COMPUTER PROGRAMS FOR ESTIMATING CIVIL AIRCRAFT ECONOMICS

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SUMMARY

Computer programs were developed to calculate airline direct operating cost, indirect operating cost, and return on investment. These programs provide a means for determining commercial aircraft life-cycle cost and economic performance. The program codes can be easily incorporated into existing aircraft design programs. A representative wide-body subsonic jet aircraft was evaluated to illustrate use of the programs.

INTRODUCTION

Those engaged in developing advanced aircraft must evaluate technology candidates for possible incorporation into the aircraft. This is usually done by attempting to understand such trades as: range versus payload; aerodynamic, propulsion, and structural interactions (impact on weight and fuel burned); and noise reduction versus performance change. Also critical, however, to any decision on whether or not to incorporate a suggested beneficial technological advance, is knowledge of the cost of developing the new technology and how it will affect the aircraft's economic performance over its lifetime. The technical tradeoffs made in preliminary aircraft analysis are usually accomplished by complex computer programs which contain individual segments representing the various aeronautical disciplines but lack a means of evaluating the aircraft's economics. Airframe manufacturers and others have developed computer programs to perform these calculations; however, these programs are not available in the open literature. In an effort to fill this need, two computer programs were developed. These programs, while not totally representative of the actual costs which an airline would incur, are sufficient to establish the overall impact which a proposed advanced technology might have on operating cost. This report describes a program that calculates Direct Operating Cost (DOC) (and its sensitivity to a number of parameters), and also a program which calculates Return on Investment (ROI). The ROI program is based on the Direct Operating Cost (DOC) and Indirect Operating Cost (IOC) of the airplane, and also on the discounted cash flow concept. Knowledge of the direct operating cost and its sensitivity to various parameters is sufficient for many advanced aircraft evaluations (ref. 1). An airline's return on investment, however, is the final and most important measure of the efficiency of a commercial aircraft.

Computer codes are compatible with the CDC 6600 computer system. The DOC model is based on the standard Air Transportation Association model (ref. 2) using 1976 cost coefficients (obtained from the Boeing Commercial Airplane Company). The indirect operating cost model is based on a model obtained from
the Lockheed-Calfornia Company (ref. 3) using 1976 cost data. Sample calculations are provided to illustrate use of the program.

DESCRIPTION OF COMPUTER PROGRAMS

Direct Operating Cost Program

The DOC program determines costs related to the operation of a subsonic aircraft in making a specific flight. Direct Operating Cost is made up of the following elements: flight operations (which includes crew, fuel, and insurance costs), maintenance (which includes labor costs for the airframe and engine, material costs for the airframe and engine, and maintenance overhead), and depreciation cost.

Appendix A-1 presents the symbol definitions for both the input requirements and the output of the program. Table I shows the equation form used for each cost element and Table II illustrates the parameters that affect these costs. Values for cost coefficients \( C_1, C_2, C_3 \) and \( C_7 \) are given in the program listing presented in Appendix A-2. The cost coefficient subscript number refers to the order in which the coefficient first appears in the computer program.

Four options are included in the DOC program: crew size may be either two- or three-man; engine type may be either high bypass ratio or low bypass ratio; the airplane may be either new or used; and either a domestic or international flight may be specified (see Appendix A-2).

The fuel cost includes all gas and oil burned in making the flight plus an allowance for nonrevenue producing flights. Depreciation is based on the straight-line method and is determined by prorating the price paid for the aircraft (plus an allowance for airframe and engine spares) over a baseline lifetime of 14 years. A printout of a sample run is shown in Appendix A-3. Calculations are initially made based on the aircraft's direct operating cost per mile. The printout also provides direct operating costs given in terms of DOC per block hour, DOC per flight hour, DOC per seat statute mile, and DOC per passenger statute mile.

The program also calculates the effect of specific percentage increases in each cost element on the DOC. For example, initially the DOC is found for a base fuel price. The DOC is then determined for a 100 (2F), 200 (3F), and 300 (4F) percent increase over the base fuel price. Other cost sensitivities calculated are increases of 25, 50, 75, and 100 percent in maintenance (MA), crew (CR), and airplane investment costs (AP), as well as the effect of various depreciation periods (DP) from 10 to 15 years.

Return on Investment Program

The Return on Investment program calculates the ratio of airline profit to airline investment generated by the operation of the aircraft during its entire life cycle. Appendix B-1 gives the input and output definitions, Appendix B-2 presents the program listings, and Appendix B-3 shows a sample case printout.
In addition to the direct operating cost (calculated in the same manner as already discussed), the program calculates indirect operating cost and uses a discounted cash flow method to determine the ROI.

The indirect operating cost section of the Return on Investment program determines costs indirectly attributable to the aircraft's operation. IOC is found by summing the following costs (see Table III): systems, local, aircraft control, cabin attendant, food, passenger handling, cargo handling, other passenger service, freight commissions and advertising, and general and administrative. Labor, property, equipment, and station maintenance cost (from ground facilities) is included in the systems cost. Local cost includes landing fees and servicing. Aircraft control cost includes all aircraft handling charges. Cabin attendant cost refers to the stewardesses. In the code, one stewardess is assigned for each 40 seats. The cost of food covers all food and refreshments served without charge to passengers. Passenger handling cost is actually the cost of handling the passenger's baggage. Cargo handling cost results from handling mail, freight, and express cargo. Other passenger service cost encompasses all activities related to passenger comfort, safety, and convenience. Freight commissions and advertising cost is the expense associated with creating a public preference for an individual air carrier, stimulating air travel, and providing timetables. The general and administrative cost represents cost of an overall corporate nature. Individual parameters which affect each IOC cost element are shown in Table IV. The IOC cost model assumes that some individual costs are dependent on the airplane's direct operating cost. In the program printout illustrated in Appendix B-3, IOC is presented as follows: IOC per block hour, IOC per flight hour, IOC per seat mile, IOC per passenger mile, and IOC per aircraft statute mile.

Table V illustrates the form of the equations used to calculate ROI and Table VI presents the parameters which affect its calculation. The following parameters are calculated and listed in the program printout (Appendix B-3): operating cost, revenue, cost of depreciation, profit before tax and interest, book value of aircraft, interest, income tax, profit after tax and interest, present value factor, and discounted cash flow.

Each of these parameters is determined for each year of the aircraft's life. Monies brought in by passenger fares and cargo transportation are calculated using 1976 yields and are included in the revenue data. Direct and indirect operating costs are summed and included under operating costs. Growth in revenue and operating costs can be accounted for by specifying the inflation rate expected in future years (see ROI input section, Appendix B-1).

Cost of depreciation is discussed in the direct operating cost section. Book value is the value of the aircraft during a specific year of the aircraft's life after subtracting the accumulated depreciation expense from the original airplane price. The program assumes that the investment in the aircraft is made with borrowed funds. Interest cost is based on a 10-percent interest rate; however, any desired interest rate can be input. The balance of the aircraft loan is amortized by specifying that a sum of money equal to the yearly depreciation expense is used to repay money borrowed to purchase the aircraft. This means that the amount of borrowed money outstanding at any point in time is also equal to the book value of the aircraft. Income remaining after taxes are paid
is referred to as "profit after tax and interest" and this parameter varies for each year of the aircraft's life. Present value calculations are made by taking the profit after tax and interest and discounting this profit at an assumed rate in order to balance the remaining life cycle income (cash flow in) against the original cash investment (cash flow out). Cash inflow is determined for each year of the aircraft's life, and an interactive calculation procedure is employed using progressively larger numbers to find the actual discount rate that will balance the discounted cash flow in against the original cash investment. The discount rate that causes all cash flows to balance is the airline's return on investment and is also known as the "internal rate of return."

The present value factor used in the discount cash flow method must always have a value between zero and one. Therefore, if the sum of the profit after taxes and interest is less than the original cash investment, the cash flows cannot be balanced and an ROI (which could be negative) cannot be calculated. In order to allow for the calculation of negative ROI values, the program calculates a constant that is added to each year's profit after taxes and interest. Application of this constant assures a positive value for the difference between the original cash investment and the adjusted profit after taxes and interest. A negative sign is then applied to the ROI.

To limit the calculations to practical values of ROI, the program calculates it within a range of ±100 percent. Should the absolute value of ROI exceed or equal 100 percent, the user is so advised in the printout.

A summary illustration of the many factors which affect a commercial airplane's ROI is given in Table VI.

SAMPLE CALCULATION

A subsonic wide-body commercial jet transport aircraft flying with a 55-percent passenger load factor over a distance of 8336 kilometers (5180 st.mi.) is used to illustrate the information which can be obtained from these economic computer programs. Input values for the sample case are given in Tables VII and VIII. A zero inflation rate is specified for both revenue and operating cost. Freight and cargo loads are considered to be essentially negligible.

Figure 1 presents the effect of increases in crew, maintenance, aircraft cost, and fuel cost on the baseline DOC. Increases in fuel cost have the greatest effect on DOC while increases in aircraft cost have about the same effect as does an increase in maintenance cost. An increase in crew cost has the smallest effect. All calculations in figure 1 (and figs. 3-6) assume the aircraft is depreciated over a 14-year period.

Figure 2 shows the effect of various depreciation time periods (10 to 15 years) on DOC.

Figure 3 illustrates the relative levels of DOC, IOC, interest, income tax, and profit for each year of the aircraft's life. Due to the assumption of zero inflation rate, DOC and IOC are constant over the aircraft's life.
Figure 4 shows the relative importance of each cost element in the DOC and the IOC over the aircraft's 14-year life cycle. In this sample case, the freight commission, airplane control, and cargo handling costs are taken as negligible. The figure also includes a summary of where the airline's revenue dollar will be used over its lifetime.

Figure 5 presents the cash flow generated by the aircraft in each year of its life (discounted to its present value) for various load factors. For load factors near the breakeven point (such as 50 percent), little variation in discounted cash flow occurs. The most profitable case, of course, is for a 100 percent load factor, for which a very high positive discounted cash flow occurs early in the aircraft's life. In later years, when positive cash flow levels are less important, the discounted cash flow tends to approach zero. A large loss occurs when the aircraft is operated with a 30-percent load factor.

The variation of return on investment with load factor is presented in figure 6. Changes in the slope of the curve result from the fact that income tax is paid only in those years in which a profit is made. For load factors above about 50-percent, a positive ROI results. In such instances, income taxes are paid and a profit is realized in each year of the aircraft's life. Below a load factor of about 30 percent, a loss is encountered each year, no income tax is ever paid, and the discounted cash flow ROI is always negative. Between load factors of about 50 percent and 30 percent, a profit may occur in some years of the aircraft's life but it will not be sufficient to return the investment made in the aircraft.

CONCLUDING REMARKS

Computer programs which calculate airline direct operating cost, indirect operating cost, and return on investment were developed to provide a computer model for determining commercial aircraft life-cycle cost and economic performance. These codes can be easily incorporated into existing aircraft design programs. A representative wide-body subsonic jet aircraft was evaluated to illustrate use of the programs.

National Aeronautics & Space Administration
Langley Research Center
Hampton, Virginia 23665
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REFERENCES


TABLE I.- DIRECT OPERATING COST EQUATIONS

(Dollars Per Airplane Statute Mile)

**FLIGHT OPERATIONS**

\[
\text{Crew} = \frac{1}{\text{Block Speed}} \left( C_1 \left( \text{Cruise Speed} \right) \left( \text{Takeoff Gross Weight} \right)^{C_2} + C_3 \right)
\]

\[
\text{Fuel} = \frac{1}{\text{Block Distance}} \left[ \left( \text{Non-revenue Block Factor} \right) \left( \text{Price of Fuel} \right) \left( \text{No. of Engines} \right) \left( \text{Oil Burn Rate per Engine} \right) \left( \text{Block Time} \right) \left( \text{Cost of Oil} \right) \right] \left( \text{Density of Fuel} \right)
\]

\[
\text{Insurance} = \frac{(\text{Insurance Rate})(\text{Aircraft Cost})}{(\text{Annual Utilization})(\text{Block Speed})}
\]

**MAINTENANCE**

\[
\text{Labor on Airframe and Engine} = \text{Labor Rate} \left[ \left( \frac{\text{Manhours}}{\text{Flight Hour}} \right) \left( \frac{\text{Flight Hours}}{\text{Block Speed}} \right) + \left( \frac{\text{Manhours}}{\text{Flight Cycle}} \right) \right]
\]

\[
\text{Material on Airframe and Engine} = \left( \frac{\text{Material Cost}}{\text{Flight Hours}} \right) \left( \frac{\text{Flight Hours}}{\text{Block Speed}} \right) + \left( \frac{\text{Material Cost}}{\text{Flight Cycle}} \right) \left( \frac{\text{Flight Cycle}}{\text{Block Time}} \right)
\]

\[
\text{Maintenance Burden} = C_7 \left( \text{Labor on Airframe and Engine} \right)
\]

**DEPRECIATION**

\[
\text{Depreciation} = \left\{ \frac{\text{Airplane Cost}}{(\text{Utilization})(\text{Block Speed})(\text{Depreciation Period})} + \frac{\text{Spare Airframe Cost}}{(\text{Spare Engines})(\text{Cost Per Engine})} + \frac{\text{Airplane Cost} - (\text{No. of Engines})(\text{Cost Per Engine})}{(\text{Engines})(\text{Engine})} + \frac{\text{Spare Engines Cost}}{(\text{Spare Engines})(\text{Engine})} \right\}
\]

Note: Constants given in program listing (Appendix A-2)
# Table II: Parameters Impacting Elements of Direct Operating Cost

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Crew</th>
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<th>Maintenance</th>
<th>Depreciation</th>
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<td>Flight time</td>
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<td>Airframe cost</td>
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<td>Engine cost</td>
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<td>Maintenance labor rate</td>
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<td></td>
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<tr>
<td>Insurance rate</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spare airframe parts</td>
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<tr>
<td>Spare engine parts</td>
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<td></td>
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</tbody>
</table>

An "X" in the Cost Element Column indicates the parameters that affect the cost element.
TABLE III.- INDIRECT OPERATING COST EQUATIONS

<table>
<thead>
<tr>
<th>Systems</th>
<th>$= K_1$ (Block Distance) (Labor on Airframe and Engine)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local</td>
<td>$= K_2$ (No. of Departures) (Takeoff Gross Weight)</td>
</tr>
<tr>
<td>Aircraft Control</td>
<td>$= K_3$ (No. of Departures)</td>
</tr>
<tr>
<td>Cabin Attendant</td>
<td>$= K_4$ (No. of Cabin Attendants) (Block Time)</td>
</tr>
<tr>
<td>Food</td>
<td>$= K_5 \left( \frac{\text{Passenger}}{\text{Load Factor}} \right) \left[ C_4 \left( \frac{\text{No. of First Class Seats}}{\text{Class Seats}} \right) + \left( \frac{\text{No. of Tourist Class Seats}}{\text{Class Seats}} \right) \right]$</td>
</tr>
<tr>
<td>Passenger Handling</td>
<td>$= K_6 \left( \frac{\text{Passenger}}{\text{Load Factor}} \right) \left( \frac{\text{No. of Seats}}{\text{Seats}} \right)$</td>
</tr>
<tr>
<td>Cargo Handling</td>
<td>$= K_7$ (Weight of Cargo)</td>
</tr>
<tr>
<td>Other</td>
<td>$= K_8 \left( \frac{\text{Passenger Load Factor}}{\text{No. of Seats}} \right) \left( \text{Block Distance} \right)$</td>
</tr>
<tr>
<td>Freight Commissions</td>
<td>$= K_9$ (Weight of Cargo) (Block Distance)</td>
</tr>
<tr>
<td>and Advertising</td>
<td></td>
</tr>
<tr>
<td>General and Administrative</td>
<td>$= K_0 \left[ \frac{\text{Indirect Operating Cost}}{\text{Direct Operating Cost of Aircraft - Depreciation}} \left( \frac{\text{Block Distance}}{\text{Distance}} \right) \right]$</td>
</tr>
</tbody>
</table>

Note: Constants given in program listing (Appendix B-2).
<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>IOC COST ELEMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Systems</td>
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<td>Takeoff gross weight</td>
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<td>Depreciation cost</td>
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<tr>
<td>Number of cabin attendants</td>
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<tr>
<td>Number of total seats</td>
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<tr>
<td>Tourist</td>
<td></td>
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<tr>
<td>First class</td>
<td></td>
</tr>
<tr>
<td>Block distance</td>
<td>X</td>
</tr>
<tr>
<td>Weight of cargo</td>
<td></td>
</tr>
<tr>
<td>Labor on airframe and engine</td>
<td>X</td>
</tr>
<tr>
<td>Block time</td>
<td>X</td>
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<td>Passenger load factor</td>
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<tr>
<td>Number of trips</td>
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<tr>
<td>Direct operating cost</td>
<td></td>
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<tr>
<td>Indirect operating cost</td>
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</tr>
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</table>

An "X" in the Cost Element Column indicates the parameters that affect the cost element.
TABLE V.- RETURN ON INVESTMENT EQUATIONS

Annual Operating Cost = (Total Operating Cost) (Annual Utilization) (Block Speed)

Annual Revenue = \[ \frac{(Block\ Distance)\ (Annual\ Utilization)}{(C_6)\ (Block\ Time)} \times \]
\[ \left\{ \left( \frac{Passenger\ Load\ Factor}{Yield\ from\ Tourist\ Class} \right) \left( \frac{No.\ of\ Tourist\ Seats}{No.\ of\ First\ Class} \right) \left( \frac{Yield\ from\ First\ Class}{No.\ of\ First\ Class\ Seats} \right) \right\} \]

Profit Before Tax and Interest = (Annual Revenue) - (Operating Costs)
Book Value = (Aircraft Investment) - (Annual Depreciation) (Number of Years Aircraft in Service)
Interest = (Interest Rate) (Book Value of Aircraft)
Taxes = (Tax Rate) (Profit Before Taxes and Interest - Interest)
Profit After Taxes and Interest = Profit Before Tax and Interest - Taxes - Interest
Present Value = \[ \frac{1}{(1 + ROI)^n} \]

Discounted Cash Flow = \[ \sum_{DP=1}^{n} \left( \frac{Revenue - Operating\ Cost - Tax - Interest}{1 + ROI} \right)^n \]

Note: Constants given in program listing (Appendix B-2).
\[ n = \text{number of years} \]
### Table VI.- Parameters Affecting Return on Investment

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>Annual Operating Cost</th>
<th>Annual Revenue</th>
<th>Profit before tax and interest</th>
<th>Book Value</th>
<th>Interest</th>
<th>Tax</th>
<th>Profit after tax and interest</th>
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<td>Yield from tourist class</td>
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<td>Yield from first class</td>
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An "X" in the ROI Factor Column indicates the parameters that affect the ROI factor.
<table>
<thead>
<tr>
<th>Input</th>
<th>Program Code</th>
<th>Value</th>
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<tbody>
<tr>
<td>Block distance, km (st. mi.)</td>
<td>REQRNGS</td>
<td>8,336</td>
</tr>
<tr>
<td>Maximum takeoff gross weight, kg (lbm)</td>
<td>WGROSS</td>
<td>352,063</td>
</tr>
<tr>
<td>Airframe weight, kg (lbm)</td>
<td>BEWMENG</td>
<td>158,664</td>
</tr>
<tr>
<td>Block fuel, kg (lbm)</td>
<td>FUELBL</td>
<td>112,588</td>
</tr>
<tr>
<td>Block time, hours</td>
<td>TBLOCK</td>
<td>9.77</td>
</tr>
<tr>
<td>Cruise speed, km/hour (st. mi./hour)</td>
<td>SPEEDE</td>
<td>1,043</td>
</tr>
<tr>
<td>Number of seats</td>
<td>NS</td>
<td>385</td>
</tr>
<tr>
<td>Total thrust, N (lbf)</td>
<td>VCJ</td>
<td>800,680</td>
</tr>
<tr>
<td>Number of engines</td>
<td>ENGNO</td>
<td>4</td>
</tr>
<tr>
<td>Time in ground maneuver, hours</td>
<td>TGNDMAN</td>
<td>0.25</td>
</tr>
<tr>
<td>Passenger load factor, percent</td>
<td>LOADF</td>
<td>55</td>
</tr>
<tr>
<td>Cost of gas, $/liter ($/gallon)</td>
<td>CSTGASB</td>
<td>0.1</td>
</tr>
<tr>
<td>Cost of oil, $/liter ($/gallon)</td>
<td>CSTOILB</td>
<td>4.0</td>
</tr>
<tr>
<td>Oil burn rate, kg/hours (lb/hour)</td>
<td>OILBR</td>
<td>0.061</td>
</tr>
<tr>
<td>Labor rate, $/manhour</td>
<td>LABRATE</td>
<td>9</td>
</tr>
<tr>
<td>Depreciation period, years</td>
<td>DEPYR</td>
<td>14</td>
</tr>
<tr>
<td>Insurance rate, percent</td>
<td>INSR</td>
<td>1</td>
</tr>
<tr>
<td>Spares, percent of airplane purchase price</td>
<td></td>
<td></td>
</tr>
<tr>
<td>engines</td>
<td>SPARENG</td>
<td>30</td>
</tr>
<tr>
<td>airframe</td>
<td>SPAREAF</td>
<td>6</td>
</tr>
<tr>
<td>Purchase price of airframe, $</td>
<td>CSTAF</td>
<td>27,500,000</td>
</tr>
<tr>
<td>Purchase price of one engine, $</td>
<td>CSTIENG</td>
<td>1,760,000</td>
</tr>
<tr>
<td>Revenue inflation rate</td>
<td>GREV</td>
<td>0</td>
</tr>
<tr>
<td>Total operating cost inflation rate</td>
<td>GCSTOP</td>
<td>0</td>
</tr>
</tbody>
</table>

( ) Metric
<table>
<thead>
<tr>
<th>Input</th>
<th>Program Code</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crew size, men</td>
<td>BC</td>
<td>3</td>
</tr>
<tr>
<td>Airplane condition</td>
<td>BN</td>
<td>New</td>
</tr>
<tr>
<td>Engine type</td>
<td>BE</td>
<td>Hi Bypass</td>
</tr>
<tr>
<td>Route structure</td>
<td>B</td>
<td>International</td>
</tr>
</tbody>
</table>

( ) Metric
TABLE VIII.- RETURN ON INVESTMENT SAMPLE CALCULATION

<table>
<thead>
<tr>
<th>Input</th>
<th>Program Code</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>First class seats (15% of total seats)</td>
<td>SEATSIC</td>
<td>58</td>
</tr>
<tr>
<td>Tourist class seats (85% of total seats)</td>
<td>SEATSTC</td>
<td>327</td>
</tr>
<tr>
<td>Weight of freight, kg (lbm)</td>
<td>WFREIGT</td>
<td>.045 (0.1)</td>
</tr>
<tr>
<td>Weight of cargo, kg (lbm)</td>
<td>WCARGO</td>
<td>.045 (0.1)</td>
</tr>
<tr>
<td>Cabin attendants (one per 40 seats)</td>
<td>NCABATT</td>
<td>10</td>
</tr>
<tr>
<td>Yield from first class passengers, ( $/\text{pass. km} ) ($/\text{pass. st. mile})</td>
<td>YLDIC</td>
<td>5.7 (9.1)</td>
</tr>
<tr>
<td>Yield from tourist passengers, ( $/\text{pass. km} ) ($/\text{pass. st. mile})</td>
<td>YLDTC</td>
<td>4.3 (7.0)</td>
</tr>
<tr>
<td>Yield from cargo, ( $/\text{ton km} ) ($/\text{ton st. mile})</td>
<td>YLDCARG</td>
<td>16.8 (27.0)</td>
</tr>
<tr>
<td>Tax rate, percent</td>
<td>TAXR</td>
<td>48.0</td>
</tr>
<tr>
<td>Interest rate, percent</td>
<td>INTR</td>
<td>10</td>
</tr>
</tbody>
</table>

( ) metric
Figure 1.- Effect of cost increases on direct operating cost.
Figure 2.- Effect of variable depreciation period on direct operating cost.
Figure 3.- Cash flow versus aircraft year of life.
Figure 4.- Illustration of relative cost levels over aircraft life cycle.
Figure 5.—Discounted cash flow variation with time for various passenger load factors.
Figure 6.- Return on Investment as a function of passenger load factor.
APPENDIX A-1. - DIRECT OPERATING COST SENSITIVITY PROGRAM

Input

B  input for route type (1 for domestic flight; 2 for international flight)

BC input for crew costs (2 for two-man crew; 3 for three-man crew)

BE input for engine costs (2 for low bypass engine; 5 for high bypass engine)

BEMENG basic empty structural weight minus engine weight

BN input for airplane costs (1 for used airplane; 10 for new airplane)

CSTAF cost of airframe = cost of airplane less engines, $

CSTGASB cost of gas at base price, $/gallon

CSTOILB cost of oil at base price, $/gallon

CST1ENG cost of one engine, $

DEPYR number of years to depreciate aircraft

ENGNO number of engines

FUELBL block fuel, pounds

INSR insurance rate, percent

LABRATE labor rate, $/hour

LOADF passenger load factor, percent

NS number of seats

OILBR oil burn rate, pounds/hour/engine

REQRNGS block distance, miles

SPAREAF spare airframes, percent of aircraft purchase price

SPARENG spare engines, percent of aircraft purchase price
<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPEEDE</td>
<td>true cruise airspeed, miles/hour</td>
</tr>
<tr>
<td>TBLOCK</td>
<td>block time, hours</td>
</tr>
<tr>
<td>TGNDMAN</td>
<td>time for ground maneuver, hours</td>
</tr>
<tr>
<td>VCJ</td>
<td>maximum certified takeoff thrust, pounds</td>
</tr>
<tr>
<td>WGROSS</td>
<td>maximum takeoff gross weight, pounds</td>
</tr>
</tbody>
</table>

**Output**

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AP</td>
<td>airplane price sensitivity</td>
</tr>
<tr>
<td>CR</td>
<td>crew cost sensitivity</td>
</tr>
<tr>
<td>CSTAP</td>
<td>cost of airplane, $</td>
</tr>
<tr>
<td>CSTCREW</td>
<td>cost of crew, $/airplane mile</td>
</tr>
<tr>
<td>CSTDEP</td>
<td>cost of depreciation, $/airplane mile</td>
</tr>
<tr>
<td>CSTENG</td>
<td>cost of engines, $</td>
</tr>
<tr>
<td>CSTFLYO</td>
<td>cost of flying operations, $/airplane mile</td>
</tr>
<tr>
<td>CSTFUEL</td>
<td>cost of fuel, $/airplane mile</td>
</tr>
<tr>
<td>CSTINS</td>
<td>cost of insurance, $/airplane mile</td>
</tr>
<tr>
<td>CSTLABF</td>
<td>cost of labor for airframe maintenance, $/mile</td>
</tr>
<tr>
<td>CSTLENG</td>
<td>cost of labor for engine maintenance, $/mile</td>
</tr>
<tr>
<td>CSTMAF</td>
<td>cost of material for airframe maintenance, $/mile</td>
</tr>
<tr>
<td>CSTMAIN</td>
<td>total cost of maintenance, $/mile</td>
</tr>
<tr>
<td>CSTMAOH</td>
<td>cost of maintenance burden, $/mile</td>
</tr>
<tr>
<td>CSTMENG</td>
<td>cost of material for engine maintenance, $/mile</td>
</tr>
<tr>
<td>DOCAP</td>
<td>direct operating cost of airplane, $/mile</td>
</tr>
<tr>
<td>DOCBL</td>
<td>direct operating cost, $/block hour</td>
</tr>
<tr>
<td>DOCFH</td>
<td>direct operating cost, $/flight hour</td>
</tr>
<tr>
<td>DOCR</td>
<td>direct operating cost, cents/revenue passenger mile</td>
</tr>
<tr>
<td>DOCS</td>
<td>direct operating cost, cents/seat mile</td>
</tr>
<tr>
<td>Symbol</td>
<td>Description</td>
</tr>
<tr>
<td>--------</td>
<td>-------------</td>
</tr>
<tr>
<td>DP</td>
<td>depreciation period sensitivity, years</td>
</tr>
<tr>
<td>F</td>
<td>fuel cost sensitivity</td>
</tr>
<tr>
<td>LABAFFC</td>
<td>labor for airframe maintenance, man-hours/flight cycle</td>
</tr>
<tr>
<td>LABAFFH</td>
<td>labor for airframe maintenance, man-hours/flight hour</td>
</tr>
<tr>
<td>LABENFC</td>
<td>labor for engine maintenance, man-hours/flight cycle</td>
</tr>
<tr>
<td>LABENFH</td>
<td>labor for engine maintenance, man-hours/flight hour</td>
</tr>
<tr>
<td>MA</td>
<td>maintenance cost sensitivity</td>
</tr>
<tr>
<td>MATAFFC</td>
<td>material cost for airframe maintenance, $/flight cycle</td>
</tr>
<tr>
<td>MATAFFH</td>
<td>material cost for airframe maintenance, $/flight hour</td>
</tr>
<tr>
<td>MATENFC</td>
<td>material cost for engine maintenance, $/flight cycle</td>
</tr>
<tr>
<td>MATENFH</td>
<td>material cost for engine maintenance, $/flight hour</td>
</tr>
<tr>
<td>SPEEDBL</td>
<td>block speed, miles/hour</td>
</tr>
<tr>
<td>TRCRUISE</td>
<td>time in cruise, hours</td>
</tr>
<tr>
<td>TFLIGHT</td>
<td>flight time, hours</td>
</tr>
<tr>
<td>UTIL</td>
<td>annual utilization time, hours/year</td>
</tr>
</tbody>
</table>
APPENDIX A-2 - DOC SENSITIVITY LISTING

1
C-----------------------------------------------DECK NUMBER 16-----------------------------------------------
C--------------------------------DIRECT OPERATING COST SENSITIVITY PROGRAM------------------------------------
C
5
PROGRAM RANG(INPUT,OUTPUT,TAPES=INPUT,TAPE6=OUTPUT)
DIMENSION ROUTE(2),ARRAY1(100)
INTEGER BCOUNT,ACOUNT,AN
REAL LABRATE,LOADF,KA,LABAFFH,LABAFFC,MATAFFH,MATAFFC,LABENF
REAL LABENFC,MATENF,MATENFC,INSPNS
DATA ROUTE(1)/10\,1-DOM. /*ROUTE(2)/10H2-INT. /

10
C-----------------------------------1976 ATA DOC CALCULATION---------------------------------------------
C-----------------------------------INPUTS---------------------------------------------------------------------

15
C READ IN BLOCK DISTANCE (STATUTE MILES), MAXIMUM TAKEOFF GROSS WEIGHT (POUNDS), BLOCK FUEL (POUNDS) AND BLOCK TIME (HOURS)
7113 READ(5,7017)REQRNGS,GROSS,FUELBL,TBLOCK
IF(EOF(5)) 7111,7112
7112 CONTINUE

20
C CRUISE SPEED (STATUTE MILES/HR)
SPEED=563,
C NUMBER OF SEATS
NS=395,
C TOTAL THRUST (POUNDS)
VCJ=180000,
C NUMBER OF ENGINES
ENBNO=4,
C TIME IN GROUND MANEUVER (HOURS)
TGNDMAN=.25
C PASSENGER LOAD FACTOR (PERCENT)
LOADF=.55,
C PRICE OF GAS AND OIL ($/GALLON)
COSTGAS=.37
COSTOIL=.15,00

35
C OIL BURN RATE (POUNDS/HOUR)
OILBR=.135
C PRICE OF LABOR FOR MAINTENANCE ($/HOUR/MAN)
LABRATE=.9,
C DEPRECIATION PERIOD (YEARS)
DEPYR=14,
C INSURANCE RATE (PERCENT)
INSR=1.0
C PERCENT OF AIRPLANE PURCHASE PRICE THAT MUST BE SPENT FOR SPARES
C ON ENGINES AND AIRFRAME
SPARENG=30.
SPAREAF=6.
C BASIC EMPTY WEIGHT MINUS ENGINE WEIGHT YIELDS AIRFRAME WEIGHT (POUNDS)
BEWENG=349794.
C
C*********************************************************************************************
C*********************************************************************************************
C*********************************************************************************************
C*********************************************************************************************
C*********************************************************************************************
C-------DOMESTIC FLIGHT B=1 , INTERNATIONAL FLIGHT B=2
B=1
B=2
C-------------3 MAN CREW BC=3 , 2 MAN CREW BC=2
    BC=2
    BC=3
C-------------NEW AIRPLANE BN=10 , USED AIRPLANE BN=1
    BN=1
    BN=10
C-------------HI BYPASS ENGINE BE=5 , LO BYPASS ENGINE BE=2
    BE=2
    BE=5
C
C*********************************************************************************************
C*********************************************************************************************
C*********************************************************************************************
C*********************************************************************************************
C*********************************************************************************************
C CHANGE PERCENTAGES FOR PROGRAM COMPATIBILITY
SPARFNG=SPARENG/100.
SPAREAF=SPAREAF/100.
C
C COUNT=1
Z1=0.
Z3=Z4=Z5=Z6=1.0
KFUElst=0
7500 KFUElst=KFUElst+1
Z1=Z1+1.
IF(KFUElst.EQ.5) Z1=1.0
IF(KFUElst.EQ.5) KCEFMA=0
80 IF(KFUElst.EQ.5) GO TO 7910
9000 CONTINUE
C PURCHASE PRICE OF AIRPLANE AND ONE ENGINE ($) 
CSTAF=27500000.
CSTENG=1790000.
C  ---------------------CALCULATION OF DOC
C
CSTGAS=71*CSTGASB
CSTOIL=Z1*CSTOILY
DEPR=10.*Z5-1. 
IF(KDEPR*EQ,4) DEPR=15.
IF(COUNT.LT.25 OR COUNT.GT.32) DEPR=14.
C AIRWAY DISTANCE INCREMENT
KA=6.02*REGRNS
IF(REGRNS.GE.0,0 AND REGRNS.LE.1400.) KA=7.015*REGRNS
TCRUISE=(REGRNS+KA+240.)/SPEED
SPEEDAL=REGRNS/TBLOCK
TFIIGHT=TBLOCK-TGDOMAN
IF(B.EQ.1 AND BC.EQ.2) CSTCREW=(22.211*(SPEEDE*(WGRSS*10000))
1 **.320.933)/SPEEDAL
IF(B.EQ.2 AND BC.EQ.2) CSTCREW=(22.211*(SPEEDE*(WGRSS*10000))
1 **.344.322)/SPEEDAL
IF(B.EQ.1 AND BC.EQ.3) CSTCREW=(29.792*(SPEEDE*(WGRSS*10000))
1 **.330.759)/SPEEDAL
IF(B.EQ.2 AND BC.EQ.3) CSTCREW=(29.792*(SPEEDE*(WGRSS*10000))
1 **.375.757)/SPEEDAL
CSTCREW=CSTCREW*(Z1=1)*.251,
CSTFUEL=1.0*(FUEHL+CGTSS/6.7*ENNO*OILIRY/CSTOIL/R,10*TBLOCK) /
1 REGRNS
C 1*02 ON FUEL AND MAINTENANCE LABOR IS NON-REVENUE FACTOR
CSTFUEL=CSTFUEL*1.02 
IF(BN.EQ.1) UTIL=3400./((1./ITBLOC+5))+530.
IF(BN.EQ.10) UTIL=4000./((1./ITBLOC+5))+630.
CSTENG=CSTENG*ENNO
CSTAF=CSTAF*(Z1=1)*.25*(ZB=1.)
CSTENG=CSTENG*(Z1=1)*.25*(ZB=1.)
CSTAF=CSTAF*CSTENG*ENNO
CSTINS=INSR*CSTAP/UTIL*SPEEDYL)/100.
CSTFLY0=CSTCREW*CSTFUEL*CSTINS
LABAFFC=(BEMENG*0.01)/(0.047*(BEMENG*0.01)+21.150)
LABAFFH=(BEMENG*0.01)/(1.045*(BEMENG*0.01)+17.919)
LABAFFE=(LABAFFH+LABAFFE)*LABAFFH/(SPEEDBL*TBLOCK))*.102
MATAFFH=(2.5091.736*CSTAF*.0000)
MATAFFC=1.235*6.261*CSTAF*.0000
CSTMAFF=(MATAFFH+MATAFFC)/(SPEEDBL*TBLOCK))*.102
LAHENVH=(.0183*(VCJ*6.001)*.17)*ENNO
IF (HE .EQ. 2) LABENFC = (.0134 * (VCJ * .001) + .142) * ENGNO
IF (HE .EQ. 5) LABENFC = (.0244 * (VCJ * .001) + .220) * ENGNO
IF (HE .EQ. 2) MATENFH = (10.81 * CSTIENG * .00001 + 1.78) * ENGNO
IF (HE .EQ. 5) MATENFH = (10.256 * CSTIENG * .00001 + 18.115) * ENGNO
IF (HE .EQ. 2) MATENFC = (5.500 * CSTIENG * .00001 + 2.700) * ENGNO
IF (HE .EQ. 5) MATENFC = (16.000 * CSTIENG * .00001 + 19.500) * ENGNO
CSTLEN = (LABENFH + TFLIGHT + LABENFC) * LABRATE / (SPEEDBL * TBLLOCK) * 1.02
CSTTENG = (MATENFH + TFLIGHT + MATENFC) / (SPEEDBL * TBLLOCK) * 1.02
CSTMAH = 2.0 * (CSTLAF + CSTLENG)
CSTMAIN = CSTMAIN + CSTLENG + CSTYENG + CSTMAH
CSTMAIN = CSTMAIN * (1. + 25 * (33 - 1,))
CSTDEP = (CSTAP + SPAREAF) * (CSTAP - ENGNO * CSTLENG) * SPAREENG * ENGNO * CSTLENG
1 / (SPEEDBL * DEPYR * UTIL)
DO CAP = CSTDEP + CSTMAIN + CSTFLY0
ARRAY1 (COUNT + 1) = DOCAP / NS * LOADF * 10000.
DO CBH = DOCAP / SPEEDBL
DO CFB = DOCBH / TBLLOCK / TFLIGHT
IF (KFAUELST .NE. 1) GO TO 7050
WRITE (6, 1130)
WRITE (6, 1131) REGN, SPEEDBL, TBLLOCK, FUEL, UTIL
WRITE (6, 51)
WRITE (6, 52) NS + VCJ + GROSS
WRITE (6, 34) DOCBH, DOCFH
WRITE (6, 36) CSTFLY0, CSTMAIN, CSTDEP, DOCAP
WRITE (6, 33) CSTLAF + CSTMAF + CSTLENG + CSTYENG, CSTMAH
WRITE (6, 41) CSTCAWR, CSTFUEL, CSTINS
WRITE (6, 42) CSTAP + CSTAF + CSTENG, CSTLENG
WRITE (6, 51)
WRITE (6, 62)
WRITE (6, 54) KA * SPEED + TFLIGHT, TCRUISE
WRITE (6, 55) LARAFFH, MATAFFH, LAMH, MATENFH
WRITE (6, 57) LARAFFC, MATAFFC, LAMH, MATENFC
WRITE (6, 58) CSTGAS8, CSTOIL8, ENGNO, DEPYR
WRITE (6, 69) ROUTE (8) + LOADF * OILAR * LABRATE
7050 COUNT = COUNT + 2
IF (KFAUELST .LE. 4) GO TO 7500
IF (KSTMAH .LE. 4) GO TO 7010
IF (KSTCR .LE. 4) GO TO 7030
IF (KDEPYR .LE. 4) GO TO 7040
IF (KSTPL .LE. 4) GO TO 7020
7010 KSTMAIN = KSTMAIN + 1
Z3=Z3+1.
IF(KCSTMAI.EQ.5) Z3=1.0
IF(KCSTMAI.EQ.5) KCSTCRW=0
IF(KCSTMAI.EQ.5) GO TO 7030.
GO TO 8000

7030 KCSTCRW=KCSTCRW+1
Z4=Z4+1.
IF(KCSTCRW.EQ.5) Z4=1.0
IF(KCSTCRW.EQ.5) Z5=Z5.
IF(KCSTCRW.EQ.5) KDEPYR=0.
IF(KCSTCRW.EQ.5) GO TO 7040
GO TO 8000

7040 KDEPYR=KDEPYR+1
Z5=Z5+1.
IF(KDEPYR.EQ.5) Z5=1.
IF(KDEPYR.EQ.5) KCSTPL=0.
IF(KDEPYR.EQ.5) GO TO 7020
GO TO 8000

7020 KCSTPL=KCSTPL+1
Z6=Z6+1.
IF(KCSTPL.LE.4) GO TO 9000
WRITE(6,51)
WRITE(6,7009)
WRITE(6,7015) (ARRAY1(I),I=1,8)
WRITE(6,7012) (ARRAY1(I),I=9,16)
WRITE(6,7013) (ARRAY1(I),I=17,24)
WRITE(6,7014) (ARRAY1(I),I=25,32)
WRITE(6,7011) (ARRAY1(I),I=33,40)
WRITE(6,51)
GO TO 7113

7111 CONTINUE

200 7009 FORMAT(9X*DCS*7X*DCS*18X*DCS*7X*DCS*1AX* 1*DCS*7X*DCS*18X*DCS*7X*DCS*1AX*)
201 7011 FORMAT(9X*1.25AP-*Fb.3.5X,Fb.3.9X,*1.50AP-*Fb.3.5X,Fb.3.9X,* 1.75AP-*Fb.3.5X,Fb.3.9X,*2.00AP-*Fb.3.5X,Fb.3.9X)
202 7012 FORMAT(9X*1.25MA-*Fb.3.5X,Fb.3.9X,*1.50MA-*Fb.3.5X,Fb.3.9X,* 1.75MA-*Fb.3.5X,Fb.3.9X,*2.00MA-*Fb.3.5X,Fb.3.9X)
203 7013 FORMAT(9X*1.25CR-*Fb.3.5X,Fb.3.9X,*1.50CR-*Fb.3.5X,Fb.3.9X,* 1.75CR-*Fb.3.5X,Fb.3.9X,*2.00CR-*Fb.3.5X,Fb.3.9X)
204 7014 FORMAT(9X*DP=10 *Fb.3.5X,Fb.3.9X,*DP=11 *Fb.3.5X,Fb.3.9X, 1 *DP=12 *Fb.3.5X,Fb.3.9X,*DP=15 *Fb.3.5X,Fb.3.9X)
205 7015 FORMAT(9X*1F-*Fb.3.5X,Fb.3.9X,*2F-*Fb.3.5X,Fb.3.9X,
APPENDIX A-3 - DOC SENSITIVITY - SAMPLE CASE

1976 ATA DOC CALCULATIONS, SURSONIC JET, 3 MAN OR 2 MAN CREW

STATUTE MILES

$\text{GEORNGS} = 5180, \quad \text{SPEEDRL} = 530.19, \quad \text{TURLOCK} = 9.770, \quad \text{FUELWL} = 2.482E+06, \quad \text{UTIL} = 4275.08$

$\text{NS} = 385, \quad \text{VCJ} = 1800E+06, \quad \text{WGRS} = 7762E+06$

$\text{AIRPLANE DOC (\$ PER MOUR)} \quad \text{DOCHL} = 3.425E+04, \quad \text{DOCFH} = 3.3515E+04$

$\text{COST OF FLT OPS, MAINT, AND DEPRECIATION (\$ PER MILE)} \quad \text{CSTFLYO} = 3.647E+01, \quad \text{CSTMAIN} = 1.587E+01, \quad \text{CSTDEP} = 1.207E+01, \quad \text{DOCAP} = 6461E+01$

$\text{COST OF MAINTENANCE (\$ PER MILE)} \quad \text{CSTLABF} = 1.235E+00, \quad \text{CSTMADF} = 1.067E+00, \quad \text{CSTENG} = 2670E+00, \quad \text{CSTENG} = 3.097E+00, \quad \text{CSTMAOH} = 7.81E+00$

$\text{COST OF FLT, OPERATIONS (\$ PER MILE)} \quad \text{CSTCREW} = 8131E+00, \quad \text{CSTFUEL} = 2701E+01, \quad \text{CSTINS} = 1.524E+00$

$\text{COST OF AIRPLANE, AIRFRAME, ENGINE (\$)} \quad \text{CSTAP} = 3.454E+08, \quad \text{CSTAF} = 2750E+08, \quad \text{CSTENG} = 7.040E+07, \quad \text{CSTENG} = 1.760E+07$

<table>
<thead>
<tr>
<th>MISCELLANEOUS PARAMETERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\text{K}\text{A} = 1.1036E+03$</td>
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<tr>
<td>$\text{LABAFFH} = 6.6463E+01$</td>
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<tr>
<td>$\text{MATAFFH} = 5.025E+02$</td>
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<tr>
<td>$\text{LABENF} = 1.389E+02$</td>
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<tr>
<td>$\text{LABEF} = 1.634E+02$</td>
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<tr>
<td>$\text{CSTGASH} = 0.370$</td>
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<td>$\text{CSTENG} = 4.0$</td>
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<tr>
<td>$\text{LOADF} = 95.00$</td>
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<tr>
<td>$\text{OILBR} = 0.135$</td>
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<tr>
<td>$\text{LABRATE} = 9.00$</td>
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<table>
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<tr>
<td>1F-</td>
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<tr>
<td>1.25MA-</td>
<td>1.781</td>
</tr>
<tr>
<td>1.25CR-</td>
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</tr>
<tr>
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<tr>
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<tr>
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<td>3F-</td>
</tr>
<tr>
<td>3.426</td>
<td>1.75MA-</td>
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<td>3.243</td>
<td>1.75CR-</td>
</tr>
<tr>
<td>3.806</td>
<td>DP-12</td>
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<tr>
<td>3.433</td>
<td>1.75AP-</td>
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<th>DOCR</th>
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<td>3.081</td>
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<td>1.75CR-</td>
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<td>3.806</td>
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<td>1.75AP-</td>
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<td>5.602</td>
<td>4F-</td>
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<tr>
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<td>2.00MA-</td>
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<tr>
<td>3.339</td>
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<tr>
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<tr>
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<td>2.00AP-</td>
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<td>3.415</td>
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</tbody>
</table>

31
APPENDIX B-1* - RETURN ON INVESTMENT PROGRAM

Indirect Operating Cost Section

Input

DEPART  number of departures
IR  inflation rate, percent
K1  system cost coefficient
K2  local cost coefficient
K3  airplane control cost coefficient
K4  cabin attendant cost coefficient
K5  food and beverage cost coefficient
K6  passenger-handling cost coefficient
K7  cargo-handling cost coefficient
K8  other passenger service cost coefficient
K9  freight commission cost coefficient
K0  general and administrative cost coefficient
NCABATT  number of cabin attendants
SEATSIC  number of first-class seats
SEATSTC  number of tourist-class seats
WCARGO  weight of cargo, pounds
WFREIGHT  weight of freight, pounds

Output

APCONT  airplane control cost, $/trip
CABATT  cabin attendant cost, $/trip

*Also see Appendix A-1.
CARHAN  cargo-handling cost, $/trip
FGTCOM  freight commission cost, $/trip
FOOD    food and beverage cost, $/trip
GENADM  general and administrative cost, $/trip
IOC     indirect operating cost, $/trip
IOCAP   indirect operating cost of airplane, $/mile
IOCBL   indirect operating cost, $/block hour
IOCFH   indirect operating cost, $/flight hour
IOCR    indirect operating cost, $/passenger mile
IOCS    indirect operating cost, $/seat mile
LOCAL   local costs, $/trip
OTHSER  other passenger service cost, $/trip
PAXHAN  passenger-handling cost, $/trip
SYSTEM  system expense, $/trip
TOC     total operating cost (direct and indirect), $/trip

Return on Investment Section
Input

DCFROI  internal rate of return on investment, percent
DCSHFLO discounted cash flow, dollars
INTR    interest rate, percent
TAXR    tax rate, percent
YLDARG  yield from cargo, cents/ton-mile
YLDTC   yield from tourist seats, cents/passenger mile
YLDIC   yield from first class passengers, cents/passenger mile
## Output

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
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<tbody>
<tr>
<td>BOOK</td>
<td>original purchase price minus accumulated depreciation, $</td>
</tr>
<tr>
<td>CSTOP</td>
<td>cost of operating, $/year</td>
</tr>
<tr>
<td>CSTOPMD</td>
<td>cost of operating minus depreciation, $/year</td>
</tr>
<tr>
<td>INTREST</td>
<td>interest, $/year</td>
</tr>
<tr>
<td>NET</td>
<td>net dollar inflow and outflow over the life of aircraft</td>
</tr>
<tr>
<td>PROATAI</td>
<td>profit after taxes and interest, $/year</td>
</tr>
<tr>
<td>PROBTAI</td>
<td>profit before taxes and interest, $/year</td>
</tr>
<tr>
<td>REV</td>
<td>revenue, $/year</td>
</tr>
<tr>
<td>TAX</td>
<td>tax, $/year</td>
</tr>
</tbody>
</table>
APPENDIX B-2 - ROI LISTING

5 C PROGRAM RANG (INPUT, OUTPUT, TAPE5=INPUT, TAPE6=OUTPUT)
   DIMENSION PRESVAL(30), DCMDFL0(30), A4HAY1(100), ROUTE(2), CSTOP(30)
   DIMENSION PRDATA(30), HOOK(30), INTREST(30), PROBTAI(30), TAX(30)
   DIMENSION REV(30), CSTOP(30), TEST(30)
   INTEGER BCOUNT
   REAL IR, INFATE, INSR, INTK, INTREST, NET, NS
   REAL K0, K1, K2, K3, K4, K5, K6, K7, K8, K9
   REAL IOC, IODCAP, IOCS, IOCPR, IOTCL4, IOCFH, IOCASATT, IOCPR
   REAL LARRATE, LOADF, KA, LABAFFH, LABAFFC, MATAFFH, MATAFFC, LABENFH
   REAL LABENFC, MATENFH, MATENFC
   DATA ROUTE(1)/10H1-DOM/ / ROUTE(2)/10H2-INT /

20 C 1976 ATA DOC CALCULATION
   C
25 C READ IN BLOCK DISTANCE (STATUTE MILES), MAXIMUM TAKEOFF GROSS WEIGHT
   C (POUNDS), BLOCK FUEL (POUNDS) AND BLOCK TIME (HOURS)
   7113 READ(5, 7017) REQNQS, WGRS, FUELAL, TYLOCK
   IF(EOF(5)) 7111, 7112

25 C CONTINUE
   C CRUISE SPEED (STATUTE MILES/HR)
   SPEED=563.9
   C NUMBER OF SEATS
   NS=.385
   C TOTAL THRUST (POUNDS)
   VCJ=.10000
   C NUMBER OF ENGINES
   ENGNO=.4
   C TIME IN GROUND MANUEVER (HOURS)
   TGNDM=.25
   C PASSENGER LOAD FACTOR (PERCENT)
   LOADF=55
   C PRICE OF GAS AND OIL ($/GALLON)
   CSTGAS=.37
   CSTOILB=15.00
   C OIL BURN RATE (POUNDS/HOUR)
   OILBR=.135

35
C PRICE OF LABOR FOR MAINTENANCE ($/HOUR/MAN)
LABRATE=9.

45 C DEPRECIATION PERIOD (YEARS)
DEPYR=14.

C INSURANCE RATE (PERCENT)
INSR=1.0

C PERCENT OF AIRPLANE PURCHASE PRICE THAT MUST BE SPENT FOR SPARES

50 C ON ENGINES AND AIRFRAME
SPARENG=30.
SPAREAF=6.

C BASIC EMPTY WEIGHT MINUS ENGINE WEIGHT YIELDS AIRFRAME WEIGHT (POUNDS)
BEWEN=349794.

55 C

C******************************************************************************
C******************************************************************************
C******************************************************************************
C******************************************************************************

C******************************************************************************
C******************************************************************************
C******************************************************************************
C******************************************************************************

C------DOMESTIC FLIGHT B = 1, INTERNATIONAL FLIGHT B = 2

60 B=1
B=2

C-------3 MAN CREW BC = 3, 2 MAN CREW BC = 2
Bc=2
Bc=3

65 C-------NEW AIRPLANE BN=10, USED AIRPLANE BN=1
BN=1
BN=10

C-------HI BYPASS ENGINE BE = 5, LO BYPASS ENGINE BE = 2
BE=2
BE=5

70 C

C******************************************************************************
C******************************************************************************
C******************************************************************************
C******************************************************************************

C******************************************************************************
C******************************************************************************
C******************************************************************************
C******************************************************************************

C CHANGE PERCENTAGES FOR PROGRAM COMPATIBILITY

75 SPARENG=SPARENG/100.
SPAREAF=SPAREAF/100.

C

COUNT=1
Z1=0.

80 Z3=Z4=Z5=Z6=1.0
KFUELST=0
7500 KFUELST=K.FUELST+1
Z1=Z1+1.
IF(KFUELST.EQ.5) Z1=1.0

36
PROGRAM RANG 74/74 OPT=1

85 IF(KFUELST.EQ.5) KCSMAI=0
IF(KFUELST.EQ.5) Go TO 7010
8000 CONTINUE
C PURCHASE PRICE OF AIRFRAME AND ONE ENGINE ($) 
CSTAF=27500000.
CSTLENG=1760000.
C
C-------------------CALCULATION OF DDC
C
90 CSTGAS=Z1*CSTGASB
CSTOIL=Z1*CSTOIL9
DEPYR=10.*Z5-1.
IF(KDEPYR.EQ.0) DEPYR=15.
IF(COUNT,LT,25, OR COUNT,GT,32) DEPYR=14.
C AIRWAY DISTANCE INCREMENT
100 KA=0.02*REQRNGS
IF(REQRNGS.GT.0.0 AND REQRNGS.LE.1.400.) KA=7.0015*REQRNGS
TCRUISE=(REQRNGS*KA+20.)/SPEED
SPEEDDL=REQRNGS/TBLOC
FLIGHT=TBLOC-TGNM
105 IF(B*EQ.1.AND.BCEQ.2) CSTCREW=(22.211*(SPEED*(WGRS*.0001))
1 **.3+20.933)/SPEED
1 IF(B*EQ.1.AND.BCEQ.2) CSTCREW=(22.211*(SPEED*(WGRS*.0001))
1 **.3+44.322)/SPEED
1 IF(B*EQ.1.AND.BCEQ.3) CSTCREW=(29.792*(SPEED*(WGRS*.0001))
1 **.3+30.750)/SPEED
1 IF(B*EQ.2.AND.BCEQ.2) CSTCREW=(29.792*(SPEED*(WGRS*.0001))
1 **.3+62.757)/SPEED
CSTCREW=CSTCREW *((Z4-1.)*.25+1.)
CSTFUEL=1.0*(FUELBL*CSTGAS/6.7*ENGN0*OILBR*CSTOIL/8.10*TBLCK)/
1 REQRNGS
C 1.02 ON FUEL AND MAINTENANCE LABOR IS NON-REVENUE FACTOR
CSTFUEL=CSTFUEL**1.02
1 IF(B*EQ.1) UTIL=3400/(11+((1/TBLOC)+.5))/536.
1 IF(B*EQ.10) UTIL=900/(11+((1/TBLOC)+.5))/530.
CSTENG=CSTLENG*ENGN0
CSTAF=CSTAF**((1.125*(Z6-1.))
CSTLENG=CSTLENG**((1.25*(Z6-1.))
CSTAP=CSTAF+CSTLENG*ENGN0
CSTN5=INSR*CSTAP/(UTIL*SPEED)100.
CSTFLY=CSTCREW*CSTFUEL*CSTINS
LABAFFC=(BEWENGE*.001)/(.0419*(REWENGE*.001)+28.159)

37
LlabFH=(*BEWMENG*001)/(1035*(BEWMENG*001)+17.919)
CSTLAFH=((LlabFH*FLIGHT+LlabFFC)*LABRATE/(SPEEDBL*TBLCK))*1.02
MATAFH=2.509+1.736*CSTAF*0.00001
MATAFFC=1.235+2.261*CSTAF*0.00001
CSTMAF=((MATAFH*FLIGHT+MATAFFC)/(SPEEDBL*TBLCK))*1.02
LABENFH=(*0.183*(VCJ*001)+178)*ENGN0
IF(BE,Eq.2) LABENFC=(*0.134*(VCJ*001)+142)*ENGN0
IF(BE,Eq.5) LABENFC=(*0.244*(VCJ*001)+220)*ENGN0
IF(BE,Eq.2) MATENFH=(*10.31*CSTLENG*000001+179)*ENGN0
IF(BE,Eq.5) MATENFH=(*10.256*CSTLENG*000001+18,115)*ENGN0
IF(BE,Eq.2) MATENFC=(*5.50*CSTLENG*000001+2.70)*ENGN0
IF(BE,Eq.5) MATENFC=(*16.00*CSTLENG*000001+19.50)*ENGN0
CSTLENG=((LlabFN*FLIGHT+LABENFC)*LABRATE/(SPEEDBL*TBLCK))*1.02
CSTMENG=((MATENFH*FLIGHT+MATENFC)/(SPEEDBL*TBLCK))*1.02
CSTMA0H=2.0*(CSTLABF*CSTLENG)
CSTMAIN=CSTLABF+CSTMAF+CSTLENG+CSTMENG+CSTMAOH
CSTMAIN=CSTMAIN*(1+.2*(1.23-1))
CSTDEP=(CSTAP+SPAREAF)*(CSTAP-ENGN0*CSTEN)*SPARENG*ENGN0*CSTEN
1/(SPEEDBL*DEPAP*UTIL)
DCAP=CSTDEP*CSTMAIN*CSTFLY0
ARRAY1(COUNT)=DCAP/NS*100
ARRAY1(COUNT+1)=DCAP/NS/LOADF*10000.
DCBL=DCAP*SPEEDBL
DOCFH=DCBL*TBLCK*FLIGHT
IF(KFUELST=NE,I) GO TO 7050
CSTDEP=CSTDEP
CSTAPB=CSTAP
DOCAPF=DOCAP
155
CSTIEN0=CSTIEN0
CSTAPB=CSTAP+SPAREAF*(CSTAP-ENGN0*CSTEN)*SPARENG*ENGN0*
CSTEN
WRITE(6,1130)
WRITE(6,1131) REQRNGS*SPEEDBL*TBLCK,FUEL*UTIL
WRITE(6,51)
WRITE(6,52) NS,VCJ,WEROSS
WRITE(6,34) DOCL,DOCFH
WRITE(6,36) CSTFLY0,CSTMAIN,CSTDEP,DOCAP
WRITE(6,38) CSTLABF,CSTMAF,CSTLENG,CSTMENG,CSTMAOH
WRITE(6,41) CSTCAE,CSTFU.Fl,CSTINS
WRITE(6,42) CSTAP+CSTAF,CSTENG,CSTLENG
WRITE(6,51)
WRITE(6,52)
38
 PROGRAM RANG  74/74  OPT=1  FTN 4,7,485  80/01/29, 15:35:55  PAGE  5

  WRITE(6,54) KA, SPEEDE, TFLIGHT, TCURSE
  WRITE(6,56) LABAFFH, MATAFFH, LABENFH, MATENFH
  WRITE(6,57) LABAFFC, MATAFFC, LABENFC, MATENFC
  WRITE(6,58) CSTGASB, CSTOILB, ENGND, DEPYR
  WRITE(6,59) ROUTE(B), LOADF, OILBR, LABRATE
  51 FORMAT(1HO)

  170
  175  1130 FORMAT(1H1, '20X, *1976 ATC DOC CALCULATIONS', SUBSONIC JET, ' 3 MAN OR
      1 2 MAN CREW', STATUTE MILES, '/')
      1 *5X, 7HFUELHL=, E10.4, 6X, SMUTL=, *F9.2)
  34 FORMAT(1H0, *AIRPLANE DOC (PER HOUR)*)
  180  36 FORMAT(1I0, *COST OF FLI OPS, MAINT, AND DEPRECIATION (PER MILE)*)
      2 2X, DOCAP=, *E10.4)
      38 FORMAT(1H0, *COST OF MAINTENANCE (PER MILE)*)
      2 2X, CSTMAH=, *E10.4)
      41 FORMAT(1H0, *COST OF FLI. OPERATIONS (PER MILE)*)
  190  42 FORMAT(1H0, *COST OF AIRPLANE, AIRFRAME, ENGINE (PER MILE)*)
      1 E10.4, 5X, CSTAF=, *E10.4, 5X, CSTENG=, *E10.4, 5X, CSTMAF=, *E10.4)
      52 FORMAT(4H NS=, F5.0, 1X, NS44VJC=, E10.4, 9X, TLGROSS=, *E10.4)
      1 8HTCRISE=, *F7.3)
      56 FORMAT(9H LABAFF=, *E11.4, 8X, 8HMATAFF=, *E12.4, 7X, 8HLABENFH=, *E11.4,
      1 8X, 8HMATENFH=, *E12.4)
      57 FORMAT(9H LABAFFC=, *E11.4, 8X, 8HMATAFFC=, *E12.4, 7X, 8HLABENFC=, *E11.4,
      1 8X, 8HMATENFC=, *E12.4)
      58 FORMAT(9H CSTGASB=, *F5.0, 13X, 9HCSTOILB=, *F5.0, 13X, 9HCSTOILH=, *F5.0,
      1 10X, 6DEPYR=, *F6.2)
      1 8HLABRATE=, *F5.2)

  62 FORMAT(4RA, *MISCELLANEOUS PARAMETERS*)

  7050 COUNT=COUNT+
      IF(KFUELS<LE.4) GO TO 7500
      IF(KCSTMAI<LE.4) GO TO 7010
      IF(KCSTOIL<LE.4) GO TO 7030
      IF(KDEPYR<LE.4) GO TO 7040
      IF(KCSTPL<LE.4) GO TO 7020

  7010 KCSTMAI=KCSTMAI+1

  210  Z3=Z3+1.
IF(KCSTMAI*EQ,5) Z3=1.0
IF(KCSTMAI*EQ,5) KCSTCRR=0
IF(KCSTMAI*EQ,5) GO TO 7030
GO TO 8000

215
7030 KCSTCRR=KCSTCRR+1
Z4=Z4+1
IF(KCSTCRR*EQ,5) Z4=1.0
IF(KCSTCRR*EQ,5) Z5=0.0
IF(KCSTCRR*EQ,5) KDEPYR=0

220
7040 KDEPYR=KDEPYR+1
Z5=Z5+1
IF(KDEPYR*EQ,5) Z5=1.0
IF(KDEPYR*EQ,5) KCSTPL=0
IF(KDEPYR*EQ,5) GO TO 7040
GO TO 8000

7020 KCSTPL=KCSTPL+1
Z6=Z6+1
IF(KCSTPL*LE4) GO TO 8000
WRITE(6,51)
WRITE(6,7009)
WRITE(6,7015) (ARRAY(I),I=1,8)
WRITE(6,7012) (ARRAY(I),I=1,21)
WRITE(6,7013) (ARRAY(I),I=1,24)
WRITE(6,7014) (ARRAY(I),I=25,32)
WRITE(6,7011) (ARRAY(I),I=1,33,40)
WRITE(6,51)

7009 FORMAT(9X,*DCS*,7X,*DOC*,19X,*DCS*,7X,*DOC*,1AX,
1 *DCS*,7X,*DOC*,15X,*DCS*,7X,*DOC*)

7011 FORMAT(1X,*1.75AP=*,F6,3,5X,F6,3,9X,1.50AP=*,F6,3,5X,F6,3,9X,
1 *,F6,3,5X,F6,3,9X,2.00AP=*,F6,3,5X,F6,3,9X)

7012 FORMAT(1X,*1.75MA=*,F6,3,5X,F6,3,9X,2.00MA=*,F6,3,5X,F6,3,9X,
1 *,F6,3,5X,F6,3,9X,1 & 2.00CR=*,F6,3,5X,F6,3,9X)

7013 FORMAT(1X,*1.75CR=*,F6,3,5X,F6,3,9X,1.50CR=*,F6,3,5X,F6,3,9X,
1 *,F6,3,5X,F6,3,9X,2.00CR=*,F6,3,5X,F6,3,9X)

7014 FORMAT(1X,*DP=10 *,F6,3,5X,F6,3,9X,DP=11 *,F6,3,5X,F6,3,9X,
1 *,F6,3,5X,F6,3,9X,DP=12 *,F6,3,5X,F6,3,9X,DP=15 *,F6,3,5X,F6,3)

7015 FORMAT(1X,*1F=*,F6,3,5X,F6,3,9X,2F=*,F6,3,5X,F6,3,9X,
1 *,F6,3,5X,F6,3,9X,*,F6,3,5X,F6,3)

7017 FORMAT(3F10,0,1FH,4)
255 C------------------1976 LOCKHEED 10C CALCULATIONS
C
255 C------------------INPUTS
256 C ASSIGNMENT OF INTEGER VALUES TO FIRST CLASS SEATS (15 PERCENT OF TOTAL SEATS)
257 C AND TOURIST SEATS (85 PERCENT OF TOTAL SEATS)
258 ISEAT=NS+.15+.5
259 SEATS1C=ISEAT
260 SEATSTC=NS-SEATS1C
C WEIGHT OF FREIGHT (POUNDS)
261 WFRIGHT=.1
C WEIGHT OF CARGO (POUNDS)
262 WCARGO=.1
C NUMBER OF CABIN ATTENDANTS
263 ICABATT=NS/40+.9999
264 WCABATT=ICABATT
C NUMBER OF DEPARTURES
265 DEPART=1.0
C INFLATION RATE (PERCENT)
266 IR=0.0
C INFLATION UPDATE FOR 1976 COSTS (PERCENT)
267 INF1TE=1.0-IR*.01
268 IF(4,EQ,2) GO TO 6051
C DOMESTIC COEFFICIENTS
275 K1 = .52
276 K2 =1.06
277 K3 =23.93
278 K4 =29.33
279 K5 =.98
280 K6 =6.56
281 K7 =98.2
282 K8 =.0056
283 K9 =.0092
284 KG =.0048
285 GO TO 6050
6051 CONTINUE
C INTERNATIONAL COEFFICIENTS
290 K1 = .56
291 K2 =4.64
292 K3 =7.72
293 K4 =37.0
294 K5 =.63
295 K6 =15.84
295      K7 = 150.69
         K8 = 0.988
         K9 = 0.999
         K0 = 0.953
   6050 CONTINUE
       SYSTEM=K1*(CSTLABF+CSTLENG)*REQRNS*INFLATE
       LOCAL=K2*WHOSS/100.*DEPART*INFLATE
       APCONT=K3*DEPART*INFLATE
       CABATT=K4*NCAABATT*TBLK*INFLATE
       FOOD=K5*LOADF*(2.25*SEATIC*SEATSC)*TBLK/100.*INFLATE
   305      IF(b.EQ.2) FOOD=K5*(3.3*SEATIC*SEATSC)*TBLK*LOADF/100.*INFLATE
       PAXHAN=K6*LOADF*N5/100.*INFLATE
       CARHAN=K7*WCARGO*INFLATE
       OTHERS=K8*LOADF*NS*REQRNS/100.*INFLATE
       GHTCMB=K9*WHEIGHT*REQRNS*INFLATE
   310      IOC=SYSTEM+LOCAL+APCONT+CABATT+FOOD+PAXHAN+CARHAN+OTHERS+GHTCMB
       GENADM=K0*(IOC*(DOCAP1F-(CSTDPH)*INFLATE*REQRNS)
       IOC=IOC+GENADM
       IOCS=IOC/REQRNS/NS*100.
       IOC=IOCS/LOADF*100.
   315      IOCAP=IOC/REQRNS
       IOBL=IOC/TBLK
       IOFH=IOC/TFLIGHT

C-------------TOTAL OPERATING COST CALCULATION
C
C TOTAL OPERATING COST (¢/STATUTE MILE)
C    IOCAP=IOCAP*DOCAPF
C
C INDIRECT OPERATING COST, PERCENTAGE OF TOTAL OPERATING COST
C    IOC=IOCAP/IOCAP*100.
C
C DIRECT OPERATING COST, PERCENTAGE OF TOTAL OPERATING COST
C    DOCP=DOCAP1F/IOCAP*100.
       WRITE(6,6000)IR
       WRITE(6,6001)IOBL
       WRITE(6,6012)IOFH
       WRITE(6,6013)IOCS
       WRITE(6,6014)IOCR
       WRITE(6,6015)IOCAP
       WRITE(6,6045)IOCAP
       WRITE(6,6016)
   335      WRITE(6,6017)SYSTEM
       WRITE(6,6018)LOCAL

WRITE(6,6020)APCONT
WRITE(6,6021)CABATT
WRITE(6,6022)FOOD
WRITE(6,6023)PAKMAN
WRITE(6,6024)CARMAN
WRITE(6,6025)OTHSER
WRITE(6,6026)FGTCOM
WRITE(6,6027)GENADM
WRITE(6,6045)
WRITE(6,6007)
WRITE(6,6008)WGROSS,NS*REQRNGS,WCARGO,TBLOCK,TFLIGHT
WRITE(6,6009)
WRITE(6,610)CSTLABF,CSTLENGTH,CSTDEP,FDCAP,LOADF
WRITE(6,6030)
WRITE(6,6031)SEATSIC,SEATSTC,NCABATT,DEPART,WFLIGHT
WRITE(6,6040)TOCAP
WRITE(6,6050)DOCP,IOCP
6000 FORMAT(1H1/10X** LOCKHEED I/O C METHOD*,///,4X*,
1 **1976 UPDATE,,F5.1,** PERCENT INFLATION*,//)
6007 FORMAT(4X,*AIRPLANE INPUTS REQUIRED*)
6008 FORMAT(1X*,WGROSS,E10,3,3X*,NS*,F5.0*3X*,REQRNGS,**E10,3*3X*,
1 *WCARGO=**E10,3,3X*,**TBLOCK=**E10,3,3X*,**TFLIGHT=**E10,3*)
6009 FORMAT(4X,**INPUTS FROM DOC,PROGRAM*)
6010 FORMAT(1X*,$/MILE COSTS)  CSTLABF=**E10,3,3X*,CSTLENGTH=**E10,3,3X*,
1 *CSTDEP=**E10,3,3X*,*FDCAP=**E10,3*1X*,*LOADF=**F5.2)
6011 FORMAT(1X*,$/HOUR,10X,*ICSHL=**E12.5)
6012 FORMAT(1X*,$/FLIGHT HOUR=,9X*,ICSHH=**E12.5)
6013 FORMAT(1X*,CENTS/PERSON, MILE  IC=**E13.5)
6014 FORMAT(1X*,CENTS/SEAT MILE=,7X*,IC=**E13.5)
6015 FORMAT(1X*,$/AIRCRAFT MILE=,7X*,IC=**E12.5)
6016 FORMAT(1X*,$1976 BREAKDOWN ($/THP)*,///)
6017 FORMAT(2X,*SYSTEM=**E13.5)
6018 FORMAT(2X,*LOCAL=**E13.5)
6020 FORMAT(2X,*APCONT=**E13.5)
6021 FORMAT(2X,*CABATT=**E13.5)
6022 FORMAT(2X,*FOOD=**E13.5)
6023 FORMAT(2X,*PAKMAN=**E12.5)
6024 FORMAT(2X,*CARMAN=**E12.5)
6025 FORMAT(2X,*OTHSEP=**E13.5)
6026 FORMAT(2X,*FGTCOM=**E12.5)
6027 FORMAT(2X,*GENADM=**E13.5)
6030 FORMAT(40X,**MISCELLANEOUS PARAMETERS*)
380 6031 FORMAT(1X,*SEAT1C=*,F5.0,3X,*SEATSTC=*,F5.0,3X,*NCARATT=*,F5.0,4X
381   1 * DEPART=*,F08.2,5X,*WFRIGHT=*,E10.3)
380 6040 FORMAT(/,1X,*1976 TOC ($/MILE)=*,E09.3)
380 6060 FORMAT(1X,*DCO IS*,F8.2,* PERCENT OF TOC=*,10X I0C IS*,F6.2,
381   1 * PERCENT OF TOC=)
380 6045 FORMAT(/)
385 C C------------------------RETURN ON INVESTMENT CALCULATIONS
C C------------------------INPUTS
C YIELD FROM FIRST CLASS PASSENGERS (CENTS/PASSENGER STATUTE MILE)
390   YLD1C=9.1
C YIELD FROM TOURIST SEATS (CENTS/PASSENGER STATUTE MILE)
   YLDTC=7.0
C YIELD FROM CARGO (CENTS/TON STATUTE MILE)
   YLCDARG=27.
395 C TAX RATE (PERCENT)
   TAXR=48.
C INTEREST RATE (PERCENT)
   INTR=10.
C CHANGE VALUES FOR PROGRAM COMPATIBILITY TO PERCENTAGES
400   TAXR=TAXR/100.
   INTR=INTR/100.
C
405   STEP=1.
   DFCR01=0.
   I=DEPYR
C INITIALIZE SUMMATION VARIABLES TO ZERO
   SREV=0.
   SCSTOP=0.
   SCSTDEP=0.
410   SPBT=0.
   SINT=0.
   SMAX=0.
   SPAT=0.
   SUM = -CSTAPBS
415   SPDCF = 0.
C GREV=REVENUE INFLATION RATE
   GREV=0.
C GCSTOP=TOTAL OPERATING COST INFLATION RATE
   GCSTOP=0.
420 C YEAR OF AIRCRAFTS LIFE UNDER CONSIDERATION
44
DO 6150 N=1,1
F*N
REV(N)=((YLDTC*SEATSC+YLD1C*SEATS1C)*LOAD*100.*
1*(YLDCARG+WCARGO/2000.))*REQ-N*S*UTIL/5BLOCK/100.*

REV(N)=REV(N)*(1.+GREV/100.)*N
CSTOP(N)=TOTAL*UTIL*SPEED/NL
CSTOP(N)=CSTOP(N)*(1.+GCSTOP/100.)*N
COSTDEP(N)=COSTDEP*UTIL*SPEED/L
PROBTAI(N)=REV(N)-CSTOP(N)
BOOK(N)=CSTOPBS-COSTDEP(N)*FN
INTREST(N)=INTER*BOOK(N)
TAX(N)=TAAX*(PROBTAI(N)-INTREST(N))
TEST(N)=PROBTAI(N)-INTREST(N)
IF (TEST(N),LE,0.0) TAX(N)=0.0

PROAIA(N)=PROBTA(N)-INTREST(N)-TAX(N)
SREV=SREV+REV(N)
SCSTOP=SCSTOP+CSTOP(N)
SCDEP=SCDEP+COSTDEP(N)
SPBT=SPBT+PROBTAI(N)

SINT=SINT+INTREST(N)
STAX=STAX+TAX(N)
SPAT=SPAT+PROAIA(N)

6150 CONTINUE
KEY = 1
100 CONTINUE
SDCF = 0.,
C PRESENT VALUE ($) C DISCOUNTED CASH FLOW FIGURES ($) DO 110 N = 1,1
PRESV(N)=(1.+DCFROI)**(-N)
DCSHFL(N)=PROAIA(N)+PRESV(N)
SDCF = SDCF + DCSHFL(N)
110 CONTINUE
IF (KEY ,LT, 0.) GO TO 220
NET = SDCF + SUM
IF (DCFROI ,EQ, 0.0.AND. NET ,LT, 0.) GO TO 220
120 CONTINUE
IF (ABS(NET) ,LT, 1000.) GO TO 6164
IF (NET) 6157,6164,N15A
6164 200 CONTINUE
KEY = -1
ALOSS = NET / I
220 CONTINUE
SRPAT = 0.
SRDCF = 0.
DO 210 N = 1, I
RPATAI(N) = PROATAI(N) - ALOSS * 2.
RDCF(N) = RPATAI(N) + PRESVAL(N)
SRDCF = SRDCF + RDCF(N)
210 CONTINUE
NET = SRDCF + SUM
GO TO 120
6158 CONTINUE
DCFROI=DCFROI+STEP
IF (DCFROI .GT. 1.) GO TO 6164
GO TO 100
6157 CONTINUE
DCFROI=DCFROI-STEP
STEP = STEP / 10.
GO TO 100
6164 CONTINUE
DCFROI= DCFOI*100,
IF (SPAT .LT. CSTAPRS) DCFROI = -DCFROI
WRITE(6,6165) SUM
DO 6152 N=1, I
IF (KEY .LT. 0.) DCFSFLO(N) = 0.
WRITE(5,6155) N,REV(N),CSTOP(N),
1COSTDEP(N),PROATAI(N),RE0K(N),INTREST(N),TAX(N),
1PROATAI(N),PRESVAL(N),DCFSFLO(N)
6152 CONTINUE
6155 FORMAT(6, I4, 10E13.3)
WRITE(6,6182) SREV,SCSTOP,SCSTDEP,SPBT,SINT,STAX,SPAT,NET
WRITE(6,6888) CSTAPRS
WRITE(6,6166) NET,LOADF
6156 FORMAT(6,6168) YLD1C,YLDTC,YLDCARG
WRITE(6,6169) SEATIC,SEATSTC,WCARGO
C TEST FOR RETURN ON INVESTMENT BEING GREATER THAN 100 PERCENT
IF (DCFROI LE 100.) GO TO 985
WRITE(6,905)
905 FORMAT(6, I4)
C TEST FOR RETURN ON INVESTMENT BEING LESSER THAN -100 PERCENT
IF (DCFROI,GE, -100.) GO TO 989
WRITE(6,906)
906 CONTINUE
505  906 FORMAT(1X,*RETURN ON INVESTMENT IS LESS THAN 100 PERCENT*)
      909 CONTINUE
      IF(DCFROI.GE.100.) GO TO 986
      WRITE(6,616)DCFROI
      986 CONTINUE
      IF KEY .GT. 0.) GO TO 7119
      WRITE (6,250)
      250 FORMAT (T95**REVISED CSHFLOS + DCSHFLOS WHEN ROI IS NEG*)
      DO 300 N = 1,1
      300 WRITE (6,310) RPATAI(N), RDCF(N)
      WRITE (6,311) SRPAT,-2*ALOSG,SHDCF
      310 FORMAT (T97,E13.3,T123,E13.3)
      311 FORMAT (T87,*TOTAL*,T97,E13.3)
      7119 CONTINUE
      GO TO 7113
      7120 CONTINUE
      6165 FORMAT(1H1/*20X,*RETURN ON INVESTMENT CALCULATIONS*/,/,
      1 2X**YEAR*,5X,**REVENUE**,5X,**OPERATING**,5X,**
      2 *COST OF**,3X,**PROFIT BEFORE**,5X,**BOOK**,7X,**
      3 *INTEREST**,8X,**TAX**,5X,**PROFIT AFTER**,3X,**PRESENT**,5X,**
      4 *DISCOUNTED**,25X,**COST**,5X,**
      5 **DEPRECIATION**,3X,**TAX AND***4X,**TAX AND**,
      6 6X,**VALUE**,6X,**CASH FLOW**,/49X,**INTEREST**,44X,**INTEREST**,/,
      7123,E13.3)
      6166 FORMAT(1X,*RESIDUE==**E12.*1X,**DOLLARS*,
      530 1 70X,**LOADF==**E6.2,**PERCENT*,
      6167 FORMAT(1X,*RETURN ON INVESTMENT (INTERNAL)==**E12.*3,**PERCENT*)
      6168 FORMAT(1X,**YLDIC==**E12.*4,** YLDC==**E12.*4,** YLDCARG==**E12.*4,**
      6169 FORMAT(1X,*SEATSC==**F5.0,** SEATSC==**F5.0,** WCAPRO==**E12.*4,**/)
      6172 FORMAT(1X,E13.3,**X*,**TOTAL==**E12.*13X,E13.4,**X*,**E13.4,**/)
      535 8888 FORMAT(1X,**BASE AIRPLANE AND SPARES COST==**E12.*1X,**DOLLARS*)
      END

SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS  DEF LINE  REFERENCES
4141  RANG  5
### APPENDIX B-3 - ROI SAMPLE CASE

1976 ATA DOC CALCULATIONS; SURSONIC JET; 3 MAN OR 2 MAN CREW; STATUTE MILES

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**AIRPLANE DOC ($ PER HOUR)**:  DOCBL= .3425E+04  DOCFH= .3515E+04

**COST OF FLT OPS, MAINT, AND DEPRECIATION ($ PER MILE)**:  CSTFLY= .3686E+01  CSTMAIN= .1587E+01  CSTDEP= .1207E+01  DUCAP= .6460E+01

**COST OF MAINTENANCE ($ PER MILE)**:  CSTLAB= .1235E+00  CSTMAF= .1067E+00  CSTENG= .2670E+00  CSTMENG= .3087E+00  CSTMAOH= .7810E+00

**COST OF FLT. OPERATIONS ($ PER MILE)**:  CSTCREW= .1314E+00  CSTFUEL= .2701E+01  CSTMINS= .1524E+00

**COST OF AIRPLANE, AIRFRAME, ENGINE ($)**:  CSTAP= .3654E+08  CSTAF= .2750E+08  CSTENG= .7040E+07  CSTMENG= .1760E+07

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**MISCELLANEOUS PARAMETERS**

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48
LOCKHEED IOC METHOD

1976 UPDATE = 0.0 PERCENT INFLATION

$/LOCK HOUR           IOCBL = 2652.2 + 0.4
$/FLIGHT HOUR          IOCFL = 27218 + 0.4
CENTS/SEAT MILE        IOCS = 12993 + 0.1
CENTS/PASSENGER MILE   IOCPR = 2362.4 + 0.1
$/AIRCRAFT MILE        IOCAP = 50023 + 0.1

1976 BREAKDOWN ($/TRIP)

SYSTEM = 11328E+04
LOCAL = 138016E+04
APCONT = 67720E+02
CA BATT = 3614E+04
FOOD = 17942E+04
PA XHAND = 33541E+04
CARHAND = 15069E+02
OTHERS = 96524E+04
FGT COM = 51282E+01
GENADM = 26739E+04

AIRPLANE INPUTS REQUIRED

W GROSS = 776E+06  NS = 385  REORNGS = 514E+04  WCARGO = .100E+00  T B LOCK = .977E+01  TF LIGHT = .952E+01

(%/MILE COSTS) CSLABF= 1.124E+00  CSLENG= 267E+00  CSTDEP= 1.121E+01  UOCAP = .646E+01

INPUTS FROM DOC PROGRAM

LOADF = 55.00

MISCELLANEOUS PARAMETERS

SEATS1C = 58  SEATSTC = 327  NCABATT = 10  DEPART = 1.00  W FREIGHT = .100E+00

1976 TOC ($/MILE) = .115E+02
UOC IS 56.36 PERCENT OF TOC
IOC IS 43.64 PERCENT OF TOC

49
## Return on Investment Calculations

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<td><strong>.5355E+08</strong></td>
<td><strong>.7823E+03</strong></td>
<td><strong>.633E+08</strong></td>
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</table>

**Base Airplane and Spares Cost:** .3830E+08 Dollars

**Residue:** .7823E+03 Dollars

**YLD1C:** .9100E+01 YLDTC: .7000E+01 YLDCARG: .2700E+02

**SEAT1C:** 186, **SEAT2C:** 327, **WCCARG:** .1000E+00

**Return on Investment (Internal) = 4.413 Percent**
### Computer Programs for Estimating Subsonic Civil Aircraft Economics

**Abstract**

Computer programs to calculate airline direct operating cost, and indirect operating cost and return on investment were developed to provide a means for determining commercial aircraft life-cycle cost and economic performance. These program codes can be easily incorporated into existing aircraft design programs. A representative wide-body subsonic jet aircraft was evaluated to illustrate use of the program.

**Key Words**

- Aircraft Economics
- Direct Operating Cost
- Indirect Operating Cost
- Return on Investment

**Distribution Statement**

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Subject Category 83

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