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## Comparalive Assessmenl of lis Public Benailils

Prepared By
Civil Aviation Advisory Group

A Publication of AEROSPACE RESEARCH CENTER Allen H. Skaggs, Director

The mission of the Aerospace Research Center is to engage in research, analyses and advanced studies designed to bring perspective to the issues, problems and policies which affect the industry and, due to its broad involvement in our society, affect the nation itself. The objectives of the Center's studies are to improve understanding of complex subject matter, to contribute to the search for more effective governmentindustry relationships and to expand knowledge of aerospace capabilities that contribute to the social, technological and economic well being of the nation.

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The energy crisis and concern for our natural environment have focused national attention on all types of transportation. Everyone, we believe, recognizes that each mode provides unique contributions to the nation's transportation needs and that the nation's transportation system should be developed on an integrated multimodal basis. There appears to exist, however, a growing concern within government organizations, academia, and even the aviation community itself over the future role and direction of the United States commercial aviation industry. This paper contributes to the resolution of that concern by describing the salient advantages of commercial aviation in the context of national passenger transportation objectives. Commercial aviation's major contributions to the nation are described through comparisons of aviation to other intercity passenger modes in their use of resources, impact on the environment, trip time, trip cost and safety.

## Criteria For Assessing Modal Benefits

The unique characteristics of U.S. commercial aviation need to be set in the context of overall national transportation system objectives. Secretary of Transportation Coleman's Statement of National Transportation Policy (September 17, 1975) contains several clear views of this nation's transportation objectives and policy principles. Secretary Coleman's statement set forth national objectives by maintaining that we need a healthy and responsive transportation system:
"To sustain and enhance our economic vitality and growth, the productivity of our commerce and the quality of our leisure, [and] to improve the economic and social well-being of all Americans."
Concerning the environment, the Statement of National Transportation Policy also says:
"The transportation sector should contribute substantially to an improved quality of life by ... protecting our air and water from pollution, reducing excessive noise . . . [and] promoting the most efficient use of scarce, finite, and costly energy supplies."
These criteria provide an objective basis for comparing commercial aviation to other intercity modes.

## What If Commercial Aviation Vanished?

An additional means of assessing aviation's contribution is to consider what would happen if this nation's commercial aviation system simply vanished. While such an approach may be somewhat unorthodox, it does focus attention on the fact that commercial aviation has become an integral and necessary part of our way of life. Were commercial aviation to vanish, the efficiency of our commercial and governmental sectors would reduce substantially as businessmen and government officials were forced to spend more of their time unproductively in transit via the much slower ground modes. Overnight bank clearing and fast mail service would likewise be gone, further degrading the efficiency of our commercial sector. Businesses that have utilized rapid travel by airplanes to centralize or de-centralize would have to reorganize and restructure their operations. The output of the nation's laboratories, research facilities, libraries and educational centers would be delayed in ground transit rather than being rapidly provided to the consumer. Visits to friends and relatives would be restricted in terms of distance, time or frequency. Most of our vacation would be spent riding in an auto, bus or train to our destination rather than relaxing on the beach in Hawaii, or at Disneyland or at other distant points. Without commercial aviation, economic growth would slow, economic vitality would be sapped, productivity of government and commerce would be diminished, and the quality of our leisure time would fall.

## Airline Profitability Is Vanishing

Although our air transportation system seems unlikely to vanish, airline profits are indeed vanishing, and privately owned commercial aviation, as we know it, may well be in danger. In 1975, partially as a result of increased fuel costs and the 1974-1975 recession, the major U.S. airlines reported losses totaling about $\$ 100$ million. While 1975 may have been an exceptionally bad year for profits, the fact remains that the airlines have historically experienced low profit levels. For example, in 1974 the trunk airlines had their best year since 1967, with profits (after taxes and interest expenses) of about $\$ 324$ million. That
profit, however, yielded a return on revenues of only 3.3 percent, certainly not high in comparison with other industries. The bus carriers by comparison earned 6.5 percent on sales in 1974, whereas Amtrak failed to meet operating expenses.

Commercial aviation's contributions to the nation and its preeminence in the marketplace have historically rested on its ability to take advantage of technology advances. These advances have provided safe, quieter and more fuel efficient airplanes, as well as faster airplanes to reduce travel time, and larger, more productive airplanes to reduce travel costs. U.S. airlines need sufficient earnings to generate and attract capital for purchasing aircraft incorporating these technology advances. And U.S. commercial aircraft and engine manufacturers need the broad market base to support continued development of design improvements. Hence, U.S. airlines' earnings are key to continued air travel improvements and continued worldwide leadership in commercial aircraft. Are the benefits of U.S. commercial aviation worth enough to justify the cost-whatever that might be-of restoring airlines to an acceptable level of long-term economic stability? Total benefits are impossible to quantify; however, some insight may be gained through comparing aviation to the other modes.

## Commercial Aviation As An "Ideal" Mode: A Summary

The "ideal" mode of transportation has been characterized as being instantaneous, free and safe. Today's concern with our environment and scarce, costly fuel would add to the "ideal" that the mode should use no energy, cause no pollution and make no noise. As summarized below, and described in a subsequent section of this paper, commercial aviation comes closest to this ideal.

Energy: Airplanes do indeed require fuel but the energy efficiency of commercial jet transports and of automobiles is comparable to most intercity passenger trains. The allocation of energy resources should be based on this modal comparability, and should recognize that the aviation sector is indeed promoting the efficient use of scarce, finite and costly energy supplies.

Environment: Airplane emissions are either lower than or comparable to those of all other intercity modes. While noise comparisons of these modes cannot be quantified with available data, both airplane operators and manufacturers are striving to reduce both the level and impact of airplane noise. As a result, aviation noise will be lower in the future.

Total Trip Time: By air, total trip time door-todoor is less than by any other intercity mode at distances of more than 250 miles. Time savings by air travel increases business efficiency as well as the quality of our leisure. Additional time savings may come from the more frequent airline departures (at major cities which account for most intercity travel) as compared to the other common carrier modes. Frequent departures enable the traveler to leave when he wants.

Total Trip Costs: Total trip costs are lower by air than by any other mode for the individual traveler who values his time. If the individual places no value on his time, trip costs by air are comparable to coach class trains. Total trip costs by air are also lower than by any other mode for a family of four who value their time. Even if the
family places no value on their time, air travel trip costs are lower than by train-and comparable to bus-at roughly equivalent levels of trip comfort.

Safety: Commercial airlines are the safest mode of intercity travel and their safety record continues to improve.

## Is U.S. Commercial Aviation Worth Saving?

Air transportation of the U.S. is, in fact, a key and critical element of our national transportation system. When commercial aviation is considered in terms of national objectives or in terms of comparison to an "ideal," air transportation stands out. Yet while the debate continues on the future role and direction of the commercial aviation industry, the airlines' very existence in the private sector is being threatened by their lack of earnings. And the future of the U.S. aircraft and engine manufacturing industry is a direct function of the U.S. airlines' financial health.

Weighing the benefits of commercial aviation against the costs of achieving airline financial stability, by whatever method, will justify the costs.

## INTRODUCTION

Transportation has been one of the most important factors shaping the economic and demographic patterns of the world. Transportation impacts living standards and life styles; where people live and work; it affects foreign policy and trade relationships and how we communicate with and view other nations and other cultures. Yet, perhaps in absence of complete understanding of the benefits and impact of our national transportation system, efforts are being made to radically alter its structure, in particular the aviation sector. The objective of the following modal comparisons is to promote understanding of the unique characteristics of each passenger transportation mode and to discuss the salient benefits of commercial aviation.

Among the commercial aviation industry's many significant benefits are its contributions to the nation's trade balance from the export of U.S. manufactured commercial airplanes and engines, contributions to national defense through airline participation in the Civil Reserve Air Fleet (CRAF) and technology transfers from airlines and manufacturers to the military and space sectors. This paper, however, deliberately focuses on the key issues that would characterize an "ideal" intercity passenger transportation mode. Such an "ideal" transportation mode would use no fuel, cause no pollution, make no noise, and would be instantaneous, free and safe. Subsequent sections will describe how commercial aviation compares to other intercity passenger modes in fulfilling this ideal.

## A PERSPECTIVE ON INTERCITY TRAVEL

Each intercity passenger mode is an integral part of our multi-mode transportation system. The following provides a perspective of each mode's role and a context for the modal comparisons.

Among the common carriers, commercial aviation has experienced such tremendous growth that today air accounts for four times as many passenger miles as buses and trains combined. Moreover, air transportation is still growing, as shown in Figure 1, while bus travel appears to have reached a plateau (in terms of passenger miles) and passenger train travel has generally been on the decline since World War II. In terms of passenger trips, air dominates common carrier travel at distances beyond 200 miles (one-way) as shown in Figure 2, while buses account for the majority of common carrier traffic at shorter distances. Commercial aviation's tremendous growth and preeminence in common carrier intercity travel reflects the response of that collective non-biased arbiter of the benefits associated with each mode-the marketplace.

Although not shown in the figures, continuing popularity of the private automobile is evidenced by the fact that it provides well over six times as many intercity passenger miles as the common carrier modes combined. In terms of passenger trips, the private auto dominates at all ranges up to about 1,000 miles, while the common carriers, particularly air, dominate at longer distànces.


## MODAL COMPARISONS

The "ideal" mode of transportation, previously characterized, would use no fuel, cause no pollution or noise, and would be instantaneous, free and safe. While modern jet transports do use fuel, an in-depth analysis of current transportation equipment revealed that the energy efficiencies of airplanes and intercity automobiles are comparable to most passenger trains-and that the energy efficiency of intercity buses surpasses all other modes. These conclusions, shown in Figure 3, are the result of:

- Analyzing the fuel consumption of specific airplanes, automobiles, buses and trains operating on a representative sample of ten city pair routes under the actual operating conditions that existed in the spring of 1974.
- Combining these data with the circuity con-
ditions that exist in a larger sample of 94 city pair routes.

The analysis credited all three common carriers with a 60 percent load factor, and the private auto load factor was dependent on range. That is, empirical data indicate that average auto occupancy increases as travel distance increases. While the common carrier load factor was chosen to provide a uniform comparison base, the assumption in fact provides some relative advantage to intercity buses and probably trains. During the past decade domestic trunk and regional air carrier load factors have averaged about 53 percent, while Class I intercity buses have averaged only about 47 percent. Although load factors for just intercity traffic are not available, the total passenger train load factors-including commut-ers-have averaged between 34 percent and 36 percent over the past decade. Thus, the available

Figure 2
PERCENT OF TRIPS BY COMMON CARRIER VS. ROUND TRIP DISTANCE - 1972


[^0]evidence suggests that commercial aviation's relative energy efficiency may be even better than shown in Figure 3. Also, contrary to what might be expected from the publicity surrounding the pressures on the airlines to raise their load factors, the airlines have been the best of all common carriers in the utilization of their capacity.


The circuity factors were developed by determining the ratio of the actual route distance of all modes to the great circle distance between each of 94 city pairs that have air, bus and passenger rail service. These circuity factors were applied as calculated except for selected passenger trains. That is, on several passenger train routes the
actual rail distance between several city pairs is many times greater than the intercity great circle distance. Since it is probable that few passengers travel between city pair end points on trains whose actual travel distance is more than 2.4 times the great circle distance, train routes with such a high circuity were excluded from the analysis. This action caused the lower band of train fuel utilization to be flat, as shown in the figure.

## Environmental Impact

While an "ideal" mode of transportation would cause no emissions or noise pollution, some impact on our environment is the inevitable price of moving machinery. Today's airplanes emissions are, however, comparable to or lower than those of other intercity modes, and although modal noise comparisons cannot be quantified with available data, both manufacturers and operators are making substantial strides in reducing both the level and impact of airplane noise.

Figure 4 presents the results of an analysis of emissions into pollution sensitive areas-that is, areas where the air quality standards are now being exceeded. The analysis determined each mode's generation of nitrogen oxides $\left(\mathrm{NO}_{\mathrm{x}}\right)$, hydrocarbons (HC) and carbon monoxide (CO) when operating in the pollution sensitive areas that exist along their route between a sample of five city pairs. These emissions are expressed in terms of pounds of pollutant per passenger carried by the mode. As shown in Figure 4, airplane emissions into pollution sensitive areas are lower per passenger than those of diesel-electric trains and equal to those of autos, buses, and trains using centrally-generated power.

The Environmental Protection Agency has determined that airplane emissions enter pollution sensitive areas only during the time the plane is below the atmospheric mixing level at the origin and destination airports. Since local atmospheric mixing heights are usually lower than 3,000 feet, airplane emissions affect the populace only during a relatively short period of time during takeoff, landing, and ground operation. Autos, buses and diesel-electric trains, on the other hand, emit pollutants continuously into all pollution sensitive (and non-sensitive) areas that lie along their

Figure 4
EMISSION RATES
For Air, Auto, Bus, and Train
For Five City Pairs
(Pounds of Emission per Passenger)




routes. Because the central electric powerplants for Metroliner-type trains are usually located in major metropolitan areas, their emissions continuously impact pollution sensitive areas.

Statistics derived from a separate study, the Nationwide Emissions Report for the U.S. (as of March 12, 1975), show that commercial aircraft account for about 5 percent of all intercity passenger transportation emissions, while land passenger vehicles are responsible for the remaining 95 percent. Thus, commercial aircraft cause a very small part of the total emissions from
intercity passenger travel-and their impact on pollution sensitive areas is lower than or comparable to other intercity passenger modes.

## Total Trip Time

The vast majority of travelers want to reach their destination as rapidly as possible. If an instantaneous form of transportation were available (that was also inexpensive and safe), it would certainly be the predominant travel mode. Although science fiction's instantaneous travel is not yet available, commercial aviation provides

the next best alternative. As shown in Figure 5, total trip time, including the time required in transit to and from the terminal and to purchase tickets and collect baggage, is less by air than by all other modes for travel between cities which are at least 250 miles apart. This time advantage becomes greater as intercity distances increase. For example, air travel saves more than 20 hours for the passenger traveling between cities 1,000 miles apart, and coast-to-coast air travel requires only one-tenth the time by bus or train, or one-twenty-fifth the time by an auto driven eight
hours per day at speeds no greater than the legal limit.

The trip time advantages of air travel accrue to business and vacation travelers alike, as shown graphically in Figures 6 and 7. A typical vacationer, for example, can combine five days "vacation time" with two weekends and travel by air anywhere in the U.S.-and most places in the world for that matter-and still spend a full week at his destination. Were travel by a surface mode, a similar vacation would be limited to a radius of about 750 miles. Similarly, on a one-day business

Figure 6
MAXIMUM RANGE FOR NINE-DAY VACATION TRIP (7 DAYS AT LOCATION, 2 DAYS TRAVEL)

trip, a person could, for example, leave the east coast, travel to the mid-west, spend four productive business hours at the destination and return, assuming the existence of convenient air schedules. The businessman traveling by any surface mode would be limited to about a $200-\mathrm{mile}$ operating radius during a comparable 12 -hour working day.

Air travel's time advantage results from two major factors. The first factor, which is included in the previous figures, is the not-too-startling
fact that airplanes travel faster than autos, buses or trains. The second factor, though not included in the figures, is the existence of more daily airplane departures from major cities-which account for most traffic-than passenger train or bus departures. (Automobiles, of course, provide the ultimate in departure availability, which in part explains their popularity.) Such frequent airline service, as shown in the table, combined with the high speeds of modern jet transports, means that a traveler can increase his business efficiency

Figure 7

## MAXIMUM RANGE FOR ONE-DAY TRIP (12 HOUR DAY WITH FOUR HOURS SPENT AT DESTINATION) No Circuity



Table
INTERCITY TRANSPORT
TYPICAL DAILY FREQUENCIES OF ALTERNATIVE MODES

| City Pairs | Rail |  | Bus | Scheduled Air Carrier |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  | Trips Each Way | Average Stops | Trips Each Way | Trips Each Way | Nonstop Trips |
| New York-Washington | 13/11 | 5/6 | 34 | 76 | 71 |
| New York-Boston | 9 | 7 | 27 | 52 | 48 |
| New York-Chicago | 2 | 11/15 | 10 | 80 | 51 |
| New York-Miami | 2 | 23/29 | 14 | 46 | 30 |
| New York-Los Angeles | 1 | 32 | 10 | 51 | 14 |
| Los Angeles-San Francisco | 2 | 7/9 | 22 | 105 | 95 |
| Chicago-San Francisco | 1 | 33 | 6 | 33 | 17 |
| Chicago-Denver | 1 | 15 | 9 | 24 | 19 |
| Chicago-Minneapolis | 2 | 9 | 9 | 42 | 26 |

Sources: Amtrak All-America Schedules, February 15, 1976; Official Airline Guide, March 1976; Russell's Official Bus Guide, March 1976.
NOTE: Rail: New York-Washington notes 13 Metroliner trips with average of five stops; 11 other trains with six stops.
New York-Chicago notes new service through Cleveland.
New York-Miami notes 23 stops on "through" train, 29 stops on "local."
Los Angeles-San Francisco notes bus connection to Oakland on coastal trip; bus connection to Oakland and Bakersfield on San Joaquin trip.
Chicago-San Francisco notes bus connection to Oakland.
Bus: includes Greyhound and National Trailways only.
Air: includes most flights; multi-stop direct flights and less convenient connecting flights omitted.
or improve the quality of his leisure time by departing when he wants or needs to on the fastest mode of intercity travel.

Frequently available airplane departures have been provided while maintaining reasonably high load factors. Indeed, during the past decade trunk and regional air carrier load factors have averaged 53 percent, while Class I intercity bus load factors averaged 47 percent. Data are not available on solely intercity traffic, but total passenger train load factors, including commuters, averaged between 34 percent and 36 percent during the past decade.

## Total Trip Cost

Though fundamental laws of economics may preclude "free rides," the intercity traveler comes closer to a free ride on commercial airplanes than on other common carrier modes or even the private auto. As shown in Figure 8, when total
trip costs include meals, lodging, ticket price, a nominal value of time, and the cost of getting to and from common carrier terminals, air travel is the most cost effective for the individual traveler at all distances beyond about 100 miles. Figure 9 reflects similar intercity total trip costs, but for an individual traveler who places no value on his time. Under this condition, costs of air and coach class train travel are comparable for the individual traveler-though both modes are somewhat more costly than bus travel.

Figure 10 reflects the total trip costs for a family of four who value their time, and shows that, at equivalent comfort levels appropriate for family travel beyond about 450 miles, air travel is the least expensive common carrier mode. Figure 11 reflects the total trip costs for a family of four who do not place a value on their time. It shows that at equivalent comfort levels, air, bus and first class train travel costs are comparable at distances up

Figure 8 TOTAL TRIP COST For Single Traveler Between Selected City Pairs (Time Valued at $\$ 6.50$ Per Hour)

to about 1,200 miles but that air travel costs are lower than the other common carrier modes at longer ranges.

The four figures present the results of comparisons among transportation modes under realistic operating conditions between the same 12 city pairs analyzed in the previous section on trip time. The results are based on the published taxi or limousine fares between city centers and the common carrier terminals, average meal costs when traveling by surface vehicles, average lodging costs when traveling by bus or auto, the cost of operating an automobile, and published common carrier fares. A value of time of $\$ 6.50$ per hour (maximum $\$ 52.00$ per day) is commensurate with the national average family income.

The cost savings of air travel help sustain the
nation's economic growth and enhance the travelers' quality of life. These cost savings in part result from the past growth in air fares being less than the growth in bus and train fares and the growth in the consumer price index. That is, between 1967 and 1973 (the last year for which comparable data are available), the cost of air travel increased in absolute terms by 16 percent, but compared to other prices (as measured by the consumer price index), decreased a real 15 percent. Rail ticket prices on the same basis increased a real 24 percent and the price of a bus ticket rose a real 2 percent. Since 1973, however, all carriers have been beset with higher fuel prices, low or no growth in demand and continued escalation in labor costs. Moreover, the airlines, in particular, have been able to add little
new equipment to improve their productivity, a major factor in their past ability to cut the real cost of transportation. Continuation of this trend may necessitate future growth in air fares more commensurate with increases in consumer prices. This should not, however, substantially alter air travel's economic advantage relative to other modes.

## Safety

Despite the risks the active American faces in the pursuit of "leisure" on the ski slopes, tennis courts and hunting or boating, we expect and de-
serve safe means of travel. And commercial aviation provides the safest means of intercity passenger travel.

As shown in Figure 12, scheduled air transportation averaged only one fatality per billion passenger miles during the past five years as compared to a fatality rate of two for bus or rail and 18 for auto. And in the 23 -year period since 1951, air has bettered its safety record by a factor of 16. On the other hand, the automobile, while showing improvement (particularly in 1974 because of the 55 mile per hour limit), retains its least favorable safety record.

Figure 9 TOTAL TRIP COST Individual Traveler Between Selected City Pairs (No Value Placed on Time)


INTERCITY DISTANCE (GREAT CIRCLE - STATUTE MILES)
Source: American Automobile Association, U.S.A. Map; AMTRAK, National Schedules; Reuben H. Donnelley Co., Official Airline Guide, North American Edition; Russell's Guide, Inc., Russell's Official National Motor Coach Guide; U.S. Department of Transportation, Cost of Operating an Automobile.

Figure 10
TOTAL TRIP COST For Family of Four
Between Selected City Pairs
(Time Valued at \$6.50 Per Hour)


## CONCLUSION

Questions concerning regulatory reform, fuel allocation and pricing, noise abatement, airplane export policies, international aviation policy, and airport and airway development are now being addressed by Congress, the Executive Branch, academia and the aviation sector. Answers to these questions will significantly influence the future structure and growth of commercial aviation. Those answers should be based on a clear
recognition that the commercial aviation industry is essential to the economic vitality and growth of the U.S. economy, contributes substantially to an improved quality of life, and is necessary to the continued productivity of government and business.

This report has focused on only a few of the primary advantages of commercial aviation, but in so doing has demonstrated that commercial aviation is essential to the satisfaction of our national transportation objectives. In fact, air
comes closer to being the "ideal" than any other intercity passenger transportation mode. The time and cost savings of commercial aviation do not benefit just the individual traveler, but lead to increased efficiency and economic advantage of benefit to the entire nation. Without aviation, the businessman, government official and pleasure traveler alike would have to devote more time to "travel" at the expense of more productive ends.

Travelers who value their time would incur greater expense traveling by other common carrier modes, and even those who place no value on their time would not find significant savings by other public modes. And air pollution due to transportation could well increase-as could total fuel use-if the many individual air passengers selected the private automobile as their alternative to air travel.

Figure 11
TOTAL TRIP COST
Family of Four Between Selected City Pairs
(No Value Placed on Time)


Source: American Automobile Association, U.S.A. Map; AMTRAK, National Schedules; Reuben H. Donnelley Co., Official Airline Guide, North American Edition; Russell's Guide, Inc., Russell's Official National Motor Coach Guide; U.S. Department of Transportation, Cost of Operating an Automobile.

The contributions of the commercial aviation industry clearly indicate the direction that should be pursued in our ongoing dialogue on aviation's future role and growth. Threats to the airlines' existence in the private sector should be rebuffed by a return to financial health. Further improvements in air travel through advances in technol-
ogy and continued worldwide leadership in commercial aviation should be encouraged through improved airline earnings. Now is the time to decide that the benefits of U.S. aviation are well worth the cost-whatever that might be-of restoring the airlines to an acceptable level of longterm economic stability.

Figure 12
TRANSPORTATION SAFETY PASSENGER FATALITIES PER BILLION PASSENGER-MILES (5-Year Moving Average)


Source: National Transportation Safety Board, Transportation Association of America, Association of American Railroads, National Safety Council, National Association of Motor Bus Owners.


[^0]:    Source: 1972 Census of Transportation - National Travel Survey, U.S. Department of Commerce.

