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The ATA-67 Formula for Direct Operating Cost

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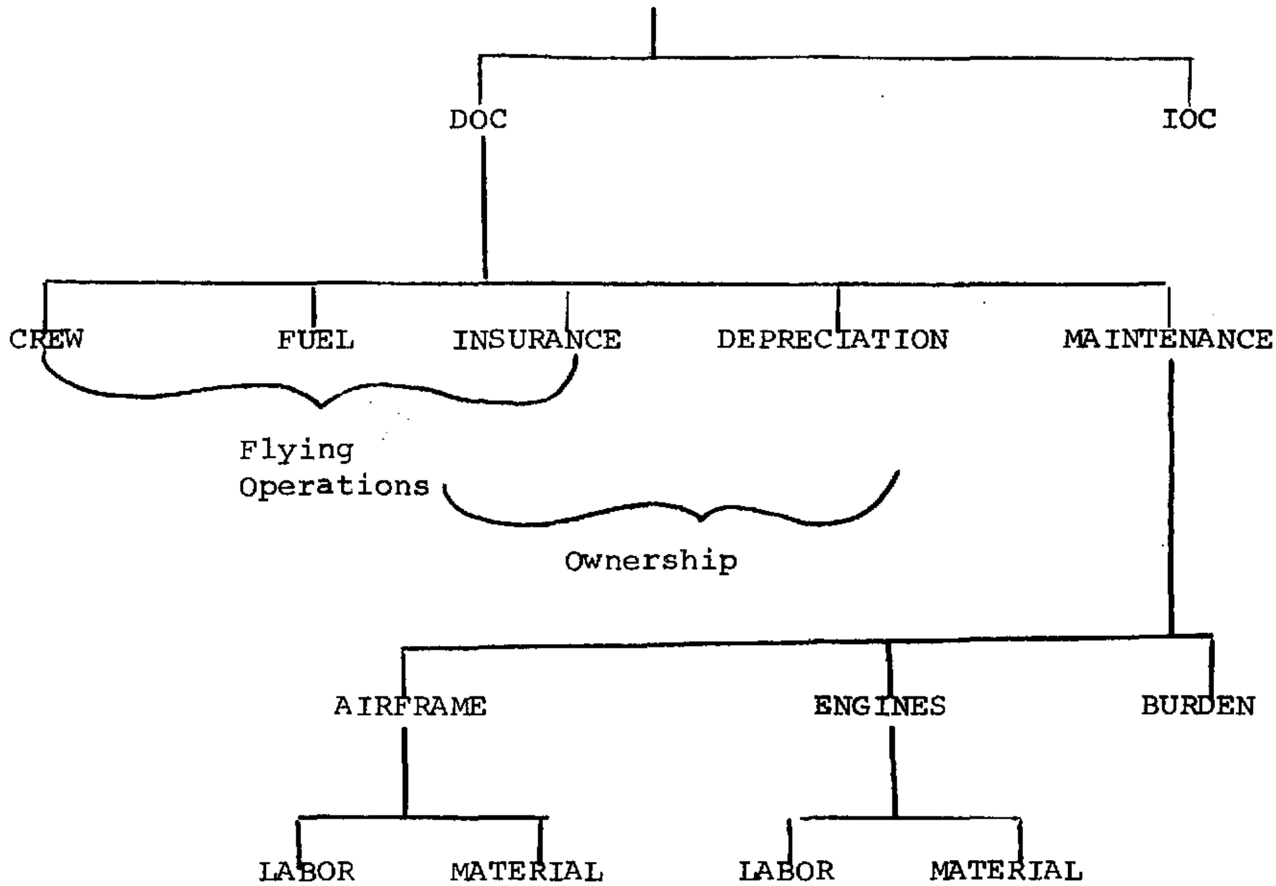
INTRODUCTION

The ATA formulas for direct operating cost were developed for the purpose of comparing different aircraft, existing or not, on the same route or the same aircraft on different routes. Such characteristics of the airline as crew pay, amintenance procedures, and depreciation schedules are kept constant. The formulas should be used for comparison only; they cannot reliably predict the actual operating cost of an airplane in service with a specific airline.

The 1967 ATA Formula is designed for turbine powered transport aircraft only. It covers only direct operating costs, which do not include such items as stewardesses and interest on investment. The formula is based on the characteristics of U.S. international and domestic airlines, and therefore it should not be applied to foreign or third level carriers. In particular, third level carriers would be likely to have smaller, unpressurized aircraft, shorter routes, and different labor rates.

In air transportation systems analysis the 1967 ATA Formula is usually used with appropriate exceptions or modifications, such as: different maintenance labor rate, total maintenance multiplied by a factor, maintenance burden deleted, different depreciation schedule, or different spares percentages. For situations outside the scope of the ATA Formula, other formulas are used, such as the Lockheed/New York Airways Formula (Reference 1) for VTOL or an updated version of the 1960 ATA formula for reciprocating power.

OUTLINE OF OPERATING COSTS



EFFECT OF MODIFICATIONS FOR NOISE ABATEMENT

The principal direct effect would be on depreciation. The cost of the modification would be spread over the remainder of the useful life of the aircraft or the depreciation period.

Other effects could occur through lower cruise speed, higher fuel consumption, or increased maintenance.

CONVERSIONS

The formula gives results in \$/aircraft mile. Knowing block speed, stage length, and the number of passenger seats, any of the following conversions can be made.

$$\$/\text{hour} = \$/\text{aircraft mile} \times \text{block speed}$$

$$\$/\text{seat mile} = \$/\text{aircraft mile} \times \frac{100}{\text{number of seats}}$$

$$\$/\text{seat trip} = \$/\text{aircraft mile} \times \frac{\text{stage length}}{\text{number of seats}}$$

$$\$/\text{seat hour} = \$/\text{aircraft mile} \times \frac{\text{block speed}}{\text{number of seats}}$$

$$\$/\text{trip} = \$/\text{aircraft mile} \times \text{stage length}$$

The following data are needed to exercise the ATA Formula. The Formula itself is provided in the appendix.

<u>INPUTS</u>

S = number of seats

D = stage length, statute miles

T_{cl} = time to climb, hr.

T_d = time to descend, hr. $\qquad V_b$ = block speed, mph.

D_c = distance to climb, mi. $\qquad$ or $\qquad t_b$ = block time, hr.

D_d = distance to descend, mi. $\qquad t_f$ = flight time,hr.

V_{cr} = cruise speed, mph

F_{gm} = ground maneuver fuel, lbs.

F_{cl} = climb fuel, lbs $\qquad$ or $\qquad F_b$ = block fuel, lbs

F_{cr} = cruise fuel, lbs

F_{am} = air maneuver fuel, lbs.

F_d = descent fuel, lbs.

$TOGW_{max}$ = maximum takeoff gross weight, lbs.

N_e = number of engines

U = utilization, hours per year

C_t = total purchase cost of aircraft without spares, $

W_a = weight of airframe, lbs.

C_a = purchase cost of airframe, $

T = takeoff thrust of one engine, lbs.

C_e = purchase cost of one engine,$

EXAMPLE

We now proceed through an example, the Boeing 737-200 as it was used on the average in 1970 (Reference 2). The following table gives the inputs to the formula. Notice that the state length is short, the block speed is low, and the utilization is low. The formula shows how to calculate block speed if that is unknown. Here we assume the full payload can be carried so we do not need to calculate reserve fuel as shown in the formula. We will show calculations for all quantities although some of them can be read from charts included with the formula.

Input

S	= number of seats = 93
D	= stage length = 262 statute miles
V_b	= block speed = 289 mph
F_b	= block fuel = 5440 lbs.
$TOGW_{max}$	= maximum takeoff gross weight = 114,500 lbs
N_e	= number of engines = 2
U	= utilization = 1865 hr/yr
C_t	= total aircraft cost = 5.20×10^6 \$
W_a	= airframe weight = 53,217 lbs
C_a	= airframe cost = 4.68×10^6 \$
T	= total takeoff thrust of one engine = 14,500 lbs.
C_e	= cost of one engine = 261,000 \$

Flight Crew

Two Man Crew:

$$C_{am} = .05\left(\frac{TOGW}{1000}\right) + 100.0 \quad \frac{1}{V_b}$$

$$= .05\left(\frac{114{,}500}{1000} + 100.0 \quad \frac{1}{289}\right.$$

$$= 5.72 + 100.0 \quad \frac{1}{289}$$

$$= 0.366 \text{ \$/mi}$$

The cost components of the formula naturally are incurred as cost per hour, cost per trip, or cost per year, which are then converted to cost per mile. The cost of flight crew is incurred as cost per hour and is converted by dividing by block speed. Note that the cost depends on gross weight and number of crew.

Fuel and Oil

$$C_{am} = 1.02 \quad \frac{(F_b \text{ x } C_{ft}) + N_e \text{ x } .135 \text{ x } C_{ot} \text{ x } t_b}{D}$$

$$= 1.02 \quad \frac{(5440 \text{ x } .0149) + (2 \text{ X } .135 \text{ x } .926 \text{ x } .906)}{262}$$

$$= 1.02 \quad \frac{81.2 + .27}{262}$$

$$= 0.317 \quad \text{\$/mi}$$

The cost of fuel and oil is incurred as cost per trip and converted to cost per mile by dividing by stage length. Note that the cost of oil is insignificant.

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Hull Insurance

$$C_{am} = \frac{.02 \times C_t}{U \times V_b}$$

$$= \frac{.02 \times 5.2 \times 10^6}{1865 \times 289}$$

$$= 0.193 \text{ \$/mi}$$

Insurance is an annual expense and is converted to cost per mile by dividing by utilization and block speed.

Maintenance

Airframe Labor

$$K_{FC_a} = .05 \left(\frac{W_a}{1000}\right) + 6 - \frac{630}{\frac{53,217}{1000} + 120}$$

$$= 2.66 + 6 - 3.63$$

$$= 6.97 \text{ hr/cycle}$$

$$K_{FH_a} = 0.59\ K_{FC_a} = 0.59 \times 6.97 = 4.11 \text{ hr/flight hr.}$$

$$C_{am} = \frac{(K_{FH_a}\ t_f + K_{FC_a}}{V_b\ \ t_b}\ (4.00)\ (1)$$

$$= \frac{4.11 \times .722 + 6.97}{289 \times .906}\ \ (4.00)$$

$$= 0.152 \text{ \$/mi.}$$

All maintenance expense is incurred as a cost per trip and is converted to cost per mile by dividing by stage length (block speed times block time). Maintenace labor costs are based on the labor man hours per flight hour and the labor man hours per flight cycle. Airframe labor is non-linear function of airframe weight.

<u>Maintenance</u>

Airframe Material:

$$C_{FH_a} = \frac{3.08\ C_a}{10^6} = \frac{3.08 \times 4.68 \times 10^6}{10^6} = 14.4$$

$$C_{FC_a} = \frac{6.24\ C_a}{10^6} = \frac{6.24 \times 4.68 \times 10^6}{10^6} = 29.2$$

$$C_{am} = \frac{C_{FH_a}\ T_f + C_{FC_a}}{V_b\ t_b}$$

$$= \frac{14.4 \times .722 + 29.2}{289 \times .906}$$

$= 0.151$ \$/mi.

Maintenace material cost is based on material cost per flight hour and material cost per flight cycle. These costs are proportional to airframe cost.

Maintenance

Engine Labor:

$$K_{FH_e} = \left[0.6 + \frac{.027T}{10^3}\right] N_e$$

$$= \left[0.6 + \frac{.027 \times 14,500}{10^3}\right] 2$$

$$= (0.6 + 0.392)\ 2$$

$$= 1.98$$

$$K_{FC_e} = \left[0.3 + \frac{.03T}{10^3}\right] N_e$$

$$= \left[0.3 + \frac{.03 \times 14,500}{10^3}\right] 2$$

$$= (0.3 + 0.435)\ 2$$

$$= 1.47$$

$$C_{am} = \frac{K_{FH_e} t_f + K_{FC_e}}{V_b t_b} \qquad (4.00)$$

$$= \frac{1.98 \times .722 + 1.47}{289 \times .906}$$

$$= 0.111 \text{ \$/mi.}$$

Note that increasing the number of engines without changing the thrust increases the engine labor cost. However this can be partially offset by reducing the thrust requirement from the engine out case.

Maintenance

Engine Material:

$$C_{FH_e} = 2.5\ N_e \left[\left(\frac{C_e}{10^5}\right)\right]$$

$$= 2.5 \times 2 \times \left[\left(\frac{261{,}000}{10^5}\right)\right]$$

$$= 13.1$$

$$C_{FC_e} = 2.0\ N_e \left[\left(\frac{C_e}{10^5}\right)\right]$$

$$= 2.0 \times 2 \times \left[\left(\frac{261{,}000}{10^5}\right)\right]$$

$$= 10.4$$

$$C_{am} = \frac{C_{FH_e}\ t_f + C_{FC_e}}{V_b\ t_b}$$

$$= \frac{13.1 \times .722 + 10.4}{289 \times .906}$$

$$= 0.076\ \$/\text{mi}$$

Engine material cost is proportional to the total cost of the engines.

Maintenance

Burden:

$$C_{am} = 1.8 \text{ (Airframe Labor + Engine Labor)}$$

$$= 1.8 \; (0.152 + 0.111)$$

$$= 0.474 \text{ \$/mi}$$

Maintenance burden is the cost of owning and maintaining the ground facilities for aircraft maintenace. It is proportional to the sum of airframe and engine labor costs.

Depreciation

$$C_t = 5.20 \times 10^6 = \text{total aircraft cost without spares}$$

$$.10(C_t - N_e C_e) = .10C = .10 \times 4.68 \times 10^6 = .468 \times 10^6$$

$$= 10\% \text{ airframe spares cost}$$

$$.40\, N_e\, C_e = .40 \times 2 \times 261{,}000 = .209 \times 10^6$$

$$= 40\% \text{ engine spares cost}$$

$$C_{am} = \frac{1}{V_b}\left[\frac{C_t + .10\,(C_t - N_e C_e) + .40\, N_e\, C_e}{D_a \times U}\right]$$

$$= \frac{1}{289}\left[\frac{5.20 \times 10^6 + .468 \times 10^6 + .209 \times 10^6}{12 \times 1865}\right]$$

$$= \frac{1}{289}\left[\frac{5.88 \times 10^6}{12 \times 1865}\right]$$

$$= 0.910 \text{ \$/mi}$$

Depreciation is an annual expense which is converted to cost per mile by dividing by utilization and block speed.

Summary 737-200

	$/mi.	$/hr.	$/s.mi.	%
Crew	.366	106	.394	13.3
Fuel and Oil	.317	92	.341	11.5
Hull Insurance	.193	56	.208	7.0
Total Flying Operations	.876	254	.943	31.8
Airframe Labor	.152	44	.164	5.5
Airframe Material	.151	44	.163	5.5
Engine Labor	.111	32	.119	4.0
Engine Material	.076	22	.082	2.8
Total Direct Maintenance	.490	142	.528	17.8
Maintenance Burden	.474	137	.510	17.2
Total Maintenance	.964	279	1.038	35.0
Depreciation	.910	263	.980	33.2
Total	2.750	796	2.961	100.0

Notice that total flying operations, total maintenance, and depreciation are each about a third of the cost. Maintenance burden,rather than flight crew or fuel, is the largest single item.

Comparison with the Real World

737-200 $/hr.

Actual Figures are for the year 1970. (Reference 2)

	1967 ATA	United	Western	Frontier	Piedmont
Crew	106	183	119	112	107
Fuel and Oil	92	101	113	101	104
Insurance	56	12	4	24	18
Flying Operations	254	296	236	237	229
Airframe	88	51	47	62	46
Engine	54	25	45	37	36
Burden	137	70	37	38	43
Total Maintenance	279	146	129	137	125
Depreciation	263	99	104	129	89
Total	796	541	470	503	443

The formula predicts flying operations expense fairly well except insurance is high. Also United Airlines has a three man crew on the 737-200, whereas we assumed two men for the formula.

The formula is very high on maintenance. This seems to be because the formula is based on long haul aircraft, which may have high cycle costs. The example is a short haul aircraft, which has been designed to have low cycle costs. The maintenance burden is correspondingly high.

Depreciation is also high because more recent (1971-82) purchase costs were used as input to the formula and because the airlines are using different depreciation schedules from the one assumed by the formula.

The total figures show that the direct operating cost does vary significantly from airline to airline. The total cost from the formula is high and indicates the danger of using the formula to predict the absolute true cost in airline service.

REFERENCES

1. Stoessel, R.F. and Gallagher, J.E., A Standard Method for Estimating VTOL Operating Expense, Lockheed-California Co., CA/TSA/013, October 1967.

2. CAB, Aircraft Operating Cost and Performance Report, Volume V August 1971