Fuel Conservation Strategies: Cost Index Explained

Used appropriately, the cost index (CI) feature of the flight management computer (FMC) can help airlines significantly reduce operating costs. However, many operators don't take full advantage of this powerful tool.

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This article is the first in a series exploring fuel conservation strategies.

VARIABLE FUEL PRICES, FUEL TANKERING, AND FUEL HEDGING MAKE THE COST INDEX CALCULATION COMPLICATED.

COST INDEX DEFINED

The CI is the ratio of the time-related cost of an airplane operation and the cost of fuel. The value of the CI reflects the relative effects of fuel cost on overall trip cost as compared to time-related direct operating costs.

In equation form:

$$CI = \frac{\text{Time cost} \sim \$/\text{hr}}{\text{Fuel cost} \sim \text{cents/lb}}$$

The range of allowable cost indices is shown in Figure 1. The flight crew enters the company-calculated CI into the control display unit (CDU) of the FMC. The FMC then uses this number and other performance parameters to calculate economy (ECON) climb, cruise, and descent speeds.

For all models, entering zero for the CI results in maximum range airspeed and minimum trip fuel. This speed schedule ignores the cost of time.

Conversely, if the maximum value for CI is entered, the FMC uses a minimum time speed schedule. This speed schedule calls for maximum flight envelope speeds, and ignores the cost of fuel (see fig. 2).

THE RANGE OF ALLOWABLE COST INDICES FOR GIVEN BOEING AIRPLANES

Figure 1

Airplane Model	737-300 737-400 737-500	737-600 737-700 737-800 737-900	747-400	757	767	777
Cost Index Range	0-200	0-500	0-9999	0-999 or 0-9999	0-999 or 0-9999	0-9999

COMPARING RESULTS FOR COST INDEX VALUES OF ZERO AND MAXIMUM

Figure 2

	CLIMB	CRUISE	DESCENT
Cost Index 0	Minimum Fuel*	Maximum Range	Max L/D
Cost Index Max	VMO/MMO	VMO/MMO	VMO/MMO

Entering zero for the cost index results in maximum range airspeed and minimum trip fuel. Entering the maximum value for cost index results in a minimum time speed schedule.

** Minimum climb contribution to trip fuel; this is different from minimum fuel to cruise altitude.*

CALCULATED VALUES FOR A TYPICAL 757 FLIGHT

Figure 3

	CLIMB	CRUISE	DESCENT	ALTITUDE RECOMMENDATIONS
Cost Index 0	290/.778	.778	250	OPT 328, MAX 362, RECMD 310
Cost Index 9999	345/.847	.847	.819/334	OPT 268, MAX 268, RECMD 260
Cost Index 70	312/.794	.794	.80/313	OPT 327, MAX 363, RECMD 310

COST INDEX IMPACT

Figure 4

FLEET	CURRENT COST INDEX	OPTIMUM COST INDEX	TIME IMPACT MINUTES	ANNUAL COST SAVINGS ($000's)
737-400	30	12	+1	US$754 – $771
737-700	45	12	+3	US$1,790 – $1,971
MD-80	40	22	+2	US$319 – $431

COST INDEX USAGE

In practice, neither of the extreme CI values is used; instead, many operators use values based on their specific cost structure, modified if necessary for individual route requirements. As a result, CI will typically vary among models, and may also vary for individual routes.

Clearly, a low CI should be used when fuel costs are high compared to other operating costs. The FMC calculates coordinated ECON climb (see fig. 5), cruise, and descent speeds (see fig. 6) from the entered CI. To comply with Air Traffic Control requirements, the airspeed used during descent tends to be the most restricted of the three flight phases. The descent may be planned at ECON Mach/Calibrated Air Speed (CAS) (based on the CI) or a manually entered Mach/CAS. Vertical Navigation (VNAV) limits the maximum target speed as follows:

- 737-300/-400/-500/-600/-700/-800/-900: The maximum airspeed is velocity maximum operating/Mach maximum operating (VMO/MMO) (340 CAS/.82 Mach). The FMC-generated speed targets are limited to 330 CAS in descent to provide margins to VMO. The VMO value of 340 CAS may be entered by the pilot to eliminate this margin.
- 747-400: 349 knots (VMO/MMO minus 16 knots) or a pilot-entered speed greater than 354 knots (VMO/MMO minus 11 knots).
- 757: 334 knots (VMO/MMO minus 16 knots) or a pilot-entered speed greater than 339 knots (VMO/MMO minus 11 knots).
- 767: 344 knots (VMO/MMO minus 16 knots) or a pilot-entered speed greater than 349 knots (VMO/MMO minus 11 knots).
- 777: 314 knots (VMO/MMO minus 16 knots) or a pilot-entered speed greater than 319 knots (VMO/MMO minus 11 knots).

FMCs also limit target speeds appropriately for initial buffet and limit thrust.

Figure 3 illustrates the values for a typical 757 flight.

FACTORS AFFECTING COST INDEX

As stated earlier, entering a CI of zero in the FMC and flying that profile would result in a minimum fuel flight and entering a maximum CI in the FMC and flying that profile would result in a minimum time flight. However, in practice, the CI used by an operator for a particular flight falls within these two extremes. Factors affecting the CI include time-related direct operating costs and fuel costs.

TIME COST

The numerator of the CI is often called time-related direct operating cost (minus the cost of fuel). Items such as flight crew wages can have an hourly cost associated with them, or they may be a fixed cost and have no variation with flying time. Engines, auxiliary power units, and airplanes can be leased by the hour or owned, and maintenance costs can be accounted for on airplanes by the hour, by the calendar, or by cycles. As a result, each of these items may have a direct hourly cost or a fixed cost over a calendar period with limited or no correlation to flying time.

In the case of high direct time costs, the airline may choose to use a larger CI to minimize time and thus cost. In the case where most costs are fixed, the CI is potentially very low because the airline is primarily trying to minimize fuel cost. Pilots can easily understand minimizing fuel consumption, but it is more difficult to understand minimizing cost when something other than fuel dominates.

FUEL COST

The cost of fuel is the denominator of the CI ratio. Although this seems straightforward, issues such as highly variable fuel prices among the operating locations, fuel tankering, and fuel hedging can make this calculation complicated.

A recent evaluation at an airline yielded some very interesting results, some of which are summarized in Figure 4. A rigorous study was made of the optimal CI for the 737 and MD-80 fleets for this particular operator. The optimal CI was determined to be 12 for all 737 models, and 22 for the MD-80. The table (see fig. 4) shows the impact on trip time and potential savings over the course of a year of changing the CI for a typical 1,000-mile trip. The potential annual savings to the airline of changing the CI is between US$4 million and $5 million a year with a negligible effect on schedule.

SUMMARY

CI can be an extremely useful way to manage operating costs. Because CI is a function of both fuel and nonfuel costs, it is important to use it appropriately to gain the greatest benefit. Appropriate use varies with each airline, and perhaps for each flight. Boeing Flight Operations Engineering assists airlines' flight operations departments in computing an accurate CI that will enable them to minimize costs on their routes. For more information, please contact FlightOps.Engineering@boeing.com.

THE EFFECT OF COST INDEX WHEN CLIMBING TO CRUISE ALTITUDE
Figure 5

A cost index of zero minimizes fuel to climb and cruise to a common point in space.

THE EFFECT OF COST INDEX WHEN DESCENDING
Figure 6

A cost index of zero minimizes fuel between a common cruise point and a common end of descent point.