.8 | NR | NR | 33.5 |

NR: No response from carrier
(1) Data from OAG editions: 8/1/73 and 5/15/76
(2) Service discontinued
(3) Primarily freight
(4) Airport indicated only if different from major city airport
(5) Demand data applies to 1975 rather than 1976
(6) 3 one-stop and 4 two-stop
(7) Certificated carrier

TABLE A-III (Cont'd)

COMMUTER AIRLINE DATA

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| City Pair: | DALLAS/FT. WORTH - KILLEEN | | DALLAS/FT. WORTH - TEMPLE | | NEW YORK - READING | | | | CHICAGO - MILWAUKEE | |
| Airline: | Rio | | Rio | | Allegh. Comm. (Suburban) | | Suburban Airlines | | Midstate Airlines | |
| Year: | 1973 | 1976 | 1973 | 1976 | 1973 | 1976 | 1973 | 1976 | 1973 | 1976 |
| Airport:(4) | | | | | EWR | | JFK | | | |
| Air Distance, mi | 126 | | 126 | | 91 | | 106 | | 66 | |
| Equipment in Use | B99 | | B99 | | DHC-6 | | Beech-18 | DHC-6 | B99 | |
| Available Seats | 15 | | 15 | | 19 | | NR | 17 | 15 | |
| Frequency - Nonstop | 10 | 11 | 5 | 0 | 3 | 4 | 0.5 | | 3 | 3.5 |
| One Stop | 1 | 0 | 0 | 10 | 0 | 0 | 0.5 | | 0 | 0 |
| One-Way Fare, $ | 22.00 | 35.00 | 23.00 | 35.00 | 24.00 | 30.00 | 32.00 | | 15.00 | 21.00 |
| , $/pass-mi | 0.175 | 0.278 | 0.183 | 0.278 | 0.264 | 0.330 | 0.302 | | 0.176 | 0.247 |
| Annual Passengers Carried(5) | 74,634 | 84,300 | 9,432 | 16,945 | 9,334 | 9,251 | <1,000 | 2,305 | ~1,740 | 4,963 |
| % O&D | 1 | | 1 | | 63 | | NR | | NR | |
| % Connecting | 99 | | 99 | | 37 | | NR | | NR | |
| Average Load Factor | NR | | NR | 60 | NR | 42.3 | NR | 32.5 | NR | 44.3 |
| Operating Cost - Total $/hr | NR | | NR | | NR | | 242 | | NR | |
| Direct $/hr | 144 | | 144 | | NR | | NR | | NR | 191 |
| Fuel Usage, gal/flight | 74 | | NR | 106 | 65 | | NR | 79 | 30 | |
| seat-mi/gal | 25.5 | | NR | 17.8 | 26.6 | | NR | 22.8 | 42.5 | |

(4) Airport indicated only if different from major city airport

(5) Demand data applies to 1975 rather than 1976

TABLE A-III (Cont'd)

COMMUTER AIRLINE DATA



| City Pair: | CHICAGO-SPRINGFIELD | | DETROIT-FORT WAYNE | | DETROIT-BATTLE CREEK | |
|---|---|---|---|---|---|---|
| Airline: | Air Illinois[6] | | Hub Airlines | Air Wisconsin | Hub Airlines | Air Wisconsin |
| Year: | 1973 | 1976 | 1976 | 1976 | 1973 | 1976 |
| Airport:[4] | CGX | | | | | |
| Air Distance, mi. | 176 | | 136 | | 99 | |
| Equipment in Use | DHC-6 | HS 748 | B99 | Metro | B99 | Metro |
| Available Seats | NR | 44 | NR | 19 | NR | 19 |
| Frequency - Nonstop | 8 | 5 | 0.5 | 2 | 2 | 6 |
| One Stop | 0 | 0 | 0 | 0 | 0 | 0 |
| One-Way Fare, $ | 26.00 | 36.00 | 24.00 | 28.00 | 22.00 | 31.00 |
| , $/pass-mi | 0.151 | 0.209 | 0.176 | 0.206 | 0.222 | 0.313 |
| Annual Passengers Carried[5] | 33,738 | 50,000 | <1,000 | NR | 5,540 | NR |
| % O&D | 100 | | NR | | NR | |
| % Connecting | 0 | | NR | | NR | |
| Average Load Factor % | NR | 59 | NR | | NR | |
| Operating Cost - Total, $/hr | NR | 400 | NR | | NR | |
| Direct, $/hr | NR | 700 | NR | | NR | |
| Fuel Usage, gal/flight | NR | 225 | NR | 60 | NR | 48 |
| seat-mi/gal | NR | 33.6 | NR | 43.1 | NR | 39.2 |

(4) Airport indicated only if different from major city airport
(5) Demand data applies to 1975 rather than 1976
(6) Commuter in 1973; Intrastate in 1976

# APPENDIX III

## POLICY ANALYSIS OF INDIVIDUAL STRATEGIES

### Approach

The purpose of this analysis was to evaluate each of the individual strategies in terms of the policies which might be used to stimulate their implementation. Analysis of the feasibility of strategy implementation was based on two separate assumptions about the 1980 environment. First, a normal energy supply situation was assumed and the feasibility of implementation was assessed over the short term (five years). Secondly, the strategies were evaluated with regard to the feasibility of their implementation as contingency plans (within one year) during a critical energy shortfall.

The analysis proceeded by first identifying specific policies for stimulating strategy implementation. The policy development drew upon recent legislative proposals and alternatives which were considered during the energy shortfall of 1973 to 1974. The second step involved determination of factors restraining implementation of the policy changes. These restraints were then categorized as regulatory, political or legislative, and operational or economic. Further evaluation of these restraints in conjunction with the Task 5 results yielded an estimate of the probability of implementing the policy change under crisis and normal conditions.

The individual strategies were then reviewed in relation to each other. Based on the probability estimates, certain strategies were eliminated from further consideration. For those strategies remaining, procedures for effecting the most feasible policy changes were identified. This analysis considered the roles of the carriers, the regulatory agencies, and the legislators.

In completing the policy analysis for each of the individual strategies, consideration was given to the costs and benefits of implementation. Many of these had already been presented in the analysis of restraints and in the evaluation (Task 5) results. Additional evaluation was undertaken as necessary and a summary matrix was prepared for the individual strategies.

### Bus Strategies

Four strategies designed to attract passengers to bus were evaluated. None of the strategies result in any absolute energy savings; however, they all reduced the energy intensity of short-haul intercity passenger transportation. In order of the greatest efficiency gains yielded, the strategies are: 1) reduce bus fares by

50 percent; 2) provide discounts of 50 percent on meals and lodging for bus patrons; 3) provide a discount of $5.00 on destination costs for bus patrons; and 4) reduce bus travel time by 10 percent. Each of these strategies raises questions as to whether the industry can accommodate substantial increases in bus ridership. Reduced fares stimulate the largest increase (83 percent) in bus passenger-miles, followed by a 63 percent increase for the meal and lodging discount, a 57 percent increase for the destination cost discount, and a 31 percent increase for the travel time reduction.

Reduce Bus Fares by 50 Percent

There is no history of a general fare reduction in regular-route bus service. In contrast, the industry, faced with rising costs and declining patronage, has sought continued rate relief from the Interstate Commerce Commission.* The industry has, however, offered special discount fares on regular route service and has made downward adjustments in fares on selected routes so as to undercut AMTRAK fares.** Special discounts, although they often remain in effect for sufficient time periods to represent base fares to potential users, do not approximate general fare reductions because of the stipulations on their applicability (such as for mid-week travel).

With no historical precedent upon which to base the policy evaluation, four broad alternatives for stimulating a general fare reduction of about 50 percent were analyzed. First, since rates require approval of the Interstate Commerce Commission (ICC), the regulatory function could conceivably be modified so as to force the bus industry to absorb increasing costs and/or reduced profits. Second, bus rates could remain unchanged and fare reductions could be indirectly effected through income tax deductions and/or rebates for bus patrons. Third, the federal government could directly subsidize bus fares. And, finally, bus fare reductions, according to some, would result from deregulation of the motor carrier industry. Each of these alternatives and the restraints on their implementation are discussed below in more detail.

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* Recent general increases include: 8 percent effective December 1974; 10 percent effective May 1975; 5 percent effective July 1976; and 9-1/2 percent suspended October 1976 with a 4 percent increase allowed. (Source: National Bus Traffic Association, Inc. Statement of Evidence in Justification: General Increase Passenger Fares and Express Rates. Filed October 22, 1976.)

** Until the Spring of 1976, the major bus companies deliberately kept their fares $0.05 below AMTRAK fares on overlapping routes Since that time the industry has determined that the greater frequency of bus service in all but the Northeast Corridor justified fares higher than those charged by AMTRAK. (Source: Lawrence Leist, Information Reporting Branch, Transportation Systems Center, U.S. Department of Transportation, December 1976.)

Approval of Rates By the ICC

Within the existing regulatory system, the only way to effect a fare reduction is to prove that the existing rates are unjust and unreasonable. Although there is a notable paucity of data, particularly on a route-by-route basis, available evidence strongly indicates that this task would be virtually impossible.

The inflation and recession of the 1970's have significantly affected the intercity bus industry. Since 1970, operating costs have increased by 38.8 percent, while revenues have increased by only 31.3 percent. This failure of revenues to keep up with costs, despite fare increases, is reflected in a worsening of the average operating ratio for the industry. In 1971 the ratio of expenses to revenues for all Class I carriers was 87.6 percent. This compares to an average operating ratio (before taxes) of 90.6 percent in 1973 and 93.6 percent in 1975 (Ref. 62).

Since 1951 the industry has maintained that an operating ratio of 85 percent before income taxes (or 93 percent overall) is essential to continued operation of adequate service (Ref. 63). As shown below, the operating results for the individual Class I carriers in 1973 and 1974 indicate that about one-third achieved this 85 percent level, and nine carriers operated with a deficit during those years.

| Operating ratio ranges | Number of Carriers 1974 | Number of Carriers 1973 |
|---|---|---|
| Less than 79.9% | 5 | 6 |
| 80.0 to 84.9% | 5 | 6 |
| 85.0 to 89.9% | 12 | 9 |
| 90.0 to 99.9% | 34 | 35 |
| 100% and above | 9 | 9 |
| Total | 65 | 65 |

In their most recent (October 1976) statement in justification of a general fare increase, the industry based its arguments largely on a prior ICC decision (No. 36105) that a fare increase to achieve a 91% operating ratio was justified in order to impede the financial deterioration of the industry. In that decision, which was dated September 1976, the ICC found that the industry's financial condition was basically sound but that it had been subject to increasing deterioration over recent years. For example, the ICC found that the return on equity fell from 18.7% in 1964 to 11.1% in 1974 (Ref. 63). Given the relatively low rates of interest and inflation during the 1960's, the 1964 return was attractive. A 1974 return of 11.1%, however, at best only matched the 1974 inflation rate, resulting in no real return on investment.

Perhaps the most significant trend that emerges from the industry's recent operating results is the nearly steady decline in regular-route intercity revenue passenger-miles. In 1965 Class I carriers logged 15.7 billion revenue passenger miles on regular-route intercity service. By 1971 that number had fallen to 14.1 billion and, with the exception of the 1973-to-1974 period when fuel shortages diverted substantial traffic to public ground transportation modes, continued to decline to 13.2 billion in 1975.* Preliminary data for 1976 indicate that passenger volumes are continuing to fall.**

The industry as a whole appears to be caught between its own cost sensitivity to inflation and its patrons' price and service sensitivity. Within the industry, labor represents about 50% of direct operating costs. (The figure is probably higher for the large carriers and lower for the small carriers.) Moreover, workers in the large companies are supported by strong unions. Consequently, inflationary forces in the general economy are reflected to a high degree in carrier operating costs. On a route operating with one bus and one driver, the only opportunity for increasing productivity (in order to offset increasing costs) is through schedule cuts. Indeed, this, as well as deferred replacement of older buses, has been the industry response to increased costs. Yet, these actions reduce service quality and thereby may contribute to declines in ridership. If ridership falls, revenues again cannot keep pace with costs. If rate relief is then sought, further reductions in patronage can be expected. (As a rule of thumb the industry expects a 3% drop in ridership for every 10% increase in fares. (Source: Nicholas Bade).)

Other factors clearly enter into the financial squeeze of the industry. For example, the costs of terminal construction and renovation have increased substantially over recent years. A new intercity bus cost about $90,000 in 1975, as compared with $65,000 in 1970.*** Insurance costs are becoming a burden for some of the smaller companies and others are having difficulty in obtaining insurance.**** And finally, fuel price increases, despite the relative efficiency of buses, have also contributed substantially to the increasing costs of operation.

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* Ref. 62 (Revenue passenger miles in intercity regular route service totaled 13.9 billion in 1973 and 14.6 billion in 1974).

** Nicholas E. Bade, Director of Marketing-East Coast, Greyhound Lines, Inc. December 1, 1976.

*** Statement of A. E. Pendleton, Vice President and Comptroller, Greyhound Lines. In <u>Statement of Evidence in Justification, General Increase Passenger Fares and Express Rates</u>. Filed October 1976.

**** Phil Nagle, United Bus Owners of America. December, 1976. (Note: The larger companies are usually self-insured.)

In view of these circumstances and the fact that no dramatic change appears likely, the potential for proving that fare levels are unjust and unreasonable is practically negligible. Over the longer term, it may be possible to achieve reductions in bus fares by some modifications in ICC procedure. For instance, the ICC could disallow certain costs or all costs over a certain level. This has been proposed on the assumption that there is insufficient incentive to keep service costs low under the existing regulatory system. In particular, the primary incentive that currently exists is the expectation that patronage will decrease with an increase in fares. Because of the low price elasticity of demand, however, reduced patronage at higher fares will still yield an increase in revenues.* This option is considered to be long-term in nature since the ICC is unlikely to apply a new set of rules to existing rates, and existing rates (in real terms) have been assumed in this study to be in effect in 1980.

In order for the ICC to maintain a reasonable basis for disallowing certain costs, some means must be open to the carriers for lowering the cost of service. Three broad alternatives for reducing the costs of bus service are briefly examined below. They are: 1) use of more appropriate equipment and/or better utilization of equipment; 2) better utilization of drivers; and 3) use of older equipment.

The use of more appropriate equipment entails the substitution of smaller vehicles (either smaller conventional buses, vans, or limousines) for larger ones in cases where the load factor is typically low. The implementation of this option is in the hands of the individual bus companies, although in some cases they would need to secure the approval of the ICC.** The cost reduction brought about by the use of smaller vehicles would not be very large, since the major cost of operating a bus is the cost of the driver. Another shortcoming of this option is that it may conflict with the most efficient utilization of equipment.

The typical bus company has different equipment requirements on different parts of its routes. A balanced picture of cost-saving in the use of equipment must recognize the trade-offs between the best type of equipment, taken alone, and the costs of having the most appropriate equipment for each situation. In the latter case, the bus company might find itself with too much underutilized capacity, as equipment

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* The price elasticity of demand for bus travel has been estimated as being in the neighborhood of 0.436. (Source: Elizabeth Pinkston. The Intercity Bus Transportation Industry. Unpublished Doctoral Thesis, Yale University (1975) p. 79).

** In some instances, equipment restrictions are written into the certificate which grants operating authority. Such cases frequently involve the rights to operate limousine service, but sometimes concern the use of school-buses in "second-class" service.

sits in the garage waiting for the appropriate demand configuration. The highly seasonal nature of the demand for bus transportation renders the optimal planning of equipment a difficult task. Typically, the first quarter of the year is one of little demand, and, consequently, of very low load factors on the equipment in use. In sharp contrast, the third quarter is generally characterized by very high load factors. It is clearly unreasonable to expect the bus companies to maintain two (or possibly three, when the intermediate-demand quarters are considered) different fleets of equipment.

Better utilization of drivers would presumably offer great potential for cost savings because labor accounts for about 50 percent of total operating expenses and roughly half of that is represented by drivers.* In the interests of safety, however, various rules regarding the length of the work day and work week have been imposed. These coupled with the carriers' recognition that efficient use of drivers is in their best interest suggest the unlikelihood that any substantial cost savings remain to be realized in this area.

Nevertheless, it is true that some small carriers, employing nonunion labor, are currently providing service at considerably lower cost. In Michigan, for example, the major carriers operate with costs of about $1.25 per bus-mile, while the small regional carriers have costs in the neighborhood of $0.75 per bus-mile.** This is largely due to lower labor costs, although other factors, such as the use of older equipment and reduced terminal costs, may also come into play. Overall, it is neither likely nor desirable to affect the outcome of labor union negotiations through regulation.

Better utilization of drivers and equipment (as described above) may be possible if advanced reservations for bus service were required. However, to do so would drastically alter the character of the bus mode, decreasing the flexibility associated with it and making it less attractive for short-haul travelers. In addition, the cost of a reservations system would be prohibitive unless fares could be increased substantially.

The use of older equipment represents another option for reducing the costs of providing service. There are currently a few routes on which a carrier has the authority to engage in a so-called "second-class" service, which typically involves the use of older buses of the school-bus variety. On these routes, the fares are generally lower than they would be if more modern equipment were employed. When these cases involve direct geographical competition with the "first-class" service

* Arnold Levine. Office of Transportation Policy Development. U.S. Department of Transportation. November, 1976.

** Jerry Rudnick. Intercity Passenger Transportation Division. Michigan Department of Transportation. November 3, 1976.

of another carrier, the ICC, awarding operating authority, specifies the type of equipment to be allowed, so that "duplication of service" is avoided. Where equipment restrictions have been written into the operating certificates, the ICC would have to be induced to change the certificates in order to effectuate this policy option. Objections could be expected from the equipment manufacturers, as well as from the carriers which prefer the status quo over experimenting with alternative types or qualities of service.

Currently, the principal area in which older equipment is used is in charter service, and the rates charged for such service depend importantly on the type of equipment. The fact that some groups prefer the low-cost, low-quality-of-equipment configuration in charter service indicates that the potential for such a demand exists within the ranks of the regular-route traveler.

All three policy options described above could currently be implemented by the bus companies with very little need for regulatory commission action. Because the carriers have not chosen to implement such strategies, one can infer that they are not regarded as profitable, or even feasible, alternatives by the individual carriers. The hesitation to implement these cost-saving alternatives might be due primarily to each company's concern about not going out on a limb, engaging in activities quite different from the rest of the industry. Through the rate-making procedure, the ICC might be able to induce a number of companies to take collective action in this regard, thereby insuring the safety of numbers. The industry, however, is likely to strongly oppose such action on the part of the ICC, based on interference with management autonomy. In addition, the net benefit to the traveling public of such action by the ICC is questionable.

Indirect subsidy of bus fares. The federal government could, through income tax deductions or rebates for bus patrons, indirectly subsidize regular-route intercity bus fares. The advantage of indirect subsidy, as opposed to directly recompensing the bus carriers for charging reduced fares, lies in its circumvention of the industry's operating and regulatory structure. The industry could continue to be guided by standards of profitability within the context of the existing regulatory framework.

However, a number of problems would be encountered with a scheme to reduce fares by subsidizing users. Clearly, the structure of the program would have to be carefully designed. In particular, bus ridership typically comprises a large proportion of lower-income groups, such as students and the elderly. Many patrons may not be paying any taxes at all. Others may not perceive a tax incentive as a fare reduction. Assuming, nevertheless, that an administratively feasible program could be designed, it would still face broadly based legislative restraints.

Congress has traditionally opposed proposals suggesting any interference with an individual's freedom of choice. An example of this opposition is provided by the recent introduction of a bill in the Senate to disallow first class air and rail travel as a business expense tax deduction. Arguments in favor of passage pointed out the substantial subsidy (in terms of revenue foregone) that the federal government was paying to first class business travelers. Debate, nevertheless, kept returning to the issue of personal choice: if this one passes, what will be next?* The bill voted down by a substantial margin. Given that a proposal to subsidize bus patrons not only challenges the Congressional stance on freedom of choice but also would result in reduced tax revenues (as opposed to the increased revenues in the above example), the potential for passage is considered low.**

Direct subsidy of bus fares. A proposal to directly subsidize bus fares would eliminate the opposition to interference with personal choice described above with regard to the indirect subsidy alternative. It would still, however, encounter the growing momentum in Congress and the Executive for private-market solutions to problems of public concern. Opposition to a subsidy proposal for the bus industry would be particularly strong since the carriers have, throughout their operations, been able to supply essential transportation services without public support.

There are two interrelated bases for the tenor of opposition to subsidy alternatives. The first, by drawing on the lessons of the past, concludes that using subsidy to correct imbalances in fact creates further, albiet different, sources of imbalance. On this base, the argument that the bus industry must compete with the subsidized air and rail modes, and, therefore, should itself receive public financial assistance.

*Phil Bakes, Senate Subcommittee on Administrative Practices and Procedures. November, 1976

**Other arguments could (and probably would) be brought to bear on the issue. These include the desirability of subsidizing a profitable industry, the potential for effectively subsidizing mobility rather than fares, and so forth.

The second base for opposition to subsidy draws on numerous examples of inefficiencies harbored and protected by the availability of federal or state subsidy. The State of New Jersey, for example, has been providing subsidies to commuter bus operations since 1970 in order to assure the maintenance of essential services.* The program is structured so as to provide funds sufficient for carriers to break even on their operation, with no allowance for profit. There is no incentive built into the program for the carriers to operate profitably. Moreover, the system has been described as penalizing successful operators by depriving them of State funds.** For the State of New Jersey, the bottom line has been a growth in subsidy requirements from $500,000 in 1970 to an astounding $40 million in 1976.***

The dangers of using subsidies to achieve public goals therefore include the generation of unintended side effects, or system imbalances, the probability of promoting inefficient operation, and the institutionalization of an initially modest spending program which is likely to grow at an exponential rate. Representatives of the bus industry have additional reservations about proposals for subsidization of fares. Of major concern are the operating requirements that may be imposed from involvement of the industry in the political arena. Amtrak has, for example, been subject to certain politically motivated operating requirements as a consequence of its reliance on federal subsidy. In addition to the concern over the possibility of becoming a political football, the industry has voiced reservations over the structure of a fare subsidy program.****

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*Passage of enabling legislation for the subsidy program was antedated by enormous public outcry when a couple of bus companies went out of business. (Bill Carroll, Supervisor, Bus Bureau, Commuter Operating Agnecy, New Jersey Department of Transportation. December, 1976.)

**Peter E. Stangle, Assistant Commissioner for Public Transportation, New Jersey Department of Transportation. (As reported in the Washington Post.)

***Ibid. (Includes subsidy to commuter rail.)

****For example, the industry asserts that it could not comply with the labor requirements applicable under the Urban Mass Transit Administration. [Charles Webb, President, National Association of Motor Bus Owners. November 30, 1976.]

The issue of administrative control is, moreover, of considerable magnitude in an industry comprising more than 900 independent carriers, ranging in size from "Ma and Pa"-type operations to the Greyhound and Continental Trailways Systems, and serving over 15,000 cities in the United States (Ref. 62). Compounding the problem are industry assertions that most companies must internally cross-subsidize their operations in order to meet regulatory requirements (particularly of the States) for service continuation. The profitable charter operations, for example, are purported to support regular-route services. Similarly, it is argued that profitable regular-route service, such as in high-density corridors, allows continuation of unprofitable rural service. And furthermore, industry spokesmen have described situations in which certain states, by virtue of their densities and/or regulatory systems are, in effect, subsidizing operations in other states.* While the carriers have not shown evidence of cross-subsidy on a route-by-route basis, there is no compelling reason to disbelieve their contentions. The complexities of such a structure indicate that institution of a subsidy program would require either foresaking administrative control or liberalizing entry and exit controls to straighten out the accounts. This latter alternative is considered to be more palatable to a cost-conscious Congress, but is nevertheless subject to numerous restraints, as described in a subsequent section.

Overall, direct subsidization of bus fares is not likely to gain acceptance during the next five years. Alone, this strategy does not result in absolute energy savings. Consequently, implementation under crisis conditions is also unlikely. If a combination of reduced bus fares with other strategies results in substantial energy savings, then implementation as a contingency plan would be possible (Policy Analysis of Final Strategies).

Deregulation of the motor carrier industry. Proposals for deregulation of the motor carrier industry are primarily aimed at carriers of property as opposed to passengers. The Motor Carrier Reform Act of 1976 (S.2929), however, would also have a significant effect on the bus industry. The primary impact,** and that which is generating the greatest controversy, involves the liberalization of entry into the business of transporting passengers by motor carrier in interstate commerce.

*Nicholas E. Bade, Director of Marketing-East Coast, Greyhound Lines, Inc. December 1, 1976.

**Other provisions which would affect the bus industry include: rate bureau provisions which may jeopardize the collective consideration of fares and rates by bus carriers; the revocation of certificates for safety violations; the merger provisions which would remove anti-trust immunity from motor carrier consolidations; and an aircraft exemption which would repeal the current exemption accorded to bus carriers for transportation incidental to air transport. [Statement of the National Association of Motor Bus Owners to the Senate Committee on Commerce on Proposed Legislation on Reform of Motor Carrier Regulation. October 18, 1976.]

Two major issues are involved in the bus industry's opposition to freedom of entry. First, the Administration's bill (S.2929) does not preempt State control over exit. In many instances, it is the States' refusal to permit discontinuance of a part of intrastate service which binds a carrier to continuation of unprofitable interstate service. Since it is unreasonable to expect new entrants into the bus industry to initiate service on unprofitable routes, the existing carriers would be at a financial disadvantage if forced by the State regulatory bodies to maintain service on such routes.

The second major area of opposition to liberalized entry is more complex. It involves the prospect of: 1) subsidization of intercity bus service at places where discontinuance would result from unrestricted entry and exit; 2) the potential for a massive influx of new entrants which would create overcapacity and reduce carrier viability on the profitable routes; and 3) the prospect of numerous fly-by-night operators endangering public safety and discrediting the entire bus industry.* To some extent, these arguments against freedom of entry and exit parallel those made by the airline industry. There is, however, a major difference: airline operations at least require an airport, whereas bus operations can be initiated between any two points connected by a road. As a result, not only are the barriers to entry negligible, but the opportunity for proliferation of both responsible and irresponsible carriers is great.**

Data upon which to base an assessment of the impact of freedom of entry into the bus industry is not available. Economists have contended that the regulation of the industry is not necessary to ensure efficient allocation of resources.*** In particular, it is argued that the industry is not a natural monopoly and does not have a high ratio of fixed to variable costs which might lead to undesirable pricing behavior. While transition costs are recognized as a concomitant of deregulation, they are not predicted to be very great.****

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*Charles Webb, President, National Association of Motor Bus Owners, December, 1976; Phil Nagle, United Bus Owners of America, December, 1976; J. J. Rudnick, Acting Administrator, Intercity Passenger Transport Division, Michigan Department of Transportation, December, 1976; Nicholas Bade, Director of Marketing-East Coast, Greyhound Lines, Inc., December, 1976; and Dennis Barron, Vice President of Marketing, Continental Trailways, December, 1976.

**J. J. Rudnick, Acting Administrator. Intercity Passenger Transport Division. Michigan Department of Transportation. December, 1976.

***Elizabeth Pinkston. The Intercity Bus Transportation Industry. Unpublished Doctoral Thesis, Yale University. 1975. p. 169.

****Ibid. p. 169.

The existence of internal cross-route subsidization within the regular-route service of the intercity bus industry indicates that liberalized entry and exit would necessitate subsidization of unprofitable routes in order to maintain service.* The net result of increased competition, however, may be substantial fare reductions on the profitable routes. In this manner the objectives of the strategy to reduce bus fares would, at least in part, be met.

Overall, motor carrier regulatory reform hinges on the trucking industry rather than the bus industry. The Department of Transportation favors deregulation. With regard to the bus industry, the DOT, although still studying the potential impact, expects that deregulation will create a stimulus for lower-cost, more attractive bus service.** The opposition to motor carrier regulatory reform is, nevertheless, substantial. Even if airline reform paves the way over the next year, it will still be at least two or three years before motor carrier economic regulation is liberalized.

Provide a discount of 50 percent on meals and lodging. This strategy is currently being implemented in a limited manner by Greyhound Lines, Inc. Through their network of Post Houses, Greyhound enables passengers to purchase discount meal tickets in conjunction with their regular-route bus tickets. Greyhound also has national contracts with hotels in nearly 40 major cities through which bus patrons obtain reduced rates when they elect to take advantage of the Slumber Stop Service. These discounts, which average about 10 to 15 percent, were initiated and are marketed as a convenience to passengers rather than just a cost savings.***

While these discounts do currently exist, the prospect of increasing the discount to around 50 percent was received as a completely different program by both hoteliers and the bus industry.**** The existing discounts incur essentially no incremental cost to either party. At a rate of 50 percent, however, the revenues foregone (or costs incurred) by provision of discounts would amount to a considerable sum. For lodging, in particular, guarantee of a room would be unlikely at a discount of 50 percent.

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*In some cases, profitable service may be provided by a lower-cost carrier. Overall, it is not possible to estimate the extent of subsidization that may be necessary.

**Arnold Levine, Office of Transportation Policy Development, U. S. Department of Transportation. December, 1976.

***Mr. G. Mahrley, Marketing Division, Greyhound Lines, Inc. December 6, 1976.

****Mr. G. Mahrley, Marketing Division, Greyhound Lines, Inc. December, 1976 and Dennis Barron, Vice President, Marketing, Continental Trailways. December, 1976, and Patty Ann McGee, Hotel Marketing, Marriott, Inc. December, 1976.

On this basis, it is unlikely that the bus industry will voluntarily negotiate inter-industry agreements to provide patrons with discounts of 50 percent on meals and lodging. Subsidization of such a program by the federal government is also unlikely in that it would be restrained by the opposition of both the direct and indirect programs proposed under fare subsidies (above).

Provide a discount of $5.00 on destination costs for bus patrons. This strategy is aimed at reducing the advantage of automobile travel in local transport within the destination city. Four alternatives for meeting this objective were evaluated. The first two, auto rental discounts and taxi fare vouchers, reflect discounts in the dollar cost of local transportation. The last two, suburban terminal construction and integration of urban and inter-city transportation networks, are aimed at increasing the convenience of local transport in the destination city.

Auto rental discounts have been offered by Greyhound in the Ameri-pass discount guide. These, like the hotel and lodging discounts, require little if any additional expenditure and provide a convenience for bus patrons. A survey of passenger use of the discounts, however, indicated that the car rental option was used very little.* The survey further indicated that most bus patrons are either picked up by relatives at the terminal or take public transportation to their destination.**

Issuance of taxi fare vouchers with purchase of a bus ticket has not apparently been tried by the carriers. A number of factors make the option relatively unattractive. First, it would probably require direct expenditure on the part of the carriers. Second, it would not have the marketing advantage of providing greater consumer convenience. Third, by the bus industry's own survey (above) the prospect for increased sales does not appear to be large. And finally, the requirements for seed money in other programs puts this comparatively risky venture at a disadvantage.

Neither of these alternatives has significant probability of widespread adoption on a voluntary basis. Subsidization by the federal government is also unlikely, as previously described. In contrast, construction of suburban terminals and increased integration of urban and intercity transportation networks are currently being undertaken by private and governmental bodies. As described below, these options for increasing the convenience of local transport in destination cities hold the greatest potential for achieving the efficiency gains of this strategy.

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*Mr. G. Mahrley, Marketing Division, Greyhound Lines, Inc. December, 1976.

***Ibid.*

Both Greyhound and Continental Trailways have started programs of suburban terminal construction. Such terminals cater to passengers traveling from the suburbs of one city to the suburbs of another, trips which represent an increasingly important segment of intercity travel demand. Not only do these terminals increase convenience for travelers in outlying areas, they also mitigate the growing fears that some people have regarding the downtown areas where bus terminals have traditionally been located.

To date, bus service to suburban terminals has also connected at the downtown terminals.* Consequently, there is an increase in terminal-to-terminal travel time for patrons with downtown origins and destinations. In the future, however, one industry spokesman has indicated that service on selected routes will be provided between suburban terminals without downtown connections.**

Restraints on widespread construction of suburban terminals are primarily economic. Costs per terminal range upward from about $100,000.*** Traditionally, the terminal problem has been left to the individual companies to handle, except in a few cities where there are union terminals serving all intercity bus traffic.**** Recently, however, the federal and state governments have shown considerable support for the construction of intermodal terminals. This phenomenon is described in more detail in later sections. With regard to this strategy, government involvement in terminal construction and renovation may promote passenger convenience but is unlikely to be initiated for that purpose.

The alternative of promoting integration of urban and intercity transportation networks is also unlikely to be initiated for the purposes of this strategy. In particular, funding for such projects is likely to come from UMTA, thereby giving the leverage to the urban as opposed to the intercity travel market. Nevertheless, the opportunities for promoting bus ridership by such integration may be substantial.

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*Arnold Levine, Office of Transportation Policy Development, U.S. Department of Transportation, November, 1976.

**Nicholas Bade, Director of Marketing-East Coast, Greyhound Lines, Inc. December, 1976.

***National Bus Traffic Association. Statement of Evidence in Justiciation: General Fare Increase Passenger Fares and Express Rates. Filed. October 22, 1976.

****Frequently, a regional carrier has arrangements with either Greyhound or Trailways to make use of its terminal facilities. Such arrangements benefit the passengers, by facilitating interline connections, as well as the carriers, which gain from more ridership as a result of the easier connections.

The State of Michigan, in particular, has made a conscious effort to promote all forms of public transportation. (Other programs undertaken by the State are described in a later section.) In developing demand-responsive (dial-a-ride) systems for urban areas, for example, an abandoned gas station may be set up as a dispatch office for the urban system with a waiting room and ticket counter for use by intercity bus patrons. The dial-a-ride operator then acts as an agent for the intercity bus company and receives commissions on ticket sales.* As a result, the integration is beneficial to the intercity bus system, the local transportation network, and most importantly, to the public at large.

Reduce bus travel time by 10 percent. Three alternatives were considered for stimulating a reduction of 10 percent in bus travel time. The first alternative, allowing higher speed limits for buses, would require legislation by federal and state governments and would almost certainly be rejected on safety grounds. (See discussion on Auto Strategies.) The second alternative, dedication of bus lanes at city end-points or on intercity routes, would necessitate (depending on the road) city, county, state, or federal approval. Such approval is restrained by the overall orientation of highway officials toward maximization of vehicle, as opposed to passenger, throughput. Intercity bus lanes are highly unlikely over the short term. Dedication of bus lanes at city end-points, which decreases travel time primarily during rush hours, is likely to continue, but in response to urban and commuter, as opposed to intercity, travel needs.

The third alternative, provision of more express bus service, offers the greatest potential for short-term implementation. Bus routes that serve many local communities typically provide much slower service than express buses. Elimination of the intermediate points would substantially decrease the transit time between terminals, thereby making the bus mode more attractive to passengers traveling the full length of the route.

Operationally, express service could not be instituted on all or even a majority of routes. While intermediate stops do increase travel time, they also attract passengers. Express service on most routes would probably not catch on with a load factor sufficient to provide even normalized energy savings.

On some high travel-density routes, however, express service probably could become self-sustaining (with positive energy benefits). On these routes a major restraint on the provision of that service is the seed money required for initiation and maintenance of the service until it becomes self-sustaining. The cost of experimenting with service and schedules can be substantial. In the New York-to-Philadelphia

*The State usually bears the cost of terminal renovation ($10,000 to $15,000) and the operating costs of the dial-a-ride service for one year ($75,000). In the second year, the community picks up the operating costs and has the intercity bus ticket commissions to augment revenues. These commissions may not exceed 5 percent, whereas the normal rate is around 10 or 12 percent. (J. J. Rudnick, Acting Administrator, Intercity Passenger Transport Division, Michigan Department of Transportation. November, 1976.)

market, for example, Greyhound normally offers hourly express service. Several times over the past few years the carrier has initiated service at headways of only one-half hour with a special ticket counter for the route. The last experiment, during the winter of 1975 and 1976, ran about 3 months.* While Greyhound representatives are reluctant to specify the cost of the service experiment, they will continue to try to penetrate that market, convinced that headways of a half-hour can be supported.** The carrier is restrained by lack of funds to get the service started.

The State of Michigan has taken positive steps toward mitigation of this restraint. In particular, a program of subsidizing new or expanded regular-route bus service in high-density travel corridors was started about a year ago. Financed by earmarking one-half cent of the existing seven cent per gallon gasoline tax for the program, its aim, in conjunction with other intercity and local transportation programs, is to foster a healthy public transportation industry in the private sector.

Under the subsidy program, operating assistance is available for up to two years. Funding levels are based on the difference between operating revenues generated and direct operating (or wheel) costs plus a profit margin, calculated from average operating ratios of all Michigan carriers over the prior three years.*** Any express shipment revenues obtained in the conduct of the demonstration operations are retained by carriers in order to provide consideration of the possible impact of the new service on existing scheduled service and any "start-up" costs which are not covered in direct funding.

After the two-year subsidy period, it is expected that, in several cases, the carriers will continue route operations because of their profitability, either independently or in conjunction with other scheduled services. In other cases, the two years of subsidized service may indicate that a route does not fulfill a transportation need and the State as well as the carrier will probably abandon the service. And finally, it may be found after the two years that the route receives a steady patronage, but does not generate revenues sufficient for profitable operation.

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*Such experiments are often started during periods of low travel demand, such as the first quarter of the year. This reduces the cost and minimizes the risk. [Lawrence Leist, Information Division, Transportation Systems Center, U.S. Department of Transportation. December, 1976.]

**Nicholas Bade, Director of Marketing-East Coast, Greyhound Lines, Inc. December, 1976.

***General company administration cost or other nonrelated system cost is not funded. A 6-1/2 percent profit margin is currently applied.

In these instances the State is considering the possibility of negotiating for the sale of a carrier's operating rights to a smaller company capable of providing service at lower cost.* Funding may also be extended on these routes.

The program's success as well as the need it fulfills is illustrated by the State's subsidy of service expansion in the Detroit-Lansing market. On that route, the State identified an untapped business demand for one-day round trips. One leg of such service was already provided by the regular-route carrier, but in the absence of the return leg, buses were not being used for business travel. For the first eight months, the cost of subsidizing the return service totalled $60,000.** But costs had been reduced to about $30 per day by the end of five months, with from 25 to 30 people making the round trip each day.*** It is expected, moreover, that the additional service will be retained without subsidy by the regular-route carrier because of the indirect stimulation of other schedules offered in the market.

In addition to the need for seed money, service experimentation is restrained by the necessity to obtain approval from the ICC to skip intermediate points. Hearings on this matter would probably feature cries of outrage from intermediate communities which would stand to lose service. Another difficulty involved in initiating more express service is that it would, in some instances, thrust regional and through carriers into competition on routes where currently the regional carrier has the operating authority (and responsibility), while the national carrier is not permitted to serve intermediate points. Whichever carrier felt most threatened by the discontinuance of intermediate-point restrictions would certainly object to the loss of monopoly rights.

Representatives of the bus industry have expressed interest in federal demonstration projects in selected high-density travel markets.**** Such projects could serve several purposes. First, as demonstrated by the Michigan program, they could reduce the economic restraint on scheduling experimentation. Second, they could provide evidence of the time and costs associated with such experimentation. This information in turn could be used as a yardstick by private companies in their planning for

*While in some cases the lower cost of operation may reflect deferred maintenance, by and large the major factor contibuting to lower costs per mile for small carriers is the reduced labor costs attributable to nonunion drivers. Some would argue that promoting lower-cost carriage involves a safety risk. In this regard, and also due to an apparent shortage of trained drivers, Michigan is developing a program for training bus drivers.

**J. J. Rudnick, Acting Administrator, Intercity Passenger Transport Division, Michigan Department of Transportation. November, 1976.

***Ibid.

****Nicholas Bade. Director of Marketing-East Coast, Greyhound Lines, Inc. December, 1976.

schedule changes. Perhaps the most important consequence of bus demonstration projects would be the commitment to all forms of public transportation represented by their initiation. This commitment at all levels of government has been sorely lacking.*

Overall, initiation of increased express bus service, particularly if stimulated by publicly funded demonstration projects, has a reasonable likelihood of reducing bus travel time over the next five years. The outlook for demonstration projects is also somewhat favorable. The major restraint on their initiation is a lock of interest in Congress and the Executive.** The Department of Transportation, however, has recently started to study the intercity bus industry.*** This effort may lead to greater recognition of the industry as an integral part of the national transportation system.

Other policies for improving bus service. Investigation of policy options for stimulating implementation of the foregoing strategies to improve bus service yielded some alternatives which could not be quantified in the Task 5 analysis. Insofar as they increase the attractiveness of the bus mode, however, they can be expected to promote ridership, thereby increasing the energy efficiency of short-haul intercity transportation.

Bus industry representatives, independently and in some cases upon questioning, indicated the need for and desirability of federal action in four areas. First, there was a general consensus that a national policy to promote all forms of public transportation is needed. Some also pointed to the desirability of a motor carrier division within the Department of Transportation.

Second, industry representatives urged an intermodal emphasis in terminal construction and renovation projects. While to a limited extent the federal government is moving toward accommodation of several modes in publicly financed terminal construction, examples of public funds being spent for single-mode terminals are not uncommon. For instance, the St. Paul Port Authority has recently agreed to finance a $4.7 million rail terminal built to AMTRAK specifications and to donate land for the new building, adjacent to an interstate highway. No provision is being made for bus carrier use of the terminal. Since terminal projects require the greatest

*At the federal level it is reflected in the absence of a motor carrier division at the DOT. At the local level this lack of commitment is reflected in the failure of town officials and police officers to respond to carrier requests for removing vagrants from bus terminals. (Ibid.)

**An interesting comparison can be made between the bus industry and Amtrak. Amtrak has 25 people working on Capitol Hill and has strong support from the Railroad Brotherhood. In contrast, the entire intercity bus industry has only about 10 people working on the Hill and union support (the Teamsters) is primarily aimed at trucking issues. (Nicholas Bade.)

***Arnold Levine, Office of Transportation Policy Development, U.S. Department of Transportation. November, 1976.

amount of bus industry capital, an intermodal emphasis in public construction could significantly aid the industry in meeting one of the fringe costs of providing service.

The third area of public involvement for improvement of bus service has already been described with regard to express bus service. The industry, as explained, could benefit substantially from federal demonstration projects aimed at service and schedule experimentation.

And finally, the regional carriers, many of which are small owner-operator enterprises, suffer from a lack of time or funds to incorporate marketing and technical expertise into their operations. This also suggests a federal role, perhaps through demonstration projects, in promoting public modes of transportation.

In conclusion, it is worthwhile to point out the active role that the Michigan Department of Transportation has taken in each of these areas. In adopting a State policy to foster public transportation and establish the importance of all modes, the State has initiated a wide variety of programs including:

- provision of short-term operating assistance to bus carriers for schedule and service expansion
- coordination with carriers receiving operating assistance to market the schedule and service expansions
- provision of capital assistance to the bus industry (through a revolving fund) for the purchase of new equipment
- development of a self-sustaining intermodal terminal in Kalamazoo
- integration of local demand-responsive public transportation with intercity bus service

Several other programs, aimed at bus, rail, and air service are underway or planned. This approach of trying to foster a healthy public transportation industry in the privatesector is not apparent at the federal level. It may, nevertheless, be more effective in conserving energy over the long term than programs aimed at outright support of individual modes of transportation. In addition, the approach parallels the growing emphasis in Congress and the Executive on private-market solutions to issues of public interest.

## Rail Strategies

Four strategies for improving the attractiveness of rail transportation were analyzed in Task 5. The strategies parallel those evaluated for the bus industry and include: 1) reduced fares; 2) meal and lodging discounts; 3) discounts on destination costs; and 4) reduced travel time. Each of these strategies stimulates passenger demand for rail service. Based on the Task 5 analysis, fare reductions yield an 80 percent increase in passenger-miles, followed by a 75 percent increase for destination cost discounts, a 56 percent increase for meal and lodging discounts, and a 26 percent increase for the travel time reduction.

### Reduce rail fares by 50 percent

The federal government is currently subsidizing rail passenger fares at an average rate in excess of 50 percent. From January to September of 1975, for instance, the cost per passenger-mile averaged 14.7 cents, compared to revenues of 7.2 cents, resulting in a deficit of 7.5 cents per passenger-mile (Ref. 64). According to AMTRAK's five-year financial and operating plan, losses on every route will continue through fiscal year 1981 (Ref. 65). Federal assumption of an operating subsidy greater than that already projected could not be justified by the limited gains in energy efficiency resulting from this strategy.

### Provide discounts of 50 percent on meals and lodging

On its western routes, AMTRAK currently issues (with ticket purchases) a brochure of coupons entitling the holder to discounts of about 10 percent on hotels, tourist attractions and restaurants. (Discounts are offered at 50 facilities in eight western cities.) The brochure is aimed at promoting leisure travel by train. In contrast to the discounts offered by the bus industry, no increase in convenience is associated with the AMTRAK discounts.

Increasing the discounts for meals and lodging to a rate of 50 percent is restrained by the same economic factors affecting such discounts in the bus industry. The cost would be considerable, nearly $4 per passenger for a total of $42.9 million in 1980 based on Task 5 results. It is highly unlikely that federal subsidization of passenger rail service would be extended to subsidize this indirect means of increasing ridership.

### Provide discounts of $5.00 on destination costs for rail users

AMTRAK currently offers car rental discounts on selected routes, such as the Florida Week of Wheels. These selected offerings are likely to continue, based on the Corporation's marketing approach of identifying sensitive markets and instituting short-term discount programs.* In the AMTRAK Five Year Corporate Plan, marketing

*Mr. Al Michaud, Vice President, Marketing. AMTRAK. November 1976.

strategies for individual routes reflect an integration of the various aspects of rail service, such as scheduling, speed, discounts and so forth, into a package tailored to the route characteristics. In conclusion, it is unlikely that this marketing approach will be changed to concentrate on destination cost discounts on all routes. Moreover, such a change may not be as effective as the approach planned.

Reduce rail travel time by ten percent

The major restraint on reducing rail travel times is the cost of road and track improvements. In the Northeast Corridor, for example, $1.75 billion has been authorized to achieve trip time goals of 2 hours and 40 minutes from Washington to New York and 3 hours and 40 minutes from New York to Boston.* While the 120-mph speeds contemplated in this reconstruction project do not reflect the more modest goal of a 10 percent reduction in travel time, authorization of the capital expenditures required by this strategy is quite unlikely in view of the small gains in energy efficiency. Alternative low-cost means of reducing travel time are not likely to be effective. For example, it is estimated that each stop on a route costs from five to ten minutes in a schedule.** This includes braking time, station dwell time, and acceleration time. Negligible time savings could, therefore, be effected in this area. The alternative of dropping service to an intermodiate point is politically intolerable, given that the public at large is paying for the service.

## Auto Strategies

Three strategies for penalizing automobile travel were evaluated. In order of decreasing potential for energy savings, they are: 1) a reduction in speed; 2) an operating cost increase; and 3) exclusion of cars from Central Business Districts (CBD's).

Reduction in speed limit to 50 miles per hour

As in the institution of a nationwide 55-mile per hour speed limit in late 1973, a further reduction to 50 mph would require federal legislation. The restraints on implementation reflect both political and economic considerations as described below.

* "The Fight for Control of the Northeast Corridor." Business Week. August 23, 1976, p. 71.

** Statement of Paul H. Reistrup, President, AMTRAK in Hearings before the Subcommittee on Transportation and Commerce of the Committee on Interstate and Foreign Commerce, House of Representatives, on the Implementation of the Rail Reorganization Act of 1973 and a Review of the Preliminary System Plan of USRA, August 1975. p. 986.

Opposition from the trucking industry to reduced speed limits can be expected to be both strong and effective.* During the 1973 Congressional Hearings on the subject of reduced speed limits, the industry cited evidence of operational and scheduling disruption, significant economic impact, and reduced energy efficiency if forced to operate at speeds of 50 or 55 miles per hour. With regard to operational problems, industry spokesmen outlined a complex system, based on existing speed limits and a federal limitation of ten hours of continuous driving:**

> Operating within these parameters (speed and driving time limitations) the carriers have developed their routing systems, terminal locations, relay points and equipment interchange points. Even a detail such as the selection of the driver's home is determined in many cases by the operational circumstances. A reduction of truck speed limits would throw these operations into a state of confusion and disrupt the carriers' scheduling.

Even small changes in allowable speed limits can make the difference between completion of a run in one day and a delay of as much as 12 hours in delivering freight. Clearly there are also added costs of spending more nights on the road.

In addition to these industry-wide problems, the earnings of individual drivers can be significantly affected by reduced speed limits. Drivers are paid on a mileage basis, receiving no hourly pay except in cases of breakdown and undue delay time.*** Prior to implementation of the 55-mile per hour speed limit, drivers averaged about 50 mph over a ten-hour period (including rest stops).**** The reduction in earning power of drivers as a result of the 55-mph speed limit was estimated by industry spokesmen at upwards of 18 percent.*****. Another estimate, by the Department of Transportation, indicated that if a $30,000 truck averaging 60 mph on a 500-mile trip were restricted to 50 mph, the per-ton hauling costs would increase by 15 percent, assuming that the driver's pay is adjusted to a per-hour rate.******

* The bus industry, for safety reasons, did not object to a uniform nationwide speed limit of 55. The only evidence presented with regard to economic impact was an estimate by Continental Trailways, Inc. that at 55 mph they would required about 15 percent more buses to operate their current service. (Hearings. p. 83).

**William A. Bresnahan, American Trucking Associations, Inc. in letter to Henry M. Jackson, U. S. Senate. October 26, 1972; as reported in Hearings.

***Statement of Frank E. Fitzsimmons, President, International Brotherhood of Teamsters. Hearings. p. 47.

****Ibid.

*****Ibid.

******Statement of Hon. Claude S. Brinegar, Secretary, Department of Transportation. In Hearings. p. 16.

The issue of the energy efficiency of trucks was also brought up in opposition to a reduced speed limit. While no hard evidence could be presented, it was noted that diesel units, unlike gasoline-powered engines, are designed to operate most efficiently in their highest road gear at fixed rpm.* Moreover, most truckers reported that they get better fuel mileage at from 60 to 65 mph on relatively flat interstate highways.** This information suggests that some partially offsetting increase in truck and bus fuel use would result from a lower speed limit.

In an effort to reach some compromise between the substantial automobile fuel savings achievable from reducing operating speeds and the operational and economic disruption of reduced speeds on commercial road users, two alternatives were considered during the 1973 Hearings. Both alternatives involved allowing different speed limits on the same road section. Under the first, trucks and buses would be allowed to operate at higher speeds than automobiles. Under the second alternative, all vehicles would be allowed to operate at higher speeds during the nighttime hours. Both were rejected on safety grounds.

There was a general consensus among the participants at the Hearings that speed diferentials of 10 mph or more created unduly hazardous conditions. Although there was some controversy over the danger associated with a differential of 5 mph, on balance the arguments against a differential speed by type of vehicle were more compelling than those seeking a compromise by allowing commercial vehicles to operate at faster speeds. The arguments against this differential included the following:

- Differential speeds will tend to increase the number of passing manuevers undertaken, with a resultant trend toward increased accidents.***
- There is a very real problem of public acceptance of a reduced speed limit if passenger cars are continually passed by trucks and buses.****
- The cost of altering existing signing is $30,000 to $50,000 more per state if differential speeds are posted.*****

*Statement of George H. Andrews, President, American Association of State Highway Officials. In Hearings. p. 61.

**Statement of Arthur L. Fox II, Executive Director, Professional Drivers Council. In Hearings. p. 205.

***Ibid. p. 61.

****Ibid. p. 61

*****Ibid. p. 61

- Allowing trucks and buses to travel at higher speeds is contrary to laws in over 30 states. Moreover, it would compound an already serious problem of incompatibility in both size and braking capability between commercial vehicles and passenger cars.*

May of these same arguments were used in opposition to a differential speed limit by time of day. In addition, the increased hazard of night driving indicated the inadvisability of this alternative. And finally, representatives of the trucking industry indicated that increased nighttime speeds would not alleviate their economic or scheduling problems, largely because operating costs would be higher for nighttime operations.**

In addition to these considerations, three additional factors concerning a further reduction in the speed limit may be mentioned. First, the strategy is likely to gain at least limited support on the basis of increased safety. The National Safety Council, for example, has reported that the chances of being killed when involved in an accident double with each 10-mph increase in speed over 50 mph.*** Second, it may not be possible to enforce the strategy, if implemented, particularly in a noncrisis situation.**** This is apparent from the gradual increase in vehicle operating speeds since the energy shortfall of 1973. And finally, any proposal involving, as this strategy does, a limitation on mobility, will be very difficult to implement. In total, these considerations lead to the conclusion that a reduction in the speed limit to 50 mph is unlikely under normal energy supply conditions. In view of the energy savings benefits associated with this strategy, and assuming that lack of compliance and the reduced energy efficiency of commercial vehicles does not substantially offset these savings, implementation during a severe energy shortfall does seem possible.

Increase direct operating costs by 50 percent. Two means of increasing automobile operating costs were explored. The first, charging tolls on all roads, was eliminated from further consideration based on: 1) the strong opposition that would come from all levels of government; and 2) the expense of collection. The second approach considered for increasing operating costs was an increase in the gas tax by $0.54 per gallon. As described below, this tax would arouse significant opposition but could probably be implemented during a severe energy shortage.

*Statement of John De Lorenzi, American Automobile Association. In Hearings. p. 196.

**Statement of Edward V. Kiley, Vice President, Research and Technical Services, American Trucking Association. In Hearings. p. 200.

***Hearings. p. 62.

****George Viverette, Highway Department, American Automobile Association, December 15, 1976.

During 1975, an increase in the federal gasoline tax was part of several Congressional proposals on energy policy. One bill, which was finally approved by the Ways and Means Committee after three months of bitter debate, had as its centerpiece a gasoline tax of $0.03 per gallon in 1976 which would rise by as much as $0.20 per gallon if consumption exceeded 1973 levels.* These modest increases, as compared with the $0.54 per gallon increase considered in this strategy, were soundly defeated.

Based on the 1975 experience, opposition to a dramatic increase in gasoline taxes is expected to be both political and economic. Public perception of energy supplies was no longer crisis-oriented during 1975. This hindered consideration of a tax as visible as the gasoline tax proposals and would also restrain implementation of such a tax in the future.

Economic arguments against the tax impose even greater restraints. A large tax on gasoline not only penalizes personal mobility, but also indirectly affects those economic activities dependent on automobile use. Opposition would come from the strong pro-automobile lobby. Moreover, the nation's economic dependence on the automobile industry, as evidence over the last three years, cannot be ignored.

Regional dependence on tourism, largely automobile-oriented, represents another aspect of the economic hardship that may result from a major increase in gasoline tax. In Florida, for example, about 65 percent of the tourists arrive by automobile and tourism is the keystone in the state's economy.** Certain industries will also be more severly affected than others as a result of their dependence on traveling sales and service representatives.

Regional differences in the accessibility of alternative modes of transportation would significantly affect the incidence of the tax nationwide. The densely settled Northeast, for example, would be in a much better position to avoid or minimize the impact of the tax as compared with areas of the Midwest and West where both population and economic activity are dispersed over large areas. The incidence of a flat tax would also vary by income group, thereby imposing a greater burden on lower income groups. This in turn implies a limitation on the employment mobility of those who require it most. Overall, the prospect of stimulating both inflation and unemployment in the economy represents a major restraint on implementing a $0.54 per gallon gas tax over the next five years.

*"Energy Legislation Continues to Crawl." Business Week. May 26, 1975. p. 27.

**Statement of Hon. Dante Fascell, Representative in Congress from the State of Florida. In Hearings. p. 6.

In a crisis situation, however, the significant untapped elasticity in the demand for gasoline makes gasoline taxation an attractive mechanism for achieving fuel savings. From 1974 to 1975, for example, retail prices for residual oil used by utilities increased 180 percent, while home heating oil climbed less than 75 percent and gasoline prices rose by only 35 percent.* It may, moreover, be possible to mitigate some of the more discriminatory characteristics of the tax by incorporating plans to rebate costs to certain groups. And finally, the impact of a flat tax is greatest immediately upon implementation, after which inflation and changing elasticities of demand are likely to decrease its effectiveness as an energy conservation measure.** As such, this strategy is more suited to implementation as a contingency measure.

Exclusion of cars from CBD's. This strategy involves exclusion of automobiles from the CBD's of metropolitan areas having populations greater than one million. It was simulated by adding 15 minutes and $0.50 to the costs of auto trips with an end-point in a major CBD. These increased costs were to account for a transfer, such as by bus, from a peripheral parking facility to the destination. Through a modest suppression of intercity travel demand, the strategy achieves small but positive absolute energy savings.

While the impact on intercity transportation has been demonstrated by the Task 5 results, the leverage required for implementation will have to come from the urban sector. Coordination among local-level institutions and the public at large is necessary for effective implementation. In a study of institutional restraints on implementation of auto-free zones in New York City, for example, it was found that approvals for the project would be required from eleven different agencies, ranging from the New York City Transportation Administration and Police Department to the Board of Franchises and City Planning Commission.*** The study also concluded that imposition of a partial ban, such as on certain streets at

*"The Case Against Both Energy Taxes and Rationing." Business Week. February 10, 1975. p. 68.

**Some states, finding that gas tax revenues are not growing as fast as anticipated, are considering imposition of a percentage tax on the pump price of gasoline. While this would enable the tax to keep up with inflation, the size of the percentage, when compared with other taxes, has been found to create severe problems in public acceptance. (Source: George Viverette, Highway Department, American Automobile Association. December 1976.)

***Institute for Public Transportation. Institutional Problems in New York City, re: Clear Air Act Implementation. May 1973.

specified times of day, would require up to 1-1/2 years for implementation while a full ban would require at least two years.

In partial auto bans that have been implemented around the country, downtown merchants have voiced some of the strongest opposition, citing the potentially adverse effect on sales volume. (Experience in foreign countries and, in a more limited manner, in the U.S. has indicated that merchants will not be adversely affected.) They have been joined by parking garage owners and operators who would surely be affected by a reduced number of automobiles in the central cities. In other cases, the availability of land for peripheral parking and the provision of express bus service have restrained implementation of auto-exclusion zones.

Overall, the degree of local-level support and planning required to effect automobile exclusions in CBD's would make it virtually impossible to promote this strategy as a contingency plan. The outlook for broad-scale implementation over the next five years is also not very promising. In particular, the Urban Mass Transit Administration is just now (1977) initiating demonstration projects in at least 2 major cities. These projects will, over the next five years, serve as testing grounds for implementation of auto-restricted zones. It is unlikely that a major thrust toward broad adoption of auto restrictions could be initiated prior to completion of these projects.

## Air Strategies

Two types of strategies which affect energy use in short-haul air travel were analyzed. The first type was designed to decrease the energy intensity of air travel, while the second type was aimed at shifting passengers away from air travel for short-haul trips. These two types are evaluated separately because the strategies included under each are substitutes for each other.

### Decrease Energy Intensity of Air Travel

The four strategies designed to decrease the energy intensity of air travel, in descending order of potential energy savings benefts, are: 1) maintain a 70 percent load factor on all short-haul routes; 2) replace large short-haul aircraft with small aircraft and maintain current (1976) schedules through 1980; 3) maintain current schedules through 1980; and 4) replace large short-haul aircraft with small aircraft. All of these strategies would require strong federal involvement for implementation. It is unlikely that any of them could be implemented under normal energy supply conditions. Policy implications of these strategies are discussed below.

#### Maintain a 70 percent load factor on all routes.

Maintenance of a 70 percent load on all routes could be stimulated by a policy of fuel allocation.

This action was undertaken in the energy shortfall of 1973 and 1974, when the allocation guidelines specified that the airlines should get 95 percent of their 1972 fuel. This represented a decrease of about 15 percent from their projected needs for 1974. In fact, during the first few months of 1974, oil companies could not always meet the allocation figure, leaving airlines with from 85 to 90 percent of the fuel they burned in 1972.*

Based on the 1973 and 1974 experience, it is clear that, in the face of a major oil shortfall, legislative and political restraints on a policy of fuel allocation can be overcome. The regulatory restraints are negligible. During the fuel shortfall, the CAB and the airlines cooperatively reduced schedules to conserve fuel. The CAB's overture to gain control of airline scheduling was unsuccessful and, as discussed below, is unlikely to occur in the future.

There are, nevertheless, numerous economic and operational restraints associated with implementation of a fuel allocation policy. One of the most significant problems resulting from reduced fuel allocations is the disruption of the complex airline scheduling process. According to an Eastern spokesman, it takes about 6 months to put a fully integrated schedule together.** The operations affected range from schedule connections to flight crew rosters and maintenance programming. Route-by-route variations in passenger demand, as well as the actions of other carriers on competitive routes, need to be accommodated in developing schedule cuts.

A fuel allocation program aimed at achieving a 70 percent load factor also has significant implications with regard to passenger convenience. If a load factor of 70 percent could be achieved on each individual flight, as assumed in the strategy design, the impact on passenger service would merely be related to such factors as longer waiting time to board a plane. Passenger demand, however, is not evenly distributed among routes or times of day. In addition, requirements for aircraft positioning and the degree of competition on a route significantly affect load factors. As a result, load factors on many routes will average more than 70 percent, while others will likely be considerably lower than the 70 percent target. Moreover, it will be considerably more difficult for passengers to get a seat on a plane, and some of the less traveled routes may be dropped altogether.***

Airline employment will also be significantly affected. During the first two months of 1974, when load factors system-wide averaged from 56.3 to 58.0 percent,

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*"The Airlines' New Austerity." In Business Week, March 30, 1974, p. 58.

**"The Airlines Face a Rough Ride." Business Week, January 19, 1974, p. 24.

***Suspension of service would, as in 1974, be strictly controlled by the CAB. As of March, 1974, service had been suspended to four domestic markets. Most of the schedule cutbacks were, moreover, undertaken in travel markets with two or three competitors. ("Load Factor Growth Continues." Aviation Week and Space Technology. March 18, 1974, p. 23.)

about 17,000 employees were furloughed.* Others were shuffled to different jobs (flight attendants working as ticket agents, for example). The magnitude of unemployment in the airline industry in 1974 reflected cutbacks in excess of those required by the allocation program, in part because of advance warnings that a reduction of 15 to 25 percent would be imposed. There is, however, little doubt that a stringent allocation program will cut deeply into the airline workforce of more than 300,000 persons.

Higher load factors and smaller payrolls, however, did not increase profits during the 1973-to-1974 period. As these changes occurred, the breakeven load factor for the airlines was also changing. It rose for several reasons. First, grounding planes or reducing daily aircraft utilization decreases some operating costs but does not affect some substantial fixed costs borne by the airlines. Interest charges are one of the largest of these costs. Others include facility agreements at airports, and overhaul expenses to return aircraft to service. A spokesman for TWA estimated that 35 percent of the carrier's costs would remain even if operations were reduced to zero.**

A second reason for the increase in breakeven load factors was, of cource, the dramatic increase in fuel prices experienced by the airlines. Because of the relatively large proportion represented by fuel in airline operating costs, fuel price increases significantly affect the earnings outlook. In the recent concern about an OPEC oil price increase, it was estimated that a 20 percent increase in the price of oil would cost the airlines half a billion dollars.*** This would more than wipe out projected 1977 profits. While fuel allocation does not strictly imply increased prices, they are a likely adjunct of a fuel supply shortfall.

One final consideration important to the application of a fuel allocation program involves the relationship between short-haul and long-haul air travel. For example, it is unlikely that a policy of fuel allocation could successfully discriminate among these markets. As a result, long-haul air travel, which is more fuel efficient, will also be penalized to a greater or lesser extent depending on the route system of a carrier. During the 1974 fuel allocation, moreover, there was some evidence that air service in some short-haul markets improved as travelers shifted from the automobile to the airplane.**** Clearly this was stimulated by

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*"The Airlines New Austerity." Business Week. March 30, 1974, p. 57. (For the individual carriers, load factors in the first 2 months of 1974 were from 0.2 to 13.1 percentage points higher than during the same period in 1973. The median increase was 5.8 percentage points.)

**"The Airlines New Austerity." In Business Week. March 30, 1974, p. 60. (Note that the percentage may be substantially lower for a purely domestic carrier.)

***George James, Air Transport Association of America in Business Week. October 18, 1976.

****"Load Factor Growth Continues." Aviation Week and Space Technology. March 18, 1974, p. 23.

uncertainty over gasoline availability. Coupled with the likely inability of a fuel allocation program to yield 70 percent load factors on each individual route, the long-haul and short-haul route relationships raise some doubt as to whether the full complement of projected fuel benefits can be achieved by implementation of this strategy.

Replace large aircraft with small aircraft and maintain current schedules through 1980. This strategy represents a combination of the following two strategies. Since there are no synergistic effects associated with dual implementation, the restraints on implementation are the same as those described for the individual strategies. Overall, as described below, it is unlikely that this strategy could be implemented under normal or crisis conditions.

Maintain current schedules through 1980. In this strategy, the current airline schedules, which include consideration of the complex scheduling, routing and aircraft positioning requirements, were assumed to be maintained through 1980. Frequencies were increased only to prevent load factors from exceeding 70 percent. The Task 5 results showed energy savings at about 2/3 of the level achieved by the fuel allocation strategy.

Scheduling is currently under the sole authority of the indivudal carriers. It is, moreover, one of the forms of service competition which the airlines actively pursue. To win more passengers, airline managements feel they should offer more flights. The objective is not only to induce new passengers to fly, but also, perhaps more importantly, to lure passengers away from other airlines, thereby increasing the market share of the carrier that increases capacity.

This relationship between output and market share creates an environment in which voluntary maintenance of current schedules by individual carriers is unlikely. If a carrier restrains capacity increases, it will suffer more than a proportional loss in market share.* In the past, as scheduling rivalry worked to drive profits down, capacity agreements were initiated by request of the carriers. These anti-competitive agreements, in effect from 1971 to 1975 in four markets, have been declared illegal by the U.S. Court of Appeals and are unlikely to be resumed in the future.

Nevertheless, it is informative to recount briefly the practical restraints encountered in negotiating the agreements during 1971.** Initially 21 "over-served" markets were identified by the carriers as candidates for capacity agreements. The

*George Eads. "Competition in the Domestic Airline Industry." Promoting Competition in Regulated Markets. Ed. Almarin Phillips. (The Brookings Institution; Washington, 1975.)

**Based on Eads. "Compeition in the Domestic Airline Industry." Ibid.

CAB allowed talks to be set up for 13 markets, but agreement could be reached in only four markets. The basic restraint on successful negotiation involved the reluctance of the carriers to accept continuation of the market shares which existed at the start of the agreement. Again, this points to the unlikelihood of voluntary restraint of capacity increases through 1980.

Mandatory restraint of capacity increases is also unlikely. The Federal Aviation Act forbids direct control by the CAB over service frequency.* Under normal conditions, and particularly in light of the momentum to freer competition, scheduling controls are unlikely. During the fuel supply shortfall of 1974, however, Congressional committees considered emergency energy legislation giving the CAB authority to dictate reductions or changes in air carrier operations. This authority was advocated by CAB Chairman, Robert Timm, and very few airlines raised heated objections.** The proposal was taken under advisement at a time when the carriers, unprepared for the reduced fuel allocations, were making unilateral cutbacks in scheduled service, waiting to see what changes other carriers made, and then repairing errors. However, this scheduling chaos was largely brought about by insufficient lead time for multilateral development of schedule cutbacks. In the future, this chaotic situation and its resulting impact on the public convenience and necessity can be averted through contingency planning and coordination, according to existing law, through the CAB. As a result, it is unlikely that Congress will act in favor of emergency authority for the CAB to take over direct control of airline scheduling, which remains the prime prerogative of airline management.

Replace large aircraft with smaller aircraft. This strategy yields energy savings from both equipment changes and increased load factors. The restraints on implementation, both voluntary and mandatory, are essentially the same as those discussed under the strategy for small aircraft replacement on connecting routes (see next section). In summary, implementation is unlikely under both normal and crisis conditions.

## Effect Shifts to Less Energy-Intensive Modes

A surcharge on airplane tickets was the only air travel penalty considered. Two types of surcharges, fixed and declining, were evaluated in Task 5. The declining surcharge resulted in an energy savings benefit about 8 percent greater than the fixed surcharge. It also cost about $2 less per unit of energy saved. The final advantage of the declining, as compared with the fixed, surcharge involves the interaction of the short-haul and long-haul travel markets. Specifically, a fixed $8.00 increase in the cost of short-haul tickets results in a fare increase of about 15 percent for trips of 500 miles. In contrast, trips of 501 miles, which

*49 USC 1371(e)(4).

**"Outlook for 1974." Aviation Week and Space Technology. (Editorial) January 7, 1974, p. 7.

would be in the long-haul market, would not be subject to any fare increase. This discontinuity is eliminated by the declining surcharge, under which fare increases disappear entirely at 500 miles.

The major restraint on implementing a surcharge on air tickets under normal conditions is legislative or political. As is well known, the issue of deregulation currently dominates ligislative consideration of the airline industry. One of the prime motivations for this interest is the prospect for, and widespread consumer support of, lower airline fares. Compounding the strategy opposition which would emanate from those seeking lower air fares is the danger of penalizing air travel during a period of financial reorganization of the industry. While the issue of penalizing one mode to the advantage of another mode is politically sensitive under any circumstances, the imminence of airline deregulation and the uncertainty of its impact on the short-term viability of the industry strongly indicates the unlikelihood of gaining legistative approval of an air fare surcharge under normal energy supply conditions.

In a severe energy supply shortfall, however, Congressional priorities may be expected to refocus. The relative magnitude of the energy savings achieved by an air far surcharge may offer a seemingly compelling reason for Congress to act in favor of the strategy. Such action would nevertheless be restrained by the identification in current law of the promotion of air travel as a goal of aviation policy and the FEA Five Year Conservation program. Because of the suppression of air travel demand caused by the strategy, it would be difficult to implement despite the apparent energy savings benefits. It might be necessary, for example, to rebate part of the surcharge to the air carriers in order to prevent a deterioration of their financial position during a fuel crisis.

## Strategies Affecting Energy Use in Connecting or Access Portions of an Intercity Trip

In Task 5, three strategies were evaluated which affect energy use in connecting or access trips. These were, in decreasing order of absolute energy savings: 1) replace connecting flights with bus service; 2) replace equipment used in connecting flights with small aircraft; and 3) replace automobile use with small aircraft for accessing hub airports. The first two of these strategies are substitutes in that only one of the two could be implemented.

### Replace Connecting Flights with Bus Service

This strategy provides a considerably lower potential fuel benefit than the small-aircraft replacement alternative. The substitution of bus service for connecting air service also results in a travel time penalty for passengers and no compensating fare inducement. These results, particularly when coupled with the administrative requirements of coordinating two modes, offer no compelling reason for the federal government to adopt a policy of mandatory replacement, under either normal or crisis conditions. In addition, the outlook is not good for voluntary initiation of the bus replacement strategy.

From the bus industry's point of view there are two restraints on the provision of connecting service. First, considerable expansion of route authority would have to be obtained from the ICC.* While this does not appear to be a major restraint, it is likely to slow down the process of bus replacement. It is also likely to limit widespread adoption of the strategy. From 1960 to 1970, for example, the percentage of applications denied by the ICC for regular-route, charter, and special service operating authority ranged from 36 to 44 percent.**

The second restraint on voluntary provision of connecting service is largely economic. Initiation of a new service is both risky and expensive, as discussed under Bus Strategies. Since the bus cannot compete with the airlines in terms of travel time or fare on these connecting routes, bus companies may require some assurance of airline cooperation. Intermodal agreements would in turn necessitate regulatory approval.

From the airlines point of view, withdrawal from connecting routes would be advantageous on only those routes operating unprofitably and not providing an important link in the airline's network. Even in these instances, the CAB and communities affected would have to agree that bus service is an adequate replacement for the previously authorized air service. Such agreement is not considered likely over the short term.

Airline deregulation may, however, provide an impetus to increase air-bus coordination over the long term. For example, communities which do not wish to share in a federal subsidy program to maintain underutilized air service may be prime candidates for promotion of airport limousine service. Limousine service appears to be sufficiently lucrative that government subsidies would not be required. It has, moreover, enjoyed a high level of acceptance at the local level. The only policy action required would be for the ICC to grant new operating rights for the service. In recent years, the ICC has been quite permissive regarding the granting of certificates of public convenience and necessity for limousine services.***

Replace Equipment Used in Connecting Flights with Small Aircraft

Three policy alternatives for stimulating the replacement of aircraft were considered: 1) mandatory adoption; 2) voluntary adoption; and 3) deregulation of

*Currently intercity bus companies provide service to 31 airports from 72 different cities and towns. [Lawrence Leist, Increasing the Attractiveness of Land Based Common Carrier Transportation in the United States. Transportation Systems Center, U.S. Department of Transportation. October, 1975. (Based on Russell's Official National Motor Coach Guide. July, 1975.)]

**Elizabeth A. Pinkston. The Intercity Bus Transportation Industry. Unpublished thesis. Yale University 1975, p. 50.

***Elizabeth Pinkston. The Intercity Bus Transportation Industry. 1975.

entry and exit. A policy of mandatory adoption of replacement aircraft, such as through federal legislation, would under normal energy supply conditions be restrained by the growing momentum in Congress and the Executive toward less regulation of the airline industry.* The strength of the private-market advocates, particularly when coupled with protests from the airline industry (as described below) indicates that mandatory adoption under normal circumstances is highly unlikely over the short term.**

In an energy supply crisis there are two major operational and economic restraints which indicate that mandatory adoption would be unlikely. First, because airlines optimize equipment use on a system-wide basis, the flight requirements for aircraft positioning may substantially reduce or offset the energy savings from the small-aircraft replacement. For example, large aircraft often serve a low-density route because the large aircraft is needed at the destination city. In such a case, prohibition of the use of the large aircraft would probably result in the flight of both the large craft (empty) and the small craft (with passengers) to the destination city.

The second major restraint in use of this small-aircraft replacement strategy as a contingency plan relates to the availability of the smaller craft. Large-scale replacement, even assuming some form of federal financing, may not be possible within one year. Currently, for example, Beech has dropped production on the Beech 99 airliner until a sizable block of orders develops. While it is possible that some 99s could now be sold, priority has been given to a backlog of corporate and military orders for the King Air.*** Overall, it appears that a sudden surge in demand for smaller aircraft could not be accommodated without start-up time lags, likely to exceed one year.

Voluntary adoption of the small-aircraft replacement strategy is restrained by two primarily economic factors. First, the Airline Pilots Association's formula for determining salaries is biased toward compensation on the basis of large plane use. As a result, flight crew costs, which typically represent about 25 percent of

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*Eleanor Sugrue, Deputy Assistant Secretary of Policy Program Development, U.S. Department of Transportation. November 29, 1976 and Alexander Morton, Civil Aeronautics Board. November 30, 1976.

**It is true that the federal government has mandated airline reequipment (or retrofit) under the Noise Control Act. This action, however, does not parallel the small-aircraft replacement considered here because of the long-standing authority for noise control. It is worth noting, however, that the replacement equipment under the Noise Control Act is considerably more fuel efficient than most of the aircraft currently in use.

***"Turbine Business Aircraft Boom Due." Aviation Week and Space Technology. September 13, 1976, p. 24.

the total operating costs of local service airlines, would not decrease in proportion to reductions in operating costs upon adoption of smaller planes.* The significance of this phenomenon is illustrated in an announcement by Frontier Airlines that it would not acquire small air taxi-type planes because of the prohibitive pilot pay scale.

The second major restraint on voluntary adoption involves the ability of the airlines to attract capital for equipment replacement. After extravagant spending on jumbo jets which nearly bankrupted the industry in the early 1970's, the airlines now find that they must replace aging 707's, DC-8's and some early 727's, which together represent about one-third of the industry's fleet.** The Air Transport Association has estimated that this major capital investment program will require about $5 billion through the rest of the 1970's and another $60 billion in the 1980's.*** The poor financial record of the industry in recent years, however, has resulted in the unwillingness of some traditional sources of external capital to invest in or lend to the airlines.**** In addition, uncertainty over the outcome of the deregulation controversy has increased the reluctance of banks and insurance companies to advance new credit to the industry. Consequently, the industry is already hard-pressed to meet its capital needs, exclusive of any additional small-aircraft replacement costs.

Several recent forthcoming federal actions may provide some aid to the airlines in this capital squeeze. Under the Tax Reform Act of 1976, the airlines are allowed to use 100 percent of their investment tax credit in each of the next two years instead of the normal 50 percent. It should be noted, however, that this provision of the tax bill only narrowly passed the Senate.***** Other federal aid, for retrofit or reequipment under the Noise Control Act, is expected during 1977.****** The proposal receiving the greatest attention, and supported by the Air Transport Association, involves allocation of 2 percent of the 8 percent ticket tax to a special fund for airline financing.

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*G. C. Eads. The Local Service Airline Experiment. (1972), p. 31.

**"Time to Fasten Seat Belts?" Forbes. October 15, 1976, p. 40.

***Air Transport Association of America. The Sixty Billion Dollar Question. September, 1976.

****Standard and Poor's Corporation. "Air Transport Current Analysis," Standard and Poor's Industry Surveys. September 16, 1976, p. A.57.

*****Phil Bakes, Senate Subcommittee on Administrative Practice and Procedure, November 30, 1976 (Passed by a margin of 3 votes.)

******Capital requirements for reequipment (which is favored by the industry as more economical over the long term) are estimated at $6 billion. Retrofit of aircraft to bring them into compliance with noise standards would cost about $300 or $400 million. Retrofit is favored by bankers and consumer groups. ("Tax to Finance Aircraft Noise Cutback Urged." Washington Post. December 2, 1976, pp. 3.11 and E.13.)

In addition to these actions, the Department of Transportation is currently considering an extension of the federal loan guarantee program for local service airlines. On the surface, this program appears to have the greatest potential for affecting voluntary adoption of the small-aircraft replacement strategy since one of its primary purposes has been to secure credit for the purchase of smaller aircraft.* Use of the program, however, has been negligible over the last 10 years. Moreover, there is no indication at this time that extension of the program, in light of other restraints, will stimulate voluntary adoption of the strategy.

The final policy alternative considered under this strategy involves the numerous proposals for airline regulatory reform which have been before Congress in Recent years. One of the key areas of controversy in these proposals involves the deregulation of entry and exit. Proponents of deregulation, including the Department of Transportation, claim that open entry and exit will bring about nationalization of the carriers' route systems, thereby enabling better matching of equipment to market demand.** This would, in a limited manner, achieve the objectives of the small-aircraft replacement strategy.

The issue of deregulating entry and exit, however, does not hinge simply on projections of route rationalization. Proponents of deregulation view the current regulatory system as promoting service rather than price competition. It is argued that service rivalry increases the level of airline fixed costs and, in turn, the volatility of earnings in response to changes in the demand for air travel.*** With freer entry and exit and flexible pricing, proponents contend that air fares will be lower, the industry more efficient, and the airlines, after some potential short-term dislocations, more prosperous under their own control.

In contrast, opponents of deregulation characterize airline operations within the current regulatory environment as intensely price-competitive, citing the speed with which any price reductions are met by competitors.**** Industry spokesmen also maintain that if they provided cheaper flights, with fewer frills, "our aggressive competitors would be filling in the schedule gaps we would be vacating . . ." Opponents, while generally unopposed to more flexible pricing, predict that freer entry and exit would result in abandonment of service on unprofitable routes

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*Peyton Wynns, Office of Regulatory Policy, Department of Transportation. November 29, 1976.

**Eleanor Sugrue, Deputy Assistant Secretary for Policy Program Development, U.S. Department of Transportation. November 29, 1976.

***John W. Barnum, Deputy Secretary, U.S. Department of Transportation. As reported in Aviation Week and Space T chnology "Deregulation Termed Financing Threat." August 16, 1976, p. 35.

****Edward E. Carlson, United Air Lines Chairman. As reported in Journal of Commerce. "Airline Chiefs Criticize Proposed Aviation Act." April 14, 1976, p. 2.

(currently cross-subsidized by profitable long-haul routes) and massive overcapacity within the industry.*

The financial community has also opposed freer entry. Lenders are already reluctant to advance new capital to the airlines. They believe that the industry is too undercapitalized to obtain more debt financing in a nonregulated environment.** As a result, a spokesman for the financial community has estimated that the five-year transition period envisioned under the Administration's legislative proposal would provide insufficient time for the industry to effect the major financial restructuring required by deregulation.*** The financially weaker carriers would probably face bankruptcy or merger, thereby compounding the already strong apprehensions of the financial community.

In responding to these assertions of financial disaster, the proponents of deregulation contend that the current regulatory system exacerbates the industry's financial instability.**** The experience of intrastate carriers in the Texas and California intrastate markets indicates that profit levels under a system of increased rate flexibility and free entry would be similar to or greater than present levels due to reduced service and capacity competition (higher load factors and reduced unit costs), and dramatic increases in passenger volumes from competitive fare reductions. Even proponents of deregulation, however, predict some short-term dislocations as inefficient carriers face bankruptcy and are replaced by new entrants.

Other sources of opposition to deregulation of the airline industry include airline employee labor unions who fear loss of jobs and are concerned about the difficulties of organizing labor groups in a fragmented industry. Airport operators have indicated concern over their ability to raise money from revenue bonds under deregulation.***** In addition, the issue of service to small communities under deregulation has been the source of considerable controversy.

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*Dr. George James, Chief Economist, Air Transport Association of America. December 2, 1976.

**In the past, lenders have accepted the high leverage inherent in most airlines capital structures (an average debt-to-equity ratio of 2.5 in 1975) because this risk is more than offset by the reduced risk resulting from regulation. ("Deregulation Termed Financing Threat" in Aviation Week and Space Technology. August 16, 1976, p. 35.)

***Frederick W. Bradley, Jr., Vice President of Citibank, in airline industry seminar sponsored by the Financial Analysts Federation. As reported in "Deregulation Termed Financing Threat" in Aviation Week and Space Technology. August 16, 1976, p. 35.

****John W. Barnum, Deputy Secretary, U.S. Department of Transportation. As reported in Aviation Week and Space Technology. "Deregulation Termed Financing Threat," August 16, 1976, p. 35.

*****"Deregulation Scares an Industry." Business Week. October 25, 1976, p. 110.

Under the current regulatory system, airlines are required to maintain service on unprofitable routes as long as the communities affected maintain a minimum number of enplanements. In a deregulated environment, the airlines assert that unprofitable points would be abandoned, leaving many small communities without service. The Administration's proposal for deregulation, however, provides a guarantee of continued air service to every small community now receiving air service. This guarantee is qualified only by the provision that a town continually unable to enplane as many as five passengers a day would eventually have to share half the costs of the federal subsidy program.

The foregoing discussion has only briefly touched on some of the major issues in the controversy over airline deregulation. It is expected that Congress will, within the next year, be acting on one of the existing or a new proposal for greater freedom of entry and rate flexibility in the industry. Moreover, it is estimated that within two years, and very possibly during 1977, the transition toward unregulated competition will begin.* Once the transition starts, the length of time before a competitive equilibrium is reached, and a rationalized route system emerges, can only be hypothesized. The process, which is highly dependent on the content of the legislation passed, may take from 5 to 20 years.

Replace Automobiles by Small Aircraft for Accessing Hub Airports

Over the short term, promotion of commuter air service to access hub airports is primarily dependent upon the existence of airfields in those communities not served by scheduled airlines and the interest of potential or existing carriers in providing that service. In communities which have airfields, the failure of commuter airlines to provide service to hub airpots indicates that such service is not commercially viable and/or that the seed money required to get the service started is not available. This experience suggests the need for government subsidy in order to stimulate implementation of the strategy.

Both the CAB and the DOT have recently published reports scrutinizing the issues involved in subsidizing air service to small communities.** Both reports recognize that the local service carriers, despite subsidization, are not providing appropriate service to small communities. This unsatisfactory experience with the existing subsidy program severely restrains the potential for instituting additional subsidies

*Phil Bakes, Senate Subcommittee on Administrative Practice and Procedure, November 30, 1976; Eleanor Sugrue, Assistant Deputy, Secretary of Policy Program Development. U.S. Department of Transportation. November 29, 1976; Alexander Morton, Civil Aeronautics Board, November 30, 1976.

**Civil Aeronautics Board. Staff Task Report on Service to Small Communities. May, 1976 and Department of Transportation. Air Service to Small Communities. May, 1976.

in order to promote commuter air service in accessing hub airports. The following comment by the DOT illustrates the tone of opposition to such a proposal:*

> While one might justify a fixed-term subsidy to provide a period of adjustment for those communities that have become dependent on existing air service, even if unecomonic, it is inappropriate to foster such dependency at additional communities.

In view of the limited energy savings potential associated with this strategy, the likelihood of overcoming objections to subsidization of additional air service is negligible.

*Comments of the United States Department of Transportation before the Civil Aeronautics Board. Air Service to Small Communities. Docket 29278. July 19, 1976.

# APPENDIX IV

## BENEFIT/COST ANALYSIS

As noted in the main text, the benefit/cost analysis was based on a technique developed by UTRC and described in Ref. 67. The analysis involves the use of the following parameters:

- Short haul, intercity travel demand ($10^9$ pass-miles/yr)
- Total user cost (\$$10^9$/yr)
- Total user time ($10^9$ hr/yr)
- Required subsides (\$$10^9$/yr)
- Number of fatalities
- Total energy ($10^{12}$ Btu/yr)
- Total emissions ($10^3$ wtd. tons/yr)

Quantitative values for these parameters are presented in Table XLII of the main text.

Depending on the point of view, any of these parameters may be stated as a benefit or a cost. For example, energy use is a cost incurred in transporting people, but energy savings achieved by modal shifts are a benefit. The policy adopted here in identifying parameters as either benefits or costs is based on the following simple definition: All parameters are stated in a form which is always numerically positive. Those for which an increase over the baseline value is beneficial (independent of all other effects) are treated as benefits and those for which an increase over the baseline value is detrimental are treated as costs. This definition avoids the most pervasive computational problem in benefit/cost analyses, namely, the occurrence of "negative" costs and benefits. It has the effect of defining more costs than benefits, but this feature is not a drawback in the UTRC method.

Using the definition, only demand for travel is viewed as a benefit, the rationale being that the purpose of a transportation system is to fulfill the public's need for mobility. System changes which induce travel are therefore beneficial in that they enable more people to fulfill their travel needs. Since "costs" are associated with each induced trip, the ultimate desirability of a strategy which stimulates travel must be judged on the basis of a ratio of benefits to costs. The remaining parameters listed above comprise the cost to the system since, by the definition, an increase in any one of them, relative to the baseline, is undesirable. A summary of pertinent parameters used in the benefit/cost study is provided in Table XLII of the main text for all combination strategies and for the baseline case.

The essence of the UTRC Benefit/Cost Analysis method is to nondimensionalize each parameter with respect to the baseline value and form individual benefit/cost ratios from these normalized values. These ratios are combined into a benefit/cost rating; ratings greater than 1.0 indicate strategies superior to the baseline. A provision is also made for weighting the costs* relative to one another to account for perceived differences in importance.

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*Benefit weightings may also be used. However, in this case, such weightings are unnecessary because there is only one benefit.

However, since it is often difficult to obtain a consensus as to what these weighting factors should be, the calculations have been made for two cases: 1) using weighting factors derived in an earlier UTRC study, and 2) using unity weighting factors. The values used in the first case are:

| Parameter | Weighting Factor |
|---|---|
| Total User Cost | 0.094 |
| Total User Time | 0.232 |
| Required Subsidies | 0.018 |
| Fatalities | 0.312 |
| Total Energy | 0.247 |
| Total Emissions | 0.097 |

These weighting factors were derived by considering the numerical value of each parameter in the transportation context compared to its national value. Thus, the fatalities weighting factor is the ratio of transportation fatalities (all modes) to accidental fatalities of all types, and the total energy weighting factor is the ratio of transportation energy use of petroleum fuels to national petroleum energy expenditures in all sectors.* Although these definitions are derived on a logical basis, the results are not likely to be accepted universally.** Therefore, it was decided that the unity weighting factor case should also be included as a basis for unbiased comparison.

As indicated above, fatalities is the cost with the highest weighting, reflecting the high percentage of accidental deaths which occur in automobile travel. Even though there has been a gradual downward trend in the auto death rate, and a particularly steep decline in 1974 due to the imposition of a national 55-mph speed limit, the overwhelming majority of transportation fatalities occur on the highway. A comparison of death rates for the different modes of travel is given below for 1973 and 1980, the latter figures having been extrapolated from five-year moving averages over the period 1950-1974.

| | Death Rate ($fatalities/10^8$ pass-mi) | | |
|---|---|---|---|
| Mode | 1973 | 1980 | |
| Auto | 1.97 | 1.45 | 55 mph |
| | | 1.34 | 50 mph |
| Bus | 0.13 | 0.12 | |
| Rail | 0.14 | 0.14 | |
| Air*** | 0.22 | 0.20 | |

Note that the effect of a further reduction in the auto speed limit to 50 mph in 1980 has been projected. This reduction is based on an analysis of the decrease in the auto death rate between 1973, when the average national speed limit was 65 mph, to

* The use of petroleum rather than total energy is in recognition that petroleum is the fuel almost exclusively used in transportation and is primarily the fuel in short supply.

** The use of a survery (Delphi) technique to derive weighting factors was tried by UTRC in earlier studies. The results were highly scattered and differences, when averaged, tended to wash out.

***Available statistics do not differentiate T/LS from Commuter Air.

1974, when it was lowered to 55 mph. This analysis indicated that a decrease of 1.5 percent in the auto death rate can be expected for each 1-mph reduction of the auto speed limit. In Table A-IV each strategy which features the 50-mph auto speed limit benefits from the slightly lower death rate indicated in the above projections.

A factor which was not considered in the analysis was the increased fleet cost to the airlines in the substitution strategies, a factor which would tend to decrease the benefit/cost rating for such strategies. Similarly, the analysis did not consider the ownership cost of auto owners who take a public mode rather than their own automobiles because of one of the auto penalty measures. A similar result would have been found.

The results of the benefit/cost calculation are presented in Table A-IV and are depicted in bar chart form in Figs. A-2 and A-3 for the calculated and unity weighting factor cases, respectively. The first notable result is that benefit/cost ratings are always improved when a 70% air load factor is imposed. This result derives entirely from energy and emissions considerations because, as can be seen in Table XLII, these are the only parameters which change between the baseline load factor and 70% load factor cases. The improvement is not only universal, but it is also of about the same amount for all strategies.

In Fig. A-4, the baseline load factor results have been repeated to illustrate the changes which occur when different weighting factor assumptions are made. It can be seen that when calculated weighting factors are used, many strategies rate better than the baseline case (1.00), but that use of unity weighting factors produces a degradation in all cases. This trend is a consequence of the high weight given to energy in the first case. Since the strategies were devised with the objective of reducing energy use, the high energy weighting tends to lead to generally favorable results, whereas equal emphasis on user cost, user time, and subsidy costs offset the energy improvements and produces a low benefit/cost ratio compared to the baseline case.

Another significant change is the considerable shift in the relative standings of the strategies between the two cases. For example, Strategy C ranks 11th with calculated weighting factors and first with unity weighting factors. Furthermore, Strategy 3 goes from 10th to 4th, Strategy 9 goes from 12th to 5th, Strategy 6 goes form 7th to 12th, and Strategy 12 goes from 9th to 14th.

On the basis of energy savings alone it was shown earlier that the strategies which include an air surcharge, Strategies 7-12, are superior to comparable Strategies 1-6 without the surcharge. The reason was an overall reduction in demand combined with a diversion from air to less energy-intensive modes However, the benefit/cost ratings reverse this trend. Regardless of which weighting factor assumption is made, Strategies 7-12 are generally poorer than the corresponding Strategies 1-6. Whereas the strategies without the surcharge are superior in demand, user time, fatalities and emissions, the surcharge strategies are superior only in

TABLE A-IV

BENEFIT/COST RATINGS

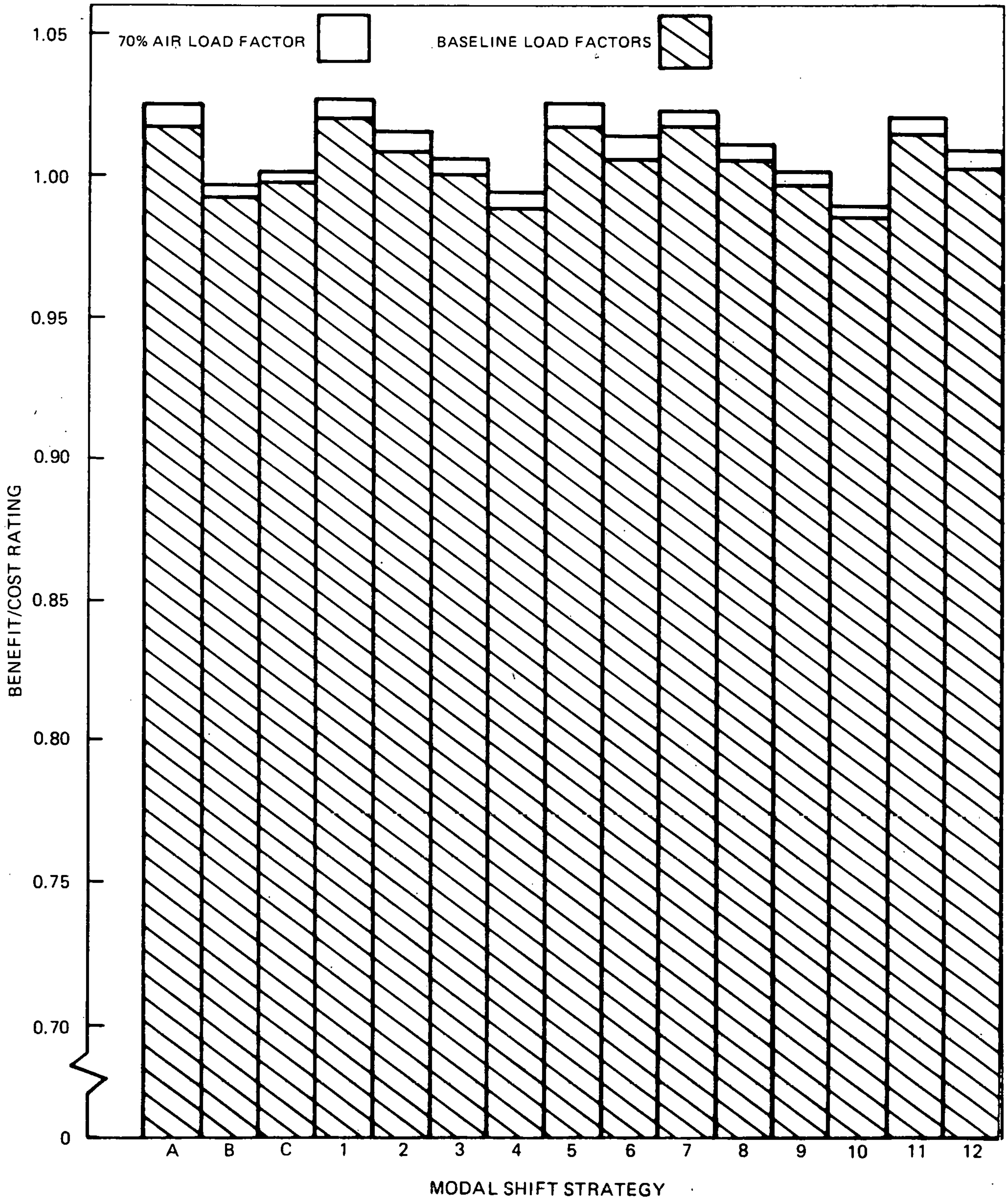
| | Baseline Air Load Factor | | 70% Air Load Factor | |
|---|---|---|---|---|
| Strategy | Calculated Wgt. | Unity Wgt. | Calculated Wgt. | Unity Wgt. |
| A | 1.0172 | 0.9666 | 1.0251 | 0.9722 |
| B | 0.9915 | 0.8319 | 0.9967 | 0.8352 |
| C | 0.9966 | 0.9959 | 1.0007 | 0.9989 |
| 1 | 1.0204 | 0.9932 | 1.0271 | 0.9981 |
| 2 | 1.0084 | 0.8320 | 1.0150 | 0.8360 |
| 3 | 0.9998 | 0.9741 | 1.0063 | 0.9788 |
| 4 | 0.9881 | 0.7900 | 0.9943 | 0.7937 |
| 5 | 1.0172 | 0.9666 | 1.0251 | 0.9722 |
| 6 | 1.0054 | 0.7936 | 1.0131 | 0.7981 |
| 7 | 1.0170 | 0.9890 | 1.0221 | 0.9927 |
| 8 | 1.0052 | 0.8250 | 1.0101 | 0.8280 |
| 9 | 0.9963 | 0.9697 | 1.0012 | 0.9731 |
| 10 | 0.9847 | 0.7829 | 0.9894 | 0.7856 |
| 11 | 1.0136 | 0.9620 | 1.0197 | 0.9662 |
| 12 | 1.0020 | 0.7861 | 1.0078 | 0.7895 |
| Baseline | 1.0000 | 1.0000 | 1.0054 | 1.0040 |

FIG. A–2

**BENEFIT/COST RATINGS**

CALCULATED WEIGHTING FACTORS

BASELINE = 1.00

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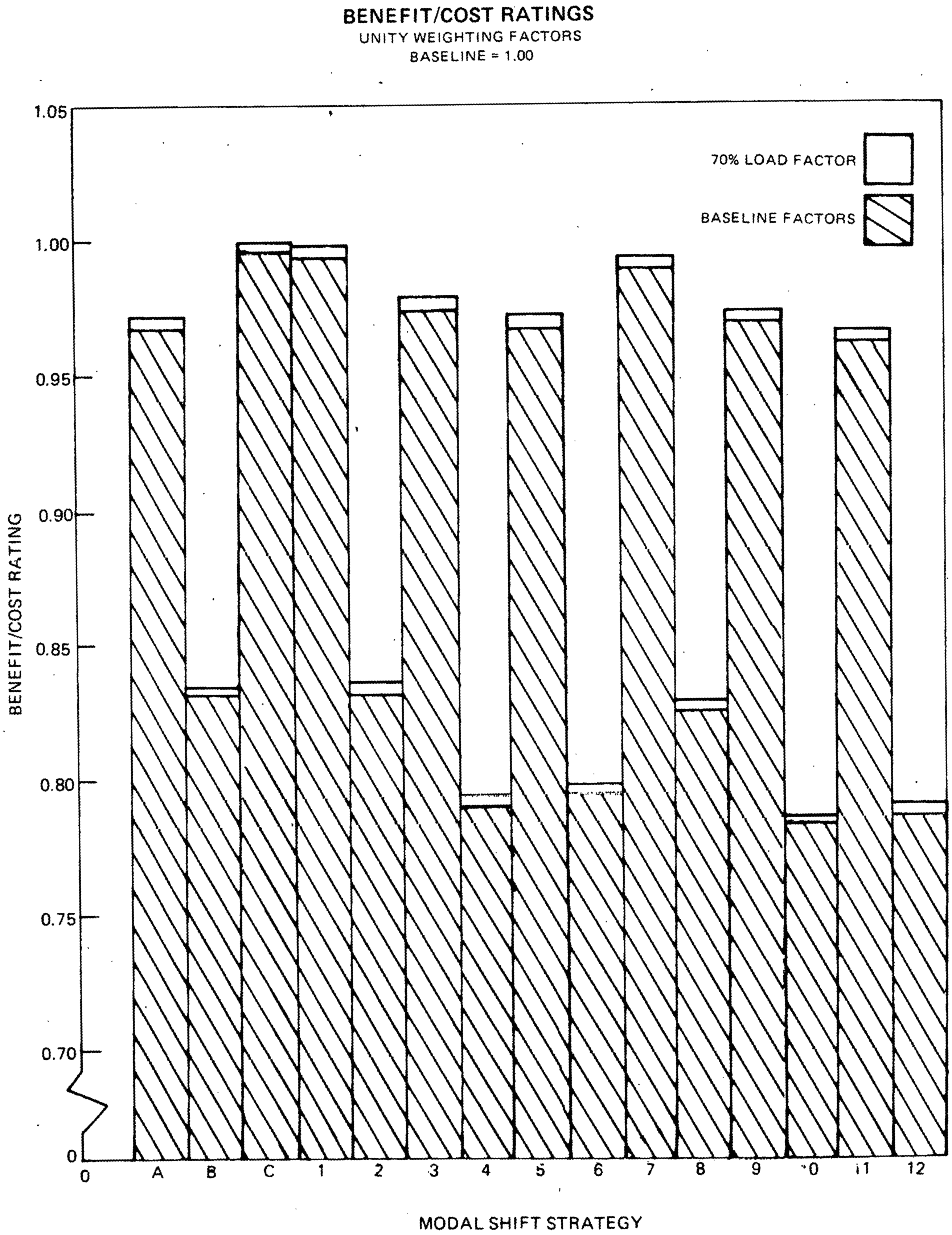
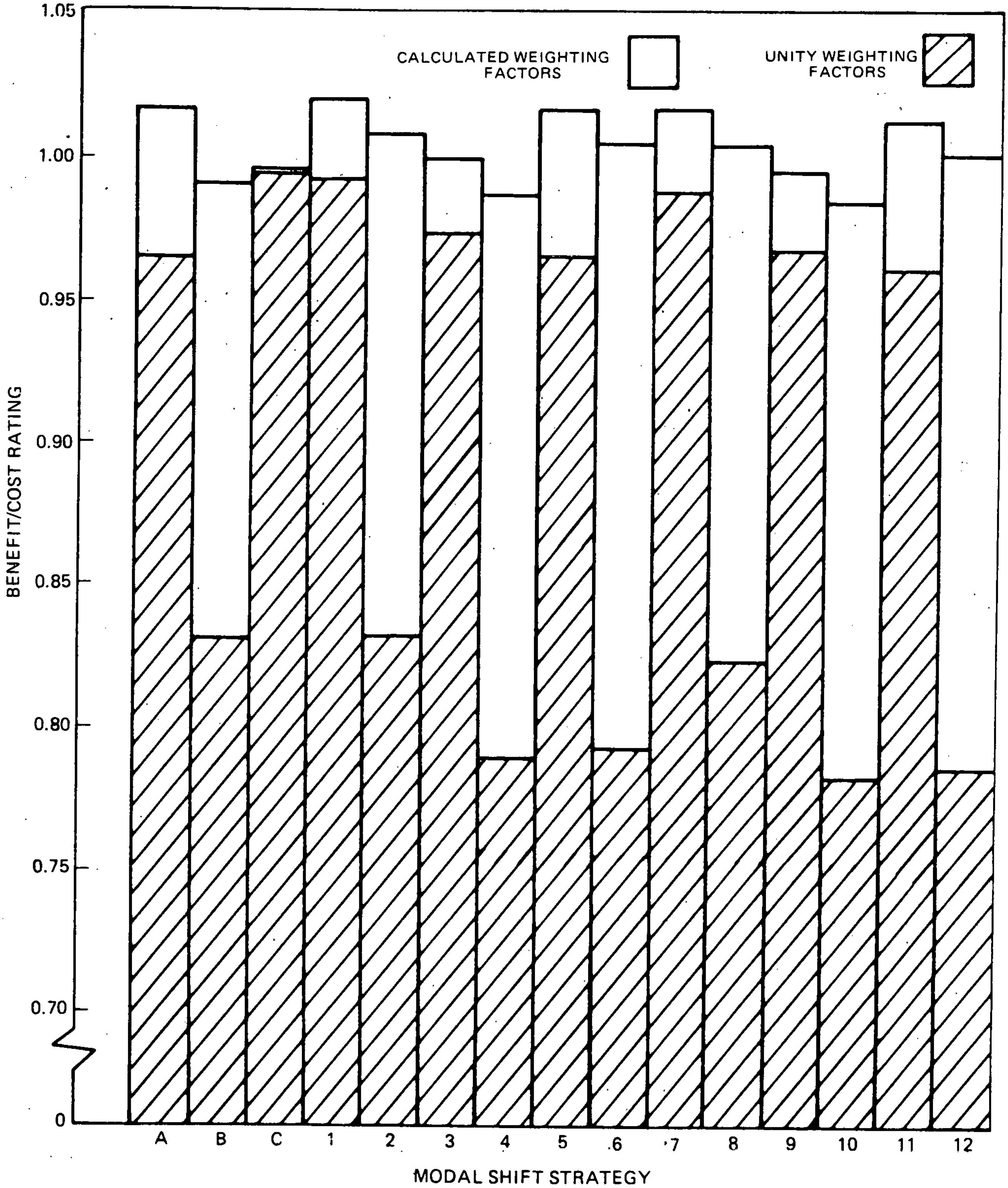

BENEFIT/COST RATINGS
UNITY WEIGHTING FACTORS
BASELINE = 1.00
70% LOAD FACTOR
BASELINE FACTORS
BENEFIT/COST RATING
1.05
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0
0
A
B
C
1
2
3
4
5
6
7
8
9
10
11
12
MODAL SHIFT STRATEGY
77–01–165–2

## BENEFIT/COST RATINGS
BASELINE LOAD FACTORS




77–01–165–3

user cost and energy. Therefore, the nonsurcharge strategies are generally better in a benefit/cost sense, although the margin is smaller with calculated weighting factors because of the importance of the energy advantage in that case.

Another noticeable trend in Fig. A-4 is the relatively poor standing of strategies featuring a bus fare reduction (Strategies B, 2, 4, 6, 8, 10, 12). In each case, the large subsidy required to achieve this fare reduction is a significant detriment, although the low weight given to the subsidy cost mitigates the effect with calculated weighting factors. Finally, the lower death rate with a 50-mph auto speed limit makes Strategies A, 1, 2, 5, 6, 7, 8, 11 and 12 relatively more attractive than the strategies with the standard 55-mph speed limit, particularly with calculated weighting factors, because fatalities are assigned the highest weighting in that case.

The benefit/cost comparisons of modal shift strategies do not reveal any obvious choices as to which strategies are clearly best or clearly poorest. Rather, the benefit/cost ratings tend to cluster about the baseline value. The only significant deviations from this trend are the poor results for bus improvement strategies (B, 2, 4, 6, 8, 10, 12) when unity weighting factors were used. However, these results are due solely to the large bus subsidy relative to the 1980 baseline value.* Overall, the benefit/cost ratings must be judged rather inconclusive as far as choosing superior strategies is concerned.

In the sense that they contrast greatly with the strategy comparisons in Fig. 22 of the main text, which are based on energy savings alone, the benefit/cost results do provide a useful perspective. They suggest that the energy savings achieved by the best strategies in Fig. A-4 tend to be neutralized by other considerations. It appears then, that the desirability of effecting modal shifts for the purpose of saving energy must be judged on the basis of the magnitude of the savings achieved relative to those that might be achieved in other energy-consuming sectors, together with the degree of difficulty associated with implementation of these modal shift measures.

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* The baseline subsidy represents projections of current AMTRAK and local service airline subsidies.

*U.S. GOVERNMENT PRINTING OFFICE : 1980 0-311-119/708