General Disclaimer

One or more of the Following Statements may affect this Document

- This document has been reproduced from the best copy furnished by the organizational source. It is being released in the interest of making available as much information as possible.

- This document may contain data, which exceeds the sheet parameters. It was furnished in this condition by the organizational source and is the best copy available.

- This document may contain tone-on-tone or color graphs, charts and/or pictures, which have been reproduced in black and white.

- This document is paginated as submitted by the original source.

- Portions of this document are not fully legible due to the historical nature of some of the material. However, it is the best reproduction available from the original submission.

CR-152035

SUMMERFIELD ASSOCIATES
201 Ocean Ave./Santa Monica, Ca. 90402/(213) 451-1922

A STUDY OF COMMUTER AIRLINE ECONOMICS

DECEMBER, 1976

(NASA-CR-152035) A STUDY OF COMMUTER AIRLINE ECONOMICS Final Report (Summerfield Associates) 24 p HC A02/MF A01 CSCL 05C

N77-29114

Unclas
G3/03 43288

Prepared under Purchase Order A-29917-B(DG)

for

Research Aircraft Projects Office
Ames Research Center
National Aeronautics and Space Administration
Moffett Field, California 94035

PREFACE

This study of Commuter Airline Operating Economics was conducted under the NASA Ames Research Center Contract A-29917-B(DG). This final report presents the results of the work accomplished by Summerfield Associates during the study program. This study is the first known undertaking to define the variables and develop cost relationships that describe the direct and indirect operating costs of commuter airlines.

The principal investigator for the study was Dr. John R. Summerfield. The study was administered by the Research Aircraft Projects Office, NASA Ames Research Center, Moffett Field, California. Joseph L. Anderson was the Technical Monitor. Mr. Anderson's counsel and assistance are acknowledged with thanks.

Data for the study were made available by the following commuter airlines:

Air Wisconsin
Command Airways
Golden West Airlines
Henson Aviation
Metro Airlines
Pilgrim Aviation and Airlines
Pocono Airlines
Ransome Airlines
Rio Airways
Suburban Airlines

Data are proprietary and hence are not included in this report.

TABLE OF CONTENTS

INTRODUCTION

Methods for estimating direct and indirect operating costs of commercial transport aircraft have been developed and refined over the past 35 years. The principal purpose of such cost models has been to enable airframe manufacturers and trunk and local service airlines to compare operating costs of two or more proposed new aircraft. These cost models have been developed from published data that trunk and local service air carriers are required to submit to the Civil Aeronautics Board (CAB). Hence these models are primarily applicable to and most useful for trunk and local service airlines.

In the past few years several studies have been conducted to develop estimates of operating costs of commuter airlines. In 1970, for example, Waldo and Edwards undertook such a study for the Federal Aviation Administration (FAA) (Reference 1). That study provided operating cost estimates for individual commuter-type aircraft (e.g., Beech-99). Estimates were developed from data on the cost of local service carrier operation of small aircraft.

A 1972 staff study of the Bureau of Operating Rights of the CAB (Reference 2) examined actual costs of a number of commuter airlines and it was concluded that the Waldo and Edwards estimates were substantially higher than those costs reported by any of the commuter carriers included in the CAB study. The CAB study showed that direct operating costs for Twin Otter aircraft as operated by certificated local service carriers were approximately 50% higher than direct operating costs of the same aircraft type as operated by commuter carriers.

In 1974 and 1975, The Aerospace Corporation conducted a series of studies of potential commuter operations in the Northwest. As a part of these studies, the Aerospace Corporation developed some cost estimates for individual commuter type aircraft in hypothetical commuter airline systems operating in the areas they studied. With the help of commuter airlines and manufacturers of commuter-type aircraft, Aerospace Corporation developed operating cost estimates for each of several aircraft types: Piper Aztec and Navajo, Britten Norman Islander, Cessna 402B, Beech 99, Swearingen Metro and deHavilland DHC-6 aircraft. Since the primary purpose of the Aerospace studies was to suggest and develop feasible commuter networks for current generation aircraft, no attempt was made to develop operating cost relationships in a parametric form so that they could be applied to new aircraft designs.

None of these studies referred to above could provide information on the effects of new aircraft or aircraft technology. The cost estimating relationships that were developed are not appropriate for NASA's purpose. A recent study undertaken by the Douglas Aircraft Company for the NASA-Ames Research Center (Reference 4) developed cost estimating relationships for short haul aircraft utilized in local service carrier operation. These relationships are useful in evaluating new aircraft technology in that they relate costs to characteristics not only of the local service system but of the performance and technology of new aircraft. A similar type of operating cost model is desirable for the NASA's technology development for commuter aircraft. Because of the vast known differences in complexity of operation between local service carriers and commuter airlines, it was questionable that the relationships developed by the Douglas study were appropriate for the commuter airlines. Sample calculations attempting to apply the Douglas formulas to commuter airline data showed gross differences from actual commuter airline operating costs.

It is, therefore, the purpose of the present study to develop a set of cost estimating relationships that will enable NASA to estimate operating costs for new aircraft or new aircraft technology when applied to the commuter airline industry. The operating cost model was designed for evaluative studies as performed by the NASA in systems studies. The structural format and content of the model is sensitive to this usage of the model. With proper judgment and selection of input variables, however, it is capable of providing economic insight into other commuter airline system evaluations. Although the model might be used, if carefully applied, for airline efficiency analysis, it was not designed for, nor is it recommended for, such use.

THE COMMUTER AIRLINE INDUSTRY

Commuter airlines are defined as "those operators which perform, pursuant to published schedules, at least five round trips per week between two or more points or carry mail." (Reference 5) The CAB also sets the maximum size of aircraft that can be used by commuter airlines at 30 seats or a 7,500-pound payload. The size of commuter aircraft is further restricted to eliminate any aircraft with maximum zero-fuel-weight greater than 35,000 pounds. This weight limit is specifically designed to exclude such aircraft as the Convair 240, 340 and 440, Martin 202 and 404, and the Hawker Siddeley 748. The CAB has granted several exemptions that permit some commuters to operate larger aircraft in particular markets. For example, Marco Island Airways is authorized to fly 44-seat Martin 404s between Miami and Marco Island.

In its report of commuter airline operations for 1975 (Reference 6), the Civil Aeronautics Board identified 235 commuter air carriers serving in the United States that filed what the CAB called "useable" reports for all or a portion of 1975. Of these 235 commuter airlines, 82 operated for less than the full year, thus leaving only 153 that reported statistics for all four quarters of the calendar year.

A substantial portion of the traffic carried by commuter airlines connects to trunk or local service airlines at hub airports for travel to or from more distant points. Much of the traffic, however, travels only between points served by the commuter airlines. In some markets the commuters may compete directly with local service or trunk carriers. But for a large number of markets a principal competition is the private automobile, bus or train since distances are relatively short. One characteristics of the operation of a commuter airline is frequent service with small aircraft in well-travelled markets.

None of the commuter airlines is large by trunk or local service airline standards. The largest passenger commuter carrier within the Continental United States, for example, has only about 200 employees and serves its market with 10 small aircraft. Many of these larger commuter airlines utilize modern computer-based reservation systems, a service offered on a contract basis by one of the trunk airlines.

Approximately 55% of the passengers traveling on commuter airlines in 1975 traveled distances of less than 100 miles. Approximately 78% of the markets served by commuter airlines carried fewer than 10 passengers per day.

Commuter airlines are not subsidized by the Federal Government. Thus their reporting requirements to the Civil Aeronautics Board and the Federal Aviation Administration are minimal and include only some traffic data but no operating cost data. Since no uniform reporting of accounts is specified for the industry, each airline has its own accounting system. Some of the larger commuter airlines, however, do utilize charts and forms of accounts similar to those specified by the Civil Aeronautics Board for the certificated carriers.

COST MODEL DEVELOPMENT

Approach

Since commuter airlines are not required to report cost information to any regulatory agency, no operating cost data for this industry, exist in the public record. It was, therefore, necessary to convince the management of each selected commuter airline that it would be to their advantage and to the advantage of the industry to furnish cost data and operating statistics for the study. In order to assure full cooperation, it was necessary to promise each airline management that any proprietary data furnished by them would be held in strict confidence. Therefore, this report does not include any tabulated data nor has such data been made available to the NASA or to any person or organization outside of the Summerfield Associates organization.

The sample of commuter airlines for which data would be sought was selected from the largest 50 commuter airlines, ranked by number of passengers carried in 1975. Commuter airlines that were wholly or principally air freight and mail carriers were excluded from the study because of the dominance of a single carrier - Federal Air Express. From this list 20 airlines for which data would be sought carried primarily passenger traffic on fleets of aircraft composed wholly or principally of turbo-prop aircraft such as the deHavilland Twin Otter, the Nord 262, the Beech 99 or the Swearingen Metroliner. Of the 20 airlines that were approached, 10 agreed to and did furnish data. In 1975 these 10 airlines carried 25% of the total airline passengers and flew 23% of the revenue passenger miles.

Each of the airlines that indicated a willingness to cooperate in the study was personally visited. Top managements of each organization were briefed on the purposes of the study and the results that were expected in order to elicit cooperation. A copy of the form for reporting data (see Appendix I) was furnished to each airline so that data from each airline would be uniform and consistent in form. Since the data sample was expected to be fairly small, each airline was asked to furnish three years of data, together with their estimates of the effects of inflation. The three years were 1973, 1974, and 1975.

Since each commuter airline records much of the data differently from the form required for the analysis, it was necessary for each airline to spend time analyzing, aggregating or disaggregating data from their records. As was indicated, all of these airlines are quite small and lack staffs to do this special reporting. As a result, airlines that had stated that they would furnish data within a week often took as long as two months to provide complete data. Some even found it necessary to withdraw from the study because of lack of manpower.

When data were received, it was discovered, as suspected, that data from different airlines were collected in different ways and in ways that were sometimes inconsistent with each other. Only limited data were available in the detail that would have been required to develop equations like those in the short haul aircraft study conducted by Douglas and referred to earlier. Especially acute were the difficulties in separating various categories of data for the indirect operationg costs. In addition, several of the airlines did not have available the operating statistics that would have been required to fully analyze the cost data that were furnished. Details will be discussed more fully later in the report.

Cost Estimating Relationships

The initial plan for developing cost estimating relationships for the commuter airline industry was to have these relationships parallel as closely as possible the variables and characteristics of the cost estimating relationships that had been developed earlier for the NASA in the short haul aircraft economic study conducted by Douglas. Thus an initial attempt was made to fit the Douglas equations to the data of the commuter airlines and to see how well they approximated commuter operating costs. As was suspected, the cost estimating relationships developed for the local service carriers over-estimated the cost of commuter airlines substantially. For example, flight crew costs per block hour, as estimated by the Douglas equations, ranged from 1.6 to 2.8 times actual flight crew costs per block hour for 1973 operation of the airlines in our sample. Thus it was necessary to develop new cost relationships for the commuter airlines.

The relationships that were developed and are presented in this report do not reproduce costs of any single carrier but rather are representative of those commuter airlines, as a group, for which data were available. Because data furnished for this study were considered by the airlines to be proprietary, none of the data can be made available in this report.

Direct Operating Costs - The analysis of direct operating costs follows the general format specified by the Civil Aeronautics Board for cost reporting of certificated carriers. Direct operating costs consist of flight operations (flight crew expense, fuel,expense, and hull insurance), maintenance and maintenance burden, and depreciation.

Flight Crew Expense (FCE) - The short-haul aircraft study (Reference 4) derived the following flight crew operating expense relationships.

$$FCE = \left[27.97 + 33.53 \begin{pmatrix} \text{FLIGHT} \\ \text{CREW} \\ \text{FACTORS} \end{pmatrix} + 0.18 \left(\frac{\text{TOGW}}{10^3} + \begin{matrix} \text{DESIGN} \\ \text{CRUISE} \\ \text{SPEED} \end{matrix} \right) \right] \begin{pmatrix} \text{ANNUAL} \\ \text{BLOCK} \\ \text{HOURS PER} \\ \text{AIRCRAFT} \end{pmatrix} \begin{pmatrix} \text{FLEET} \\ \text{SIZE} \end{pmatrix} 10$$

As was indicated, when this formula was applied to the operations of each of the airlines in the commuter sample it was found that these costs per block hour were overestimated by 60 to 180%. In keeping with the desire to maintain the same category of relationship as that developed in the Douglas study, we attempted to develop commuter operating cost relationships of the same general characteristic as those Douglas had developed for local service operations. The resulting relationships produced such low coefficients of determination (on the order of .01 or less) that it was necessary to try a variety of other relationships.

The use of takeoff gross weight and cruise speed in the formula for local service carriers was appropriate because of clauses in union contracts that include these two items as elements in the pay of flight crew members. Most commuter airlines, however, have no such arrangements in pilot contracts since most of the commuter airlines are non-unionized. Those that are do not tie flight pay to cruise speed, gross takeoff weight, or to both.

A further difference between commuter airlines and local service carriers relates to the size differences of the airplanes used. Although cruise speeds are similar (though somewhat slower for the commuter airlines), takeoff gross weights are so much lower for commuter aircraft that, when takeoff gross weight (in thousands of pounds) is added to cruise speed, the effect of takeoff gross weight becomes a negligible factor. That is, cruise speeds of 150 to 300 (miles per hour) far outweigh takeoff gross weights of 10.4 to 23.4 (thousand pounds) when the two are added together. As a variant, therefore, we tried fitting a curve like the Douglas curve using takeoff gross weight in thousands of pounds plus 1/10th of the cruise speed in order that both elements would be fairly represented in the formula. Coefficients of determination for equations fitted in this fashion were also very low. Other correlations were examined and the relationships that closely fitted the data were those that related flight crew expenses per annum with the number of available seat miles flown by the airline during the year.

As was indicated earlier, data were collected for the 3 years of 1973, 1974 and 1975, toegether with inflation factors. This tripled the sample size, but it was found that coefficients of determination were much higher when only the 1975 data were used than when the composite data inflated to 1975 cost levels were used. An explanation of this result is that the available inflation factors were insufficient to properly reflect the total effect of inflation. Each of the carriers was asked to provide estimates of the rate of change in flight crew pay, in other personnel costs, in fuel price, in hull insurance, in spare parts, and in purchased services. Most of the airlines declined to provide this information but for those airlines that did provide it, we used their factors applied to their data. For those that did not, we utilized the appropriate ATA cost index. These indexes are reproduced in Appendix II to this study.

To illustrate the difference between the cost estimating relationship developed using 1975 data only and that developed using 3-year data, the following is the equation for the flight crew expense derived from the three year data base:

$$FCE = 22,460 \left(\frac{\text{AVAILABLE SEAT MILES}}{10^6}\right)^{0.90}$$

The flight crew expense relationship based only on the 1975 data base is:

$$FCE = 21,060 \left(\frac{\text{AVAILABLE SEAT MILES}}{10^6}\right)^{0.91}$$

Note that the exponent and the initial multiplying factor are of the same order of magnitude in both equations. However, the coefficient of determination for the equation derived from 1975 data is 0.88 whereas as that derived from the 3-year data is only 0.81. This result would suggest that more research is required to develop appropriate inflationary factors to be used when applying the formulas or cost relationhips developed in this study to any future year's operations.

One important conclusion in this area of the study is that, at the present state of development of the commuter airline industry, flight crew pay is not systematically tied to the characteristics of the aircraft but more nearly to the total amount of flying that pilots do, as measured by aircraft size and amount of use of the aircraft.

It should be further noted that all of the aircraft included in this study utilize 2-man crews. It is, therefore, unnecessary to include a term for crew size.

Fuel, Oil and Taxes (FOT) - Because it was not possible to get fuel cost estimates from more than a few of the contributing airlines, it was not possible to make a separate analysis of fuel, oil and taxes in the format of the Douglas short haul study. Since all of the aircraft included in this study are turbo-prop aircraft with fuel and oil and taxes (FOT) relationships similar enough to those included in the Douglas study, use of the Douglas formula, which follows, is recommended:

$$FOT = \left[\begin{pmatrix}\text{FUEL}\\\text{CONSUMPTION}\\\text{RATE}\end{pmatrix}\begin{pmatrix}\text{FUEL}\\\text{COST}\end{pmatrix}\begin{pmatrix}1.045\end{pmatrix}\right]\begin{pmatrix}\text{ANNUAL}\\\text{BLOCK}\\\text{HOURS PER}\\\text{AIRCRAFT}\end{pmatrix}\begin{pmatrix}\text{FLEET}\\\text{SIZE}\end{pmatrix} 10^{-6}$$

Insurance (INS) - Hull insurance (INS) is computed for the commuters in the same way it would be computed for the local service carriers. That is, according to the formula developed from the Douglas study, insurance costs would be:

$$INS = \left[\begin{pmatrix}\text{AIRCRAFT}\\\text{UNIT COST}\end{pmatrix}\begin{pmatrix}\text{INSURANCE}\\\text{RATE}\end{pmatrix}\right]\begin{pmatrix}\text{FLEET}\\\text{SIZE}\end{pmatrix} 10^{-6}$$

Hull insurance rates, judging from the limited available data, are lower for commuter airlines than for local service carriers, The Aerospace Corporation reached an opposite conclusion, however. The following table summarizes insurance rates from various sources:

SOURCE	HULL INSURANCE AS % OF ASSET VALUE
Douglas Study	1.5
The Aerospace Corporation Studies	1.8
Commuter airline A	0.7
B	1.0
C	0.9

Pending a wider survey, it is recommended that a value of 1 be used in applying the above insurance formula to the commuter airline industry.

Maintenance Costs (TME) - Although several of the commuter airlines contributing cost data to this study operate fleets of more than one aircraft type, typically they did not record their maintenance costs separately by aircraft type. Furthermore, some did not report maintenance overload or burden as a separate item. Some did not segregate engine and airframe costs. Others did not separate labor and material costs. Given this disparity in cost accounting techniques among the participating commuter airlines, it was not possible to develop detailed cost estimating relationships along the lines of those developed in the short haul aircraft study. Attempts to develop total maintenance costs (TME), including burden, as a function of both departures and flight hours produced a relationship that was not valid; namely, that maintenance costs decrease as the ratio of departures to flight hours increases. Knowledge of the maintenance characteristics of aircraft and the peculiar maintenance requirements imposed by landings and takeoffs makes it clear that this would be an unrealistic relationship. Among the various relationships that were examined, the best representation of the total maintenance expense data is:

$$TME = \left[3.14\left(\frac{\text{OWNERS WEIGHT EMPTY}}{10^3}\right)^{1.21}\right]\left(\begin{array}{l}\text{ANNUAL}\\ \text{BLOCK}\\ \text{HOURS PER}\\ \text{AIRCRAFT}\end{array}\right)\left(\begin{array}{c}\text{FLEET}\\ \text{SIZE}\end{array}\right)10^{-3}$$

where

TME = Total Direct Maintenance + Total Maintenance Burden.

The above equation is the best representation of the 1975 data. When data for all three years are included a different but similar relationship was found, as follows:

$$TME = \left[2.48\left(\frac{\text{OWNERS WEIGHT EMPTY}}{10^3}\right)^{1.34}\right]\left(\begin{array}{l}\text{ANNUAL}\\ \text{BLOCK}\\ \text{HOURS PER}\\ \text{AIRCRAFT}\end{array}\right)\left(\begin{array}{c}\text{FLEET}\\ \text{SIZE}\end{array}\right)10^{-3}$$

As in the case of flight crew expense, the coefficient of determination for the TME relationship developed from the three year data base is lower than that developed from only the 1975 data base.

From the data supplied by those commuter airlines that made sufficient maintenance cost detail available, it was estimated that labor constituted approximately 50% of the total direct maintenance and maintenance burden expense of these airlines. For the latter equation, based on the three year data base, data were escalated to 1975 price levels by a labor cost index and a maintenance materials index, equally weighted. In this relationship, as in previous ones, individual airline inflation factors were used when available. In the other cases the ATA indexes were employed.

<u>Depreciation - Flight Equipment (DFE)</u> - Estimates of the annual flight equipment depreciation costs can best be made by use of the formula employed in the short haul cost model developed by Douglas. Namely,

$$DFE = \begin{pmatrix} \text{AIRCRAFT} \\ \text{UNIT} \\ \text{COST} \end{pmatrix} \begin{pmatrix} \text{AIRCRAFT} \\ \text{SPARES} \\ \text{FACTOR} \end{pmatrix} \left(1 - \begin{matrix} \text{RESIDUAL} \\ \text{VALUE} \end{matrix} \right) \begin{pmatrix} \text{FLEET} \\ \text{SIZE} \end{pmatrix} \left(10^{-6} \right) \left(\frac{1}{\text{DEPREC. PERIOD}} \right)$$

An aircraft spares factor of 12% was suggested in the Douglas study, but this is probably too high for commuter airlines because their operation is simpler and they operate from fewer bases. No data are available for actual spares factors employed by the commuter airlines, but a figure of 8% appears to be reasonable, based on the differences between local service carrier operation and commuter operation.

Depreciation accounting practices including the depreciation period and the residual value to which the aircraft are depreciated, vary from airline to airline. The following table shows depreciation periods and residual values, together with the resulting annual depreciation rate, from various sources including the Douglas Study, the CAB Standard for Two-Engine Turbo-Prop Aircraft, The Aerospace Corporation studies of commuter airlines, and the experience of several of the commuter airlines included in this study.

	SPARES FACTOR (%)	DEPRECIATION PERIOD (YR.)	RESIDUAL (%)	ANNUAL RATE(%)
Douglas Study	12	12	15	7.1
CAB (2 Engine, turbo-prop)		10	15	8.5
The Aerospace Corporation		8	20	10.0
Commuter Airline				
A		10	10	9.0
B		8	15	8.1
C		7	0	14.3

It appears that a depreciation period of 8 years and a residual value of 10% is a good representative value for purposes of the commuter airline cost model. This combination of depreciation period and residual value results in an annual depreciation rate of 11.25%.

As in the Douglas study (Reference 4), no differentiation is made in this study between depreciation of owned flight equipment and rental or lease expense of leased flight equipment.

Indirect Operating Costs (IOC) - As was stated earlier, data for indirect operating costs (IOC) are recorded in such diverse ways for each of the commuter airlines that it has proved impossible to consider individual elements of indirect operating costs. Most of the commuters did not separate aircraft servicing from traffic servicing. Many included reservations as a portion of aircraft and traffic servicing rather than as a portion of promotion and sales. However, detail was not available in the data provided to separate reservations expense and recompute data to conform to CAB classification categories. One airline, for example, purchased passenger handling service, aircraft turn-around, and reservations service from a local service carrier at one or more stations on its system. It carried on its books only the total amount for the sum of those services as billed by the local service carrier.

Most of the airlines included maintenance of ground property and equipment in direct maintenance and maintenance burden. Only those commuter aircraft with more than 19 seats have passenger service (that is, flight attendant, in-flight service and the like). Operators of the Nord 262 fell within this category.

As a result of these many major differences in accounting practices among the airlines, it was necessary to treat indirect operating cost as a total item rather than to treat separately each individual subcategory. An understanding and knowledge of the operations of the commuter airlines leads one to relate indirect operating costs to departures, to the number of passengers carried, and to the available seat miles (ASM) flown by the airline. This mix of variables takes into consideration the fact that landing fees are a function of departures, that the cost of reservations and of loading passengers is a function of the number of passengers carried, and that aircraft servicing costs are related to the amount of flying. On these bases the following relationship for indirect operating costs per departure was derived, using only the 1975 data base:

$$IOC/_{DEPARTURE} = -6.16 - 23.67\left(\begin{matrix}\text{NUMBER OF}\\ \text{PASSENGERS}\end{matrix}\right) + 1.92\left(\frac{\text{AVAILABLE SEAT MILES}}{10^6}\right)$$

The correlation coefficient was 0.98 for this relationship.

To use the three years of data the relationship of personnel costs to total indirect operating costs within the indirect operating portion of airline operations was examined. One airline reported detailed costs separated into these categories. On the basis of that information it appeared that about 40% of the total indirect operating costs were personnel costs. To escalate earlier year costs to 1975 costs, therefore, we escalated 40% of the costs by a labor cost index and 60% of the costs by a GNP deflator. For those airlines that provided estimates of labor cost escalation, their labor cost escalation factors reported were used. Using all 3-years data it was possible to derive the following equation, similar in form to that for the 1975 data but with a lower coefficient of correlation of 0.75.

$$IOC/_{DEPARTURE} = -7.83 - 39.58\left(\begin{matrix}\text{NUMBER OF}\\ \text{PASSENGERS}\end{matrix}\right) + 2.32\left(\frac{\text{AVAILABLE SEAT MILES}}{10^6}\right)$$

SUMMARY

A series of equations have been developed to describe the cost relationships of commuter airlines flying turbo-prop aircraft falling within the limitations of Civil Aeronautics Board Economic Regulations, Part 298. These equations, based on 1975 data only, are:

DIRECT OPERATING COST:

Flight Crew Expenses:

$$\text{FCE} = 21{,}060 \left(\frac{\text{AVAILABLE SEAT MILES}}{10^6}\right)^{0.91}$$

Fuel Oil and Taxes:

$$\text{FOT} = \left[\begin{pmatrix}\text{FUEL}\\ \text{CONSUMPTION}\\ \text{RATE}\end{pmatrix}\begin{pmatrix}\text{FUEL}\\ \text{COST}\end{pmatrix}\left(1.045\right)\right]\begin{pmatrix}\text{ANNUAL}\\ \text{BLOCK}\\ \text{HOURS PER}\\ \text{AIRCRAFT}\end{pmatrix}\begin{pmatrix}\text{FLEET}\\ \text{SIZE}\end{pmatrix} 10^{-6}$$

Hull Insurance:

$$\text{INS} = \left[\begin{pmatrix}\text{AIRCRAFT}\\ \text{UNIT COST}\end{pmatrix}\begin{pmatrix}\text{INSURANCE}\\ \text{RATE}\end{pmatrix}\right]\begin{pmatrix}\text{FLEET}\\ \text{SIZE}\end{pmatrix} 10^{-6}$$

Maintenance:

$$\text{TME} = \left[3.14 \left(\frac{\text{OWNERS WEIGHT EMPTY}}{10^3}\right)\right]^{1.21}\begin{pmatrix}\text{ANNUAL}\\ \text{BLOCK}\\ \text{HOURS PER}\\ \text{AIRCRAFT}\end{pmatrix}\begin{pmatrix}\text{FLEET}\\ \text{SIZE}\end{pmatrix} 10^{-3}$$

Depreciation:

$$\text{DFE} = \begin{pmatrix}\text{AIRCRAFT}\\ \text{UNIT}\\ \text{COST}\end{pmatrix}\begin{pmatrix}\text{AIRCRAFT}\\ \text{SPARES}\\ \text{FACTOR}\end{pmatrix}\left(1 - \begin{matrix}\text{RESIDUAL}\\ \text{VALUE}\end{matrix}\right)\begin{pmatrix}\text{FLEET}\\ \text{SIZE}\end{pmatrix} 10^{-6}\left(\frac{1}{\text{DEPREC. PERIOD}}\right)$$

INDIRECT OPERATING COSTS:

$$\text{IOC}/_{\text{DEPARTURE}} = -6.16 - 23.67 \begin{pmatrix}\text{NUMBER OF}\\ \text{PASSENGERS}\end{pmatrix} + 1.92 \left(\frac{\text{AVAILABLE SEAT MILES}}{10^6}\right)$$

Despite widely disparate airline accounting systems, it was possible to develop relationships with relatively good fits to 1975 data. Somewhat less satisfactory fits to the data were obtained when data for 3 years, escalated by various price indexes to 1975 price levels, were used.

Using these results to evaluate future alternative aircraft designs for the commuter airline industry, it will be important to carefully determine how to inflate 1975 costs to later years of operation. Additional research in these areas will be required to provide better inflation estimating equations than those that were available for use in this study.

At the present, some consideration is being given by the U.S. Congress and the CAB to a change in the maximum size of aircraft certificated under Part 298 from 30 to 55 passengers. Use of cost relationships from this study (based on aircraft with seating configurations in the range of 15-30 seats) for estimating costs of aircraft as large as 55 seats would stretch the cost estimating relationships further than the data and analysis warrant. Discussions with executives of the airlines that supplied data for this study however raise questions about the size of the market for much larger aircraft than those now employed. Commuter airline operators are sensitive to the experience of trunk airlines that moved from DC8-707 size aircraft to 747 aircraft, causing major reductions in frequencies or low load factors and serious financial difficulties. A jump from present size commuter aircraft to 55 passenger aircraft could present a similar problem for many commuter airlines. Therefore, in considering new commuter aircraft, it is important to undertake careful market studies before proceeding to develop aircraft of much larger size than those in current commuter use. As a necessary part of its further consideration of commuter type aircraft it is recommended that NASA undertake studies of the commuter airline market for the next decade to determine aircraft configuration, operating costs, price and market size.

REFERENCES

1. The U.S. Commuter Airline Industry - Its Current Status and Future Outlook, FAA, November 1970.

2. Service to Small Communities, Part II, Small Aircraft and Small Communities - A History and Economic Analysis, CAB, March, 1972.

3. Pacific Northwest Region Air Service Project, Final Report, February, 1975; Oregon Commuter Air Service Project, May, 1975; and Old West Region Commuter Air Service Feasibility Study, December, 1975. The Aerospace Corporation.

4. Study of Short-Haul Aircraft Operating Economics, September, 1975, Douglas Aircraft Company. NASA CR-137685 and 137686.

5. CAB Economic Regulations, Part 298 - Classification and Exemption of Air Taxi Operators.

6. Commuter Air Carrier Traffic Statistics, Year Ended December 31, 1975, CAB, Washington, D.C., May, 1976.

APPENDIX I

DATA REPORTING FORMS

AIRLINE CODE NO. ________

(One set for each Aircraft Type)

AIRCRAFT MANUFACTURER ____________________

DESIGNATION/NAME/MODEL ____________________

CONFIGURATION DESCRIPTION

Maximum Take-Off Gross Weight (lbs.) ....
Maximum Landing Weight (lbs.) ....
Operator's Weight Empty (lbs.) ....
Manufacturer's Weight Empty (lbs.) ....
Airframe Weight (lbs.) ....
Engine Weight, per engine (lbs.) ....
No. of seats ....
Maximum Payload (lbs.) ....
Type Engine ....
Engine Designation ....
Take-Off Rating at Sea Level:
Thrust (lbs.) or ....
Horsepower, ESHP ....
No. of Engines per Aircraft ....

UNIT PRICE DATA

Purchase Price, Airframe and Electronics ....
Purchase Price, each engine ....
Date Purchased (or date manufactured if aircraft rented) ....
Was Aircraft Purchased New? ....

OPERATIONAL PERFORMANCE (1975) -

Design Cruise:
Speed, mph. ....
Altitude, feet ....
Average Stage Length, stat. mi. ....
Average Block Speed, mph ....
Average Fuel Consumption, USG/block hr. ....

Please return to: Summerfield Associates
201 Ocean Avenue
Santa Monica, California 90402

AIRLINE CODE NO. ______________

AIRCRAFT TYPE ______________________

DIRECT OPERATING COSTS (ANNUAL)	1973	1974	1975
FLYING OPERATIONS (Less Rentals)			
FLIGHT CREW EXPENSE (Includes salaries of flight crews, trainees & instructors plus payroll taxes, fringe benefits and flight crew personnel expense)	$	$	$
AIRCRAFT FUEL & OIL EXPENSE			
HULL INSURANCE			
DIRECT MAINTENANCE			
AIRFRAME & AVIONICS MAINTENANCE LABOR			
AIRFRAME & AVIONICS MAINTENANCE MATERIAL			
ENGINE MAINTENANCE LABOR			
ENGINE MAINTENANCE MATERIAL			
PURCHASED SERVICES			
MAINTENANCE BURDEN			
AIRCRAFT DEPRECIATION and/or			
AIRCRAFT RENTAL			
OPERATING STATISTICS			
Revenue Passenger Miles (000)			
Revenue Ton Miles (000)			
Available Ton Miles (000)			
Available Seat Miles (000)			
Revenue Aircraft Miles			
Revenue Aircraft Hours (airborne)			
Revenue Aircraft Hours (block)			
Total Aircraft Hours (airborne)			
Total Aircraft Days in Service			
Gallons Aircraft Fuel Issued			
Average No. of Aircraft in Service			
No. of Departures Performed			
No. of Passengers Enplaned			
No. of Tons of Mail & Freight Enplaned			

Please return to: Summerfield Associates
201 Ocean Avenue
Santa Monica, California 90402

AIRLINE CODE NO. ____________

INDIRECT OPERATING COSTS (ANNUAL)

	1973	1974	1975
PASSENGER SERVICE (Includes cabin attendant, food, and beverage, if any)	$	$	$
AIRCRAFT SERVICING			
LANDING FEES			
ALL OTHER			
TRAFFIC SERVICING			
PROMOTION and SALES (Includes reservations, advertising, etc.)			
GROUND PROPERTY & EQUIPMENT EXPENSE (Includes maintenance and depreciation)			
GENERAL & ADMINISTRATIVE			

SUMMARY

	1973	1974	1975
TOTAL DIRECT OPERATING COSTS (All Aircraft Types			
TOTAL INDIRECT OPERATING COSTS			
TOTAL OPERATING COSTS			

Please return to: Summerfield Associates
201 Ocean Avenue
Santa Monica, California 90402

AIRLINE CODE NO. ________

GENERAL INFORMATION

	1973	1974	1975
NO. OF STATIONS SERVED			
INFLATION FACTORS (% INCREASE OVER PRIOR YEAR)			
FLIGHT CREW PAY/FLIGHT HR.			
OTHER PERSONNEL COSTS/HR.			
FUEL PRICE/GALLON			
HULL INSURANCE RATE			
SPARE PARTS			
OTHER PURCHASED SERVICES			
NO. OF EMPLOYEES			

Please Return to:

Summerfield Associates
201 Ocean Avenue
Santa Monica, California 90402

APPENDIX II

AIR TRANSPORT ASSOCIATION

COST INDEXES

ATA AIRLINE
LABOR COST INDEX

	Total Cost ($ Millions)	Average Number of Employees	Average Compensation Per Employee (Annualized)	Cost Index (1967=100)	Percent of Total Cash Operating Expenses
1967	2,465.27	253,661	9,723	100.0	45.3
1968	2,930.73	279.035	10,503	108.0	45.2
1969	3,429.89	297,239	11,539	118.7	45.6
1970	3,841.25	294,376	13,049	134.2	46.2
1971	4,060.94	284,163	14,291	147.0	46.3
1972	4,479.31	283,643	15,792	162.4	47.0
1 Qtr 73	1,223.78	286,202	17,104	175.9	48.0
2 Qtr 73	1,242.48	289,448	17,170	176.6	46.6
3 Qtr 73	1,295.78	297,285	17,435	179.3	45.9
4 Qtr 73	1,248.30	302,140	16,526	170.0	45.7
1973	5,010.34	293,769	17,055	175.4	46.5
1 Qtr 74	1,293.91	291,250	17,770	182.8	43.3
2 Qtr 74	1,327.01	292,874	18,124	186.4	41.9
3 Qtr 74	1,373.64	293,775	18,703	192.4	40.7
4 Qtr 74	1,401.86	294,090	19,067	196.1	42.1
1974	5,396.42	292,997	18,418	189.4	42.1
1 Qtr 75	1,411.34	287,972	19,604	201.6	42.3
2 Qtr 75	1,418.61	288,963	19,637	202.0	41.9
3 Qtr 75	1,464.63	287,602	20,370	209.5	40.5
4 Qtr 75	1,475.63	280,352	21,017	216.2	41.0
1975	5,770.26	286,347	20,151	207.3	41.4
1 Qtr 76	1,549.85	285,796	21,692	223.1	42.2
2 Qtr 76					
3 Qtr 76					
4 Qtr 76					
1976					

ATA AIRLINE
AIRCRAFT MAINTENANCE MATERIAL COST INDEX

	Total Cost ($ Millions)	Available Ton Miles (Millions)	Cost Per ATM (Cents)	Cost Index (1967=100)	Percent of Total Cash Operating Expenses
1967	248.20	28,675.9	0.865	100.0	4.9
1968	275.36	35,222.4	0.782	90.3	4.2
1969	288.86	40,373.2	0.707	82.0	3.8
1970	273.58	41,935.9	0.652	75.5	3.3
1971	257.81	44,682.5	0.577	66.7	2.9
1972	306.57	45,829.9	0.669	77.3	3.2
1 Qtr 73	88.23	11,660.4	0.757	87.4	3.5
2 Qtr 73	84.94	12,355.3	0.687	79.4	3.2
3 Qtr 73	92.00	13,389.3	0.687	79.4	3.3
4 Qtr 73	83.87	11,242.2	0.746	86.2	3.1
1973	349.04	48,647.2	0.717	82.9	3.2
1 Qtr 74	88.48	10,710.7	0.836	95.4	3.0
2 Qtr 74	93.10	11,528.8	0.808	93.3	2.9
3 Qtr 74	97.72	12,300.3	0.794	91.8	2.9
4 Qtr 74	105.55	11,606.8	0.910	105.1	3.2
1974	384.85	46,146.6	0.834	96.4	3.0
1 Qtr 75	98.16	11,341.[illegible]	0.865	100.0	3.0
2 Qtr 75	98.38	11,676.7	0.843	97.3	2.9
3 Qtr 75	111.37	12,385.7	0.899	103.9	3.1
4 Qtr 75	93.45	11,027.4	0.847	97.9	2.6
1975	401.36	46,431.7	0.864	99.9	2.9
1 Qtr 76	110.87	11,629.4	0.953	110.2	3.0
2 Qtr 76					
3 Qtr 76					
4 Qtr 76					
1976					