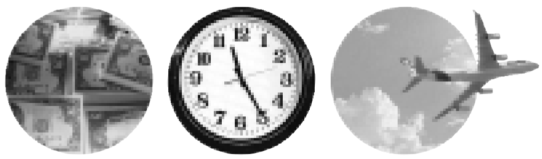
Flight Operations Support & Line Assistance



getting to grips with the
cost index

Issue II - May 1998

Customer Services

AIRBUS

Flight Operations Support & Line Assistance

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1. PREAMBLE

Today's tough competitive environment forces airlines to consider operational costs in every facet of their business. All ways and means to achieve this goal have to be rationally envisaged, safety being of course the prime factor in any airline operation. A wide spectrum of considerations intervene in this process stemming from airline economics, marketing management, crew scheduling, flight operations, engineering and maintenance management, technical condition of aircraft.

The idea behind this document is to revisit the cost index concept with a view towards balancing both fuel- and time-related costs.

With the surge of fuel prices in the early 1970s both airlines and aircraft manufacturers started concentrating on systems for reducing fuel consumption. In some airlines, fuel cost at one point represented no less than 45%, but gradually decreased to a mere 20% effectively emphasizing the other aspects of the cost equation. The widespread use of flight management systems since the early 1980s enabled airlines to take into account the other cost- and time-related aspects as well.

In addition to navigation functions, the Flight Management Computer (FMC) carries out real-time performance optimization aimed at providing best economics, not necessarily in terms of fuel consumption, but rather in terms of direct operating costs :

- climb, cruise and descent speed as a function of selectable constraints (altitude, arrival time, ...)
- minimum fuel, time or cost.

The purpose of this brochure is to clarify the cost index as a tool aimed at achieving this flexibility with regard to Airbus aircraft performance.

Moreover, some misconceptions need to be cleared up with regard to its utilization and more in-house analysis is required for its determination, always bearing in mind that the primary and essential goal of the cost index is **trip cost or mission optimization** and **not speed control.**

The following engineers and managers from Airbus made an important contribution to reviewing and editing this brochure : Michel TREMAUD, Laval CHAN, Guy Di SANTO, Christian MONTEIL, Monique FUERI, Philippe BURCIER (STL dept.), Robert LIGNÉE, Jacques ROSAY (EVT dept), Frank REPP (SE-MX), Jean-Pierre DEMORTIER (BTE/EG/PERF).

Many thanks also to Mr Laurent SYLVESTRE and Mr Frederic DUPOUY who brought this brochure to fruition through numerous calculation saga's whilst being on standby waiting for pilot recruitment by the airlines.

Would you please send your comments and remarks to the following contact point at Airbus. The topic of the cost index has been the subject of so much correspondence / communication, agreement / disagreement, action / inaction in recent years that we value your contributions very much. These will be taken into account in the following issues to be edited.

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2. INTRODUCTION : COST INDEX DEFINITION AND DETERMINATION

The fundamental rationale of the cost index concept is to achieve minimum trip cost by means of a trade-off between operating costs per hour and incremental fuel burn. In essence, the cost index is used to take into account the relationship between fuel-and time-related costs. As a matter of fact, this underlying idea had already been introduced with the Performance Data Computer (PDC), the predecessor of the Flight Management System (FMS).

2.1 Trip cost

Without having to resort to complicated mathematics we can readily appreciate that the total cost of a specific trip is the sum of fixed and variable costs :

$$\mathbf{C = C_F \times \Delta F + C_T \times \Delta T + C_c}$$

with C_F = cost of fuel per kg
C_T = time-related cost per minute of flight
C_c = fixed costs independent of time
ΔF = trip fuel
ΔT = trip time

In order to minimize C or the total trip cost we therefore need to minimize the variable cost :

$$C_F \times \Delta F + C_T \times \Delta T$$

For a given sector and period, the fuel price may be assumed to be a fixed value.

Let us consider a cost function $\tau = C/C_F = \Delta F + C_T/C_F \times \Delta T$ with $C_T/C_F = CI$ (defined as the cost index)

Over a certain stage length ΔS this means :

$$\tau \text{ (1 nautical mile)} = 1/SR + CI \times 1/V$$

with SR being the specific range at weight, altitude and other conditions

$$SR = \Delta S/\Delta F \text{ (nautical miles per kg)}$$

with V being the ground speed to cover ΔS stage nautical miles including winds

$$V = aM + Vc \text{ (Vc as the average head or tail wind component)}$$

For a given sector, minimum trip cost is therefore achieved by adopting an operational speed that properly proportions both fuel- and time-related costs.

For a given cost index Mach Number (MN) variations will actually compensate for fluctuations in wind (see 7.5).

2.2 Time-related costs

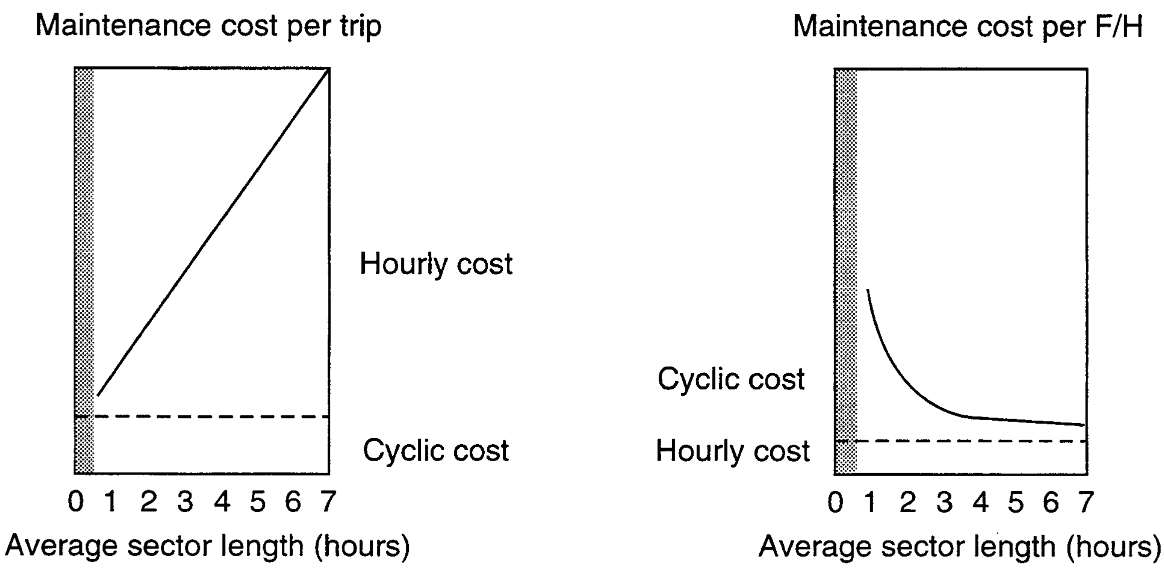
Time-related costs contain the sum of several components :

- **hourly maintenance cost** (i.e. excluding cyclic cost as shown in Figure 1),
- **flight crew and cabin crew cost** per flight hour :
  * Even for crews with fixed salaries, flight time has an influence on crew cost. On a yearly basis, reduced flight times can indeed lead to :
    - normal flight crews instead of reinforced ones,
    - lower crew rest times below a certain flight time (i.e. better crew availability on some sectors),
    - better and more efficient use of crews.
- **marginal depreciation or leasing costs** (i.e. the cost of ownership or aircraft rental) for extra flying per hour, not necessarily a fixed calendar time cost, but possibly a variable fraction thereof.

  In practice, these costs are commonly called marginal costs : they are incurred by an extra minute or an extra hour of flight.

  In addition to the above time-related costs, extra cost may arise from overtime, passenger dissatisfaction, hubbing or missed connections. These costs are airline-specific. If an airline can establish good cost estimates, it is possible to draw a cost versus arrival time function and hence to derive a cost index.

Figure 1. Direct maintenance cost



With time-related costs, the faster the aircraft is flown, the more money is saved. This is because the faster the aircraft is flown, the more miles time-related components can be used and the more miles can be flown and produced between inspections when just considering maintenance cost. However, if the aircraft is flown faster to reduce timerelated costs, fuel burn increases and money will be lost in turn.

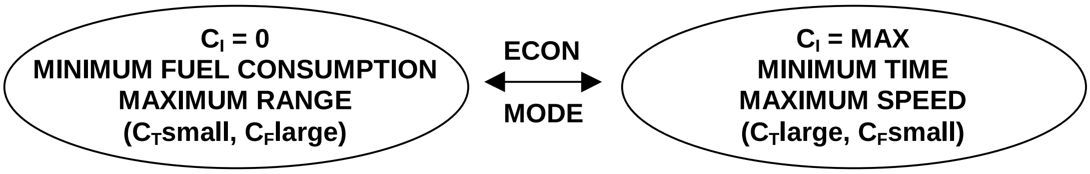
On the other hand, to avoid over-consumption of fuel, the aircraft should be flown more slowly. To solve this dilemma, the FMS uses both ingredients, and is therefore able to counterbalance these cost factors and to help select the best speed to fly, therefore called ECON (i.e. minimum cost) speed.

2.3 Cost index calculation

$$C_I = \frac{C_{Time}}{C_{Fuel}}$$

This mathematical expression is to be found as such or through an equivalent transform of respectively Sperry/Honeywell or Smiths Flight Management Systems. Whereas is scaled 0 to 999 on the first two, it is going from 0 to 99 on the latter.

Units are given in kg/min or alternatively as 100 Ib/h



scaled 0 to 99 or 999
(depending on FMS vendor)

Extreme cases :

1) C_I = 0 or practically, when C_T small, C_F large or
MINIMUM FUEL MODE for Maximum Range (MRC).

This is the case of greatest influence of fuel cost in the operating bill.

2) C_I = MAX or practically, when C_T large, C_F small or
MINIMUM TIME MODE for Maximum Speed (MMO - 0.02 = M 0.82 for A300-600, A310, M 0.80 for A320 Family, M 0.84 for A330/A340).

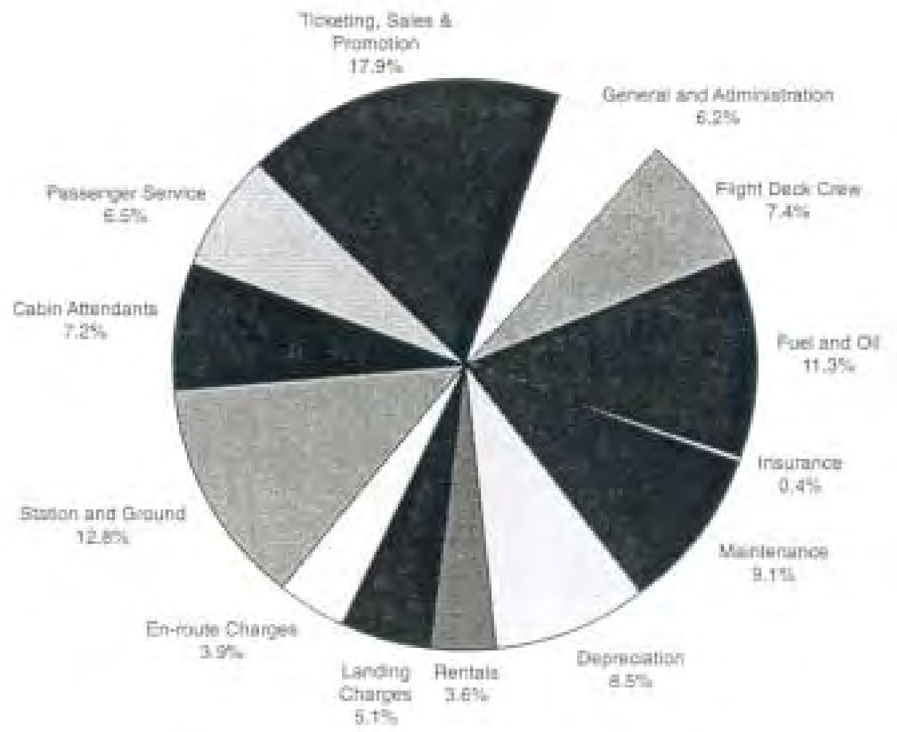
The cost index effectively provides a flexible tool to control fuel burn and trip time between these two extremes. Knowledge of the airline cost structure and operating priorities is essential when aiming to optimize cost by trading increased trip fuel for reduced trip time or vice-versa.

The mere fact that fuel costs can significantly vary from one sector to another and throughout the year should prompt airlines to consider adopting different cost indices for their various routes, seasonally readjusted to account for recurring fluctuations.

At Airbus, the Customer Services Directorate runs a department specialized in evaluating and modelling direct maintenance costs. Much progress could be obtained by having airline accountants look into the other time-related costs also. In practice, however, it has been hard for flight operations departments to persuade their airline financial analysts into assessing marginal operating costs.

This is probably because the latter have not yet integrated the importance of the cost index itself, largely an unknown concept to their decision-makers. And, despite the fact that airline econometrics nowadays is a field in itself, worldwide statistics on the distribution of operating costs are currently as shown below.

Figure 2. Distribution of operating costs



Source : IATA

Efforts to perform realistic cost index calculations in specific, airline-relevant cost brackets (low, medium, high) should pay off, rather than over-meticulous but undocumented computations of time-related to fuel-related cost ratios. The practical case for this is made in the next section.

2.4 Variation of airline practices

A large variation exists in how airlines actually use the cost index : some of this variation is related to specific operator requirements, some of it may reflect difficulties with the concept that may lead to inappropriate application. Some cases are cited here :

Airline A : use of the cost index to approximate Long Range Cruise (LRC)

Airline B : use of the cost index between LRC and Maximum Range Cruise (MRC)

Airline C : higher cost index if necessary for scheduling irrespective of fuel consumption issues

Airline D : Cost index variation according to fuel prices irrespective of time considerations (transparent / not considered)

Airline E : use of the cost index to approximate LRC, except cost index = 0 for fuel critical routes

Airline F : cost index calculation resulting in cruise speed between MRC and LRC

Airline G : cost index calculation resulting in cruise speed slightly below LRC

Airline H : use of the cost index to meet schedule requirements route by route

Airline I : use of the cost index route by route differentiating by fuel price only

Airline J : adoption of cost index values by adapting from other aircraft models/ manufacturers

Airline K : adoption of cost index values by a adapting for speed requirements only

Airline L : cost index adaptation according to sector fuel price variations after an initial rigorous fuel and time calculation.

3. COST INDEX TABLES

Although we recommend treating each airline route individually, cost brackets ranging from low to medium to high fuel and time-related costs led us to consider the following cost index tables.

3.1 A300/A310 Family

Considering, with good approximation, that the following range of time-related costs cover the maintenance cost difference between A300 and A310 as well as the cabin crew contingent (plus or minus two) difference, the following cost brackets result :

	6 < Hourly maintenance cost	< 12 (US$/min)
+	7 < Crew cost	< 14 (US$/min)
	13 < Time-related cost	< 26 (US$/min)

NB : Crew composition = 2 cockpit crews + 8 (± 2) cabin crews.

In turn, the following cost index tables reflect these cost ranges for the A300 and for the A310.

Table 1. A300/A310 cost index

(kg/min)
(Honeywell FMS)

TIME COST (US$/min) / FUEL COST (US$/USG)	LOW < 15	MEDIUM 15 < to < 20	HIGH > 20
LOW < 0.7	**65**	**85**	**100**
MEDIUM 0.7 < < 0.9	**50**	**65**	**80**
HIGH > 0.9	**40**	**55**	**65**

3.2 A320 Family

As dealt with for the A300 and A310, we obtain the following cost ranges for the A320 family :

	3 < Hourly maintenance cost	< 7 (US$/min)
+	5 < Crew cost	< 10 (US$/min)
	8 < Time-related cost	< 17 (US$/min)

NB : Crew composition = 2 cockpit crews + 5 (± 1) cabin crews.

Table 2. A319/A321 cost index

(kg/min)

TIME COST (US$/min) / FUEL COST (US$/USG)	LOW < 10	MEDIUM 10 < to < 15	HIGH > 15
LOW < 0.7	**40**	**60**	**80**
MEDIUM 0.7 < < 0.9	**30**	**45**	**60**
HIGH > 0.9	**25**	**40**	**50**

3.3 A330/A340 Family

In a first approximation, costs are judged to be identical for both models : flight crew, cabin and airframe maintenance costs being the same, engine maintenance costs are estimated similar on the big twin and on the quad.

The following brackets result from this :

	10 ≤ Crew cost	≤ 20 (US$/min)
+	7 ≤ Maintenance cost	≤ 17 (US$/min)
	17 ≤ Time-related cost	≤ 37 (US$/min)

NB : Crew composition = 2 or 3 cockpit crews + 10 (± 2) cabin crews.

Table 3. A330/A340 cost index

(kg/min)

TIME COST (US$/min) / FUEL COST (US$/USG)	LOW < 20	MEDIUM 20 < to < 30	HIGH > 30
LOW < 0.7	**90**	**110**	**130**
MEDIUM 0.7 < < 0.9	**70**	**100**	**120**
HIGH > 0.9	**60**	**80**	**100**

Reflecting realistic costs, these indices represent typical values that were prevailing in the industry for both the A330 and A340 aircraft types.

Although still valid for the ECON speeds of the A330, new definitions had to be adopted for MRC and LRC speeds on the A340 which lead, respectively, to Tables 4 (A340-211/311) and 5 (A340-213/313) for FMS Load 6. Pending Load 7, Tables 4 and 5 will become obsolete and Table 3 will prevail for both the A330 and A340.

Table 4. A340 cost index
A340-211 / CI FMS (L5)
A340-311 / CI FMS (L6)

(kg/min)

TIME COST (US$/min) / FUEL COST (US$/USG)	LOW < 20	MEDIUM 20 < to < 30	HIGH > 30
LOW < 0.7	**150**	**180**	**200**
MEDIUM 0.7 < < 0.9	**130**	**160**	**180**
HIGH > 0.9	**110**	**140**	**160**

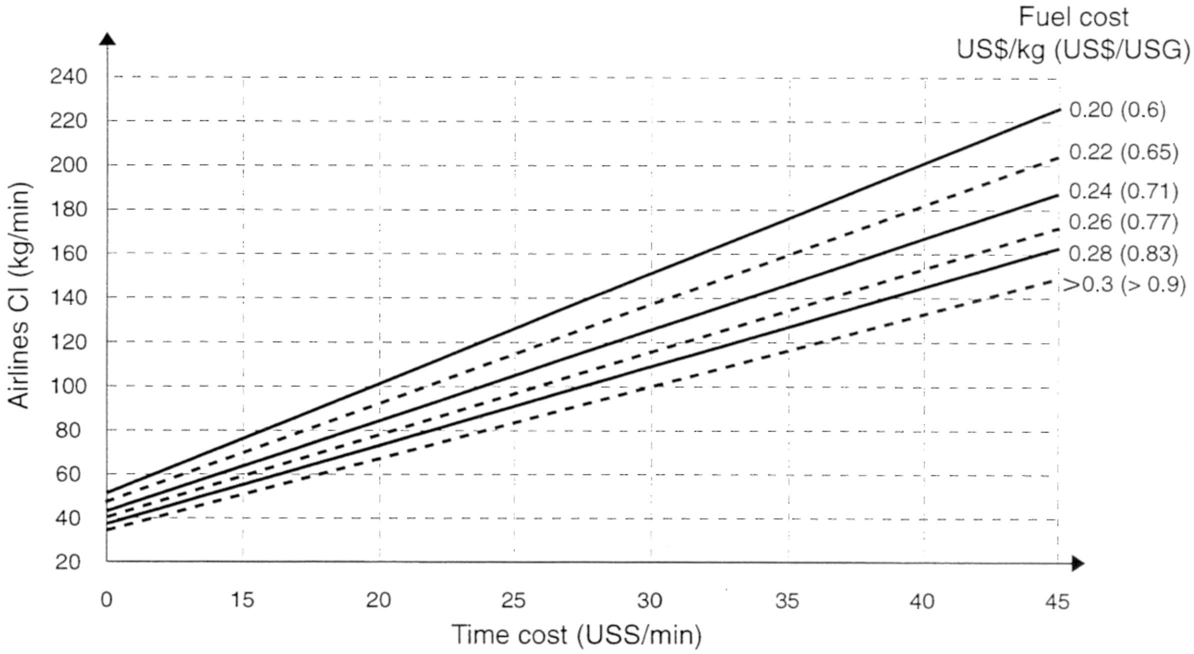
Table 5. A340 cost index
A340-313 / CI FMS (L6)

(kg/min)

TIME COST (US$/min) / FUEL COST (US$/USG)	LOW < 20	MEDIUM 20 < to < 30	HIGH > 30
LOW < 0.7	**180**	**240**	**270**
MEDIUM 0.7 < < 0.9	**160**	**200**	**240**
HIGH > 0.9	**140**	**180**	**210**

Figure 3 provides a practical curve for obtaining cost indices based on specific knowledge of Time and Fuel Cost.

Figure 3. Cost index calculation



3.4 Basic options with the cost index concept

If an airline decides to adopt genuine cost index flight management, two possibilities exist :

- specific airline cost analyses can be performed, route and aircraft specific, tailored to the network and its operating and economic environment which the airline may know better than anybody else,
- aggregate approximations can be performed, bundling routes in low/medium/high fuel-and time-cost brackets (or the like), which the airline may decide to adopt as the most pragmatic approach.

We call these the **Calculated Cost Index** Option.

As will be reviewed in the next chapter, airlines should at least determine their average cost indices, possibly categorizing these in one way or another and periodically review these in order to alleviate trip cost penalties that could be incurred with inappropriate values. Periodic reviews should consider both fuel- and time-related costs.

If the company cost index is not known and the airline is not keen to calculate it, a **Default Cost Index** can be assessed using the FCOM for the A300-600/A310 and depending on the operational objective (e.g. optimum Mach, LRC or any Mach Number). This option is presently not available for the other models and we therefore refer to Appendix 2 for a detailed outline on this approach.

4. TRIP COST PENALTY AS A FUNCTION OF THE COST INDEX

As shown in 2.1, trip cost varies according to fuel-related costs on the one hand, and to time-related costs on the other.

The purpose of this section is to explain the sensitivity of the actual trip cost, firstly to errors in cost index which result from uncertainty as to the correct value of time-related costs, and secondly due to unaccounted fuel price fluctuations.

4.1 Trip cost variations at fixed fuel cost

A trip cost penalty may occur when the calculated cost index calls for a fast speed schedule, resulting in an increased fuel burn which is not offset by reduced time cost.

Alternatively, a trip cost penalty may occur when the calculated cost index calls for too slow a speed schedule, resulting in an increased time cost which is not offset by the reduced fuel burn (see the following Figures 4 - 10 Δ Trip cost=f(CI)).

Figure 4. Δ Trip cost = f(CI)

A300/A310
(All models)

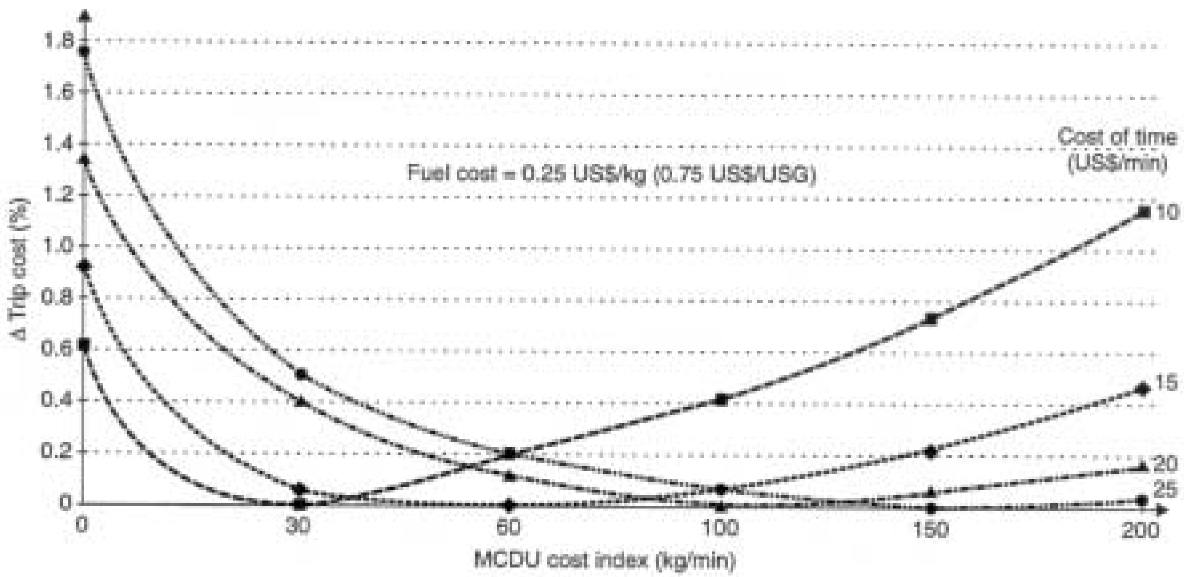


Figure 5. Δ Trip cost = f(CI)

A319/A320/A321
(All models)

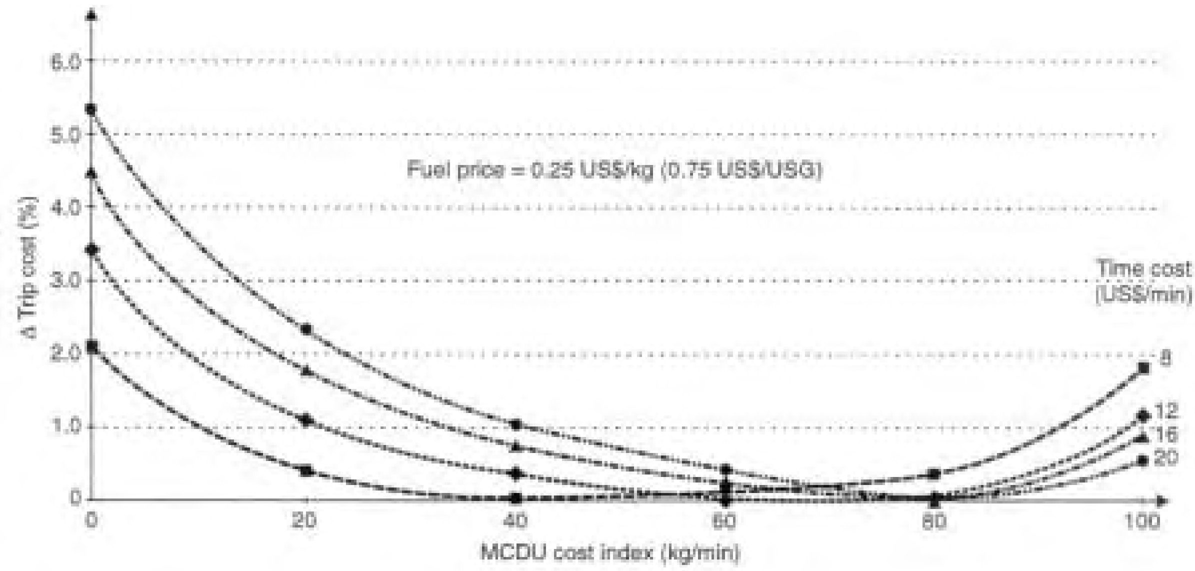
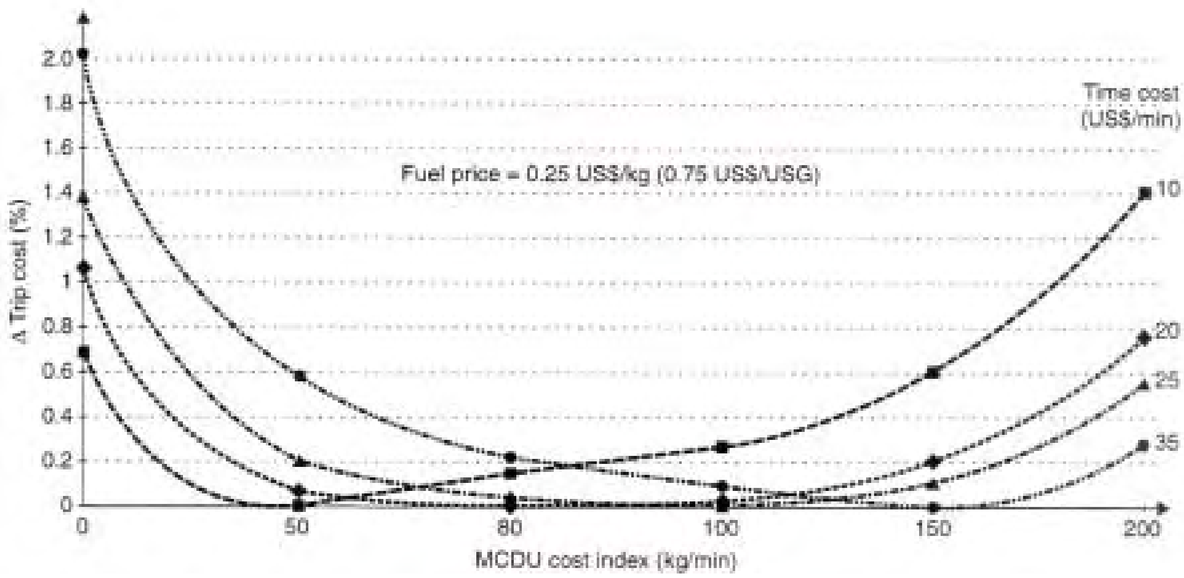


Figure 6. Δ Trip cost = f(CI)

A340
(All models)



Obviously, we can see that the higher the time-related cost, the higher the cost index corresponding to the minimum trip cost (different minima for each time cost value).

For the flat areas of these preceding curves, trip cost penalties are negligible when cost of time errors are made. We call these the "least risk areas". As depicted, trip cost penalties are marginal when the utilized cost index values are close to the theoretically correct ones. Elsewhere, trip cost penalties are rather sensitive.

An error of 5 US$/min in the time cost computation which leads to a cost index error of 20 (fuel price = 0.25 US$/kg) can increase the trip cost from 0.2 up to almost 2% (especially for the A320) depending on the cost index range and the aircraft model.

Although possibly negligible on a single flight, this becomes rather meaningful on a yearly basis when applied to a whole fleet.

4.2 Trip cost variations at fixed time-cost

This section shows the importance of adapting the cost index to each airline route sector, that is to say to each fuel price sector.

The following graphs illustrate trip cost variations according to different fuel prices and for each Airbus model, depicting similar curves to those in 4.1 above.

Figure 7. Δ Trip cost = f(CI)

A300/A310
(All models)

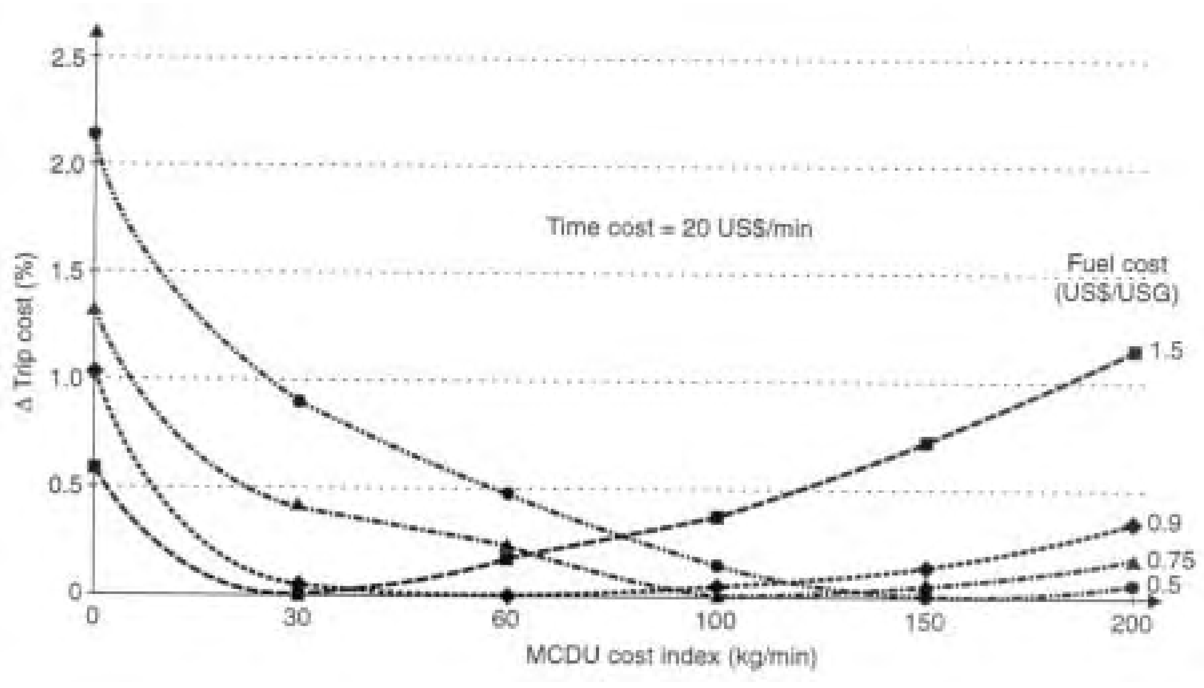


Figure 8. Δ Trip cost = f(CI)

A319/A320/A321
(All models)

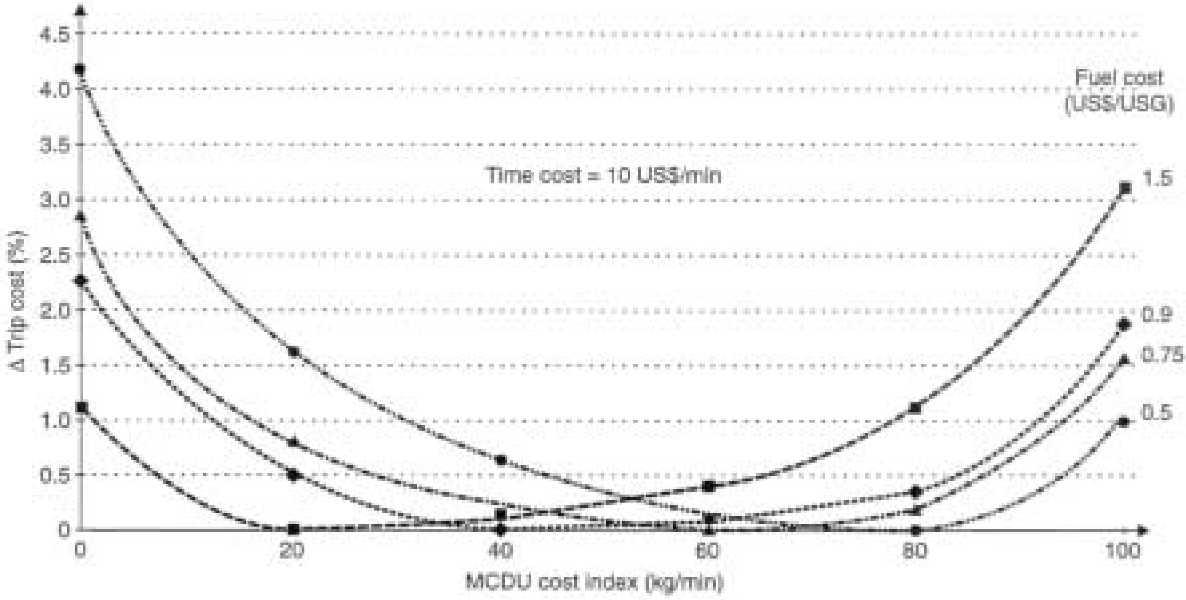


Figure 9. Δ Trip cost = f(CI)

A330
(All models)

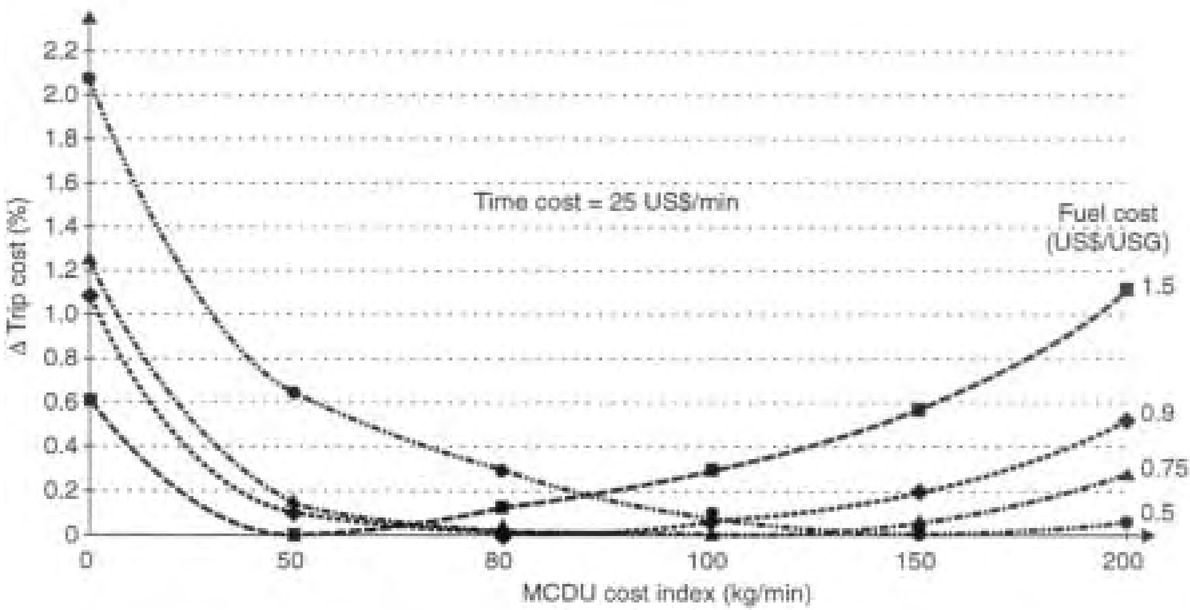
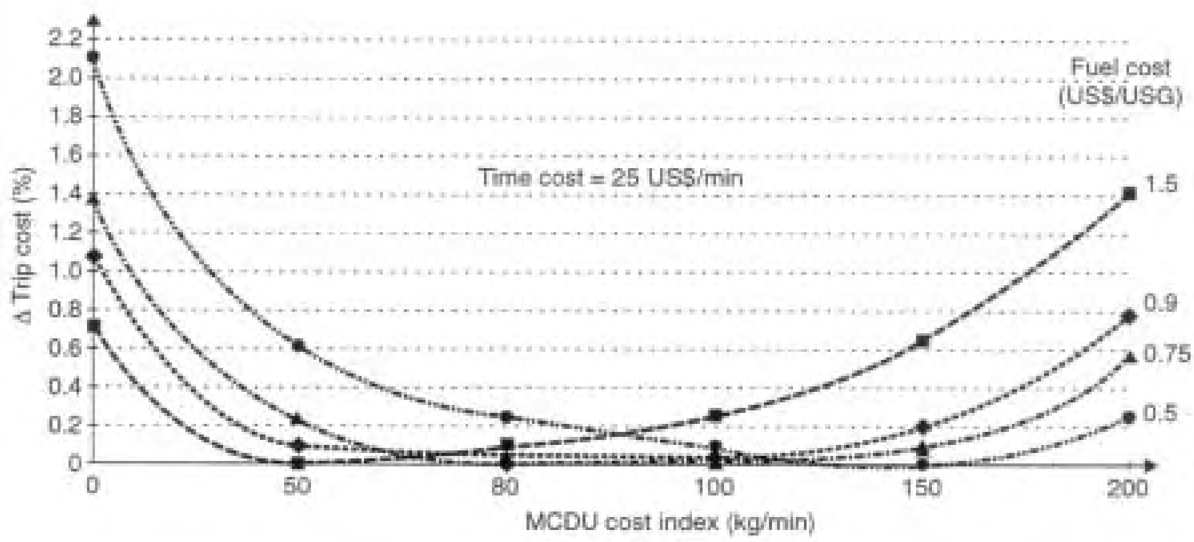


Figure 10. Δ Trip cost = f(CI)

A340
(All models)



In a similar manner, we notice that the lower the fuel price, the higher the cost index corresponding to the minimum trip cost (different minima for each fuel price value).

Moreover, we also appreciate that a fuel price variation of 0.25 U$/USG may lead to a trip cost increase of up to 1% if not properly taken into account.

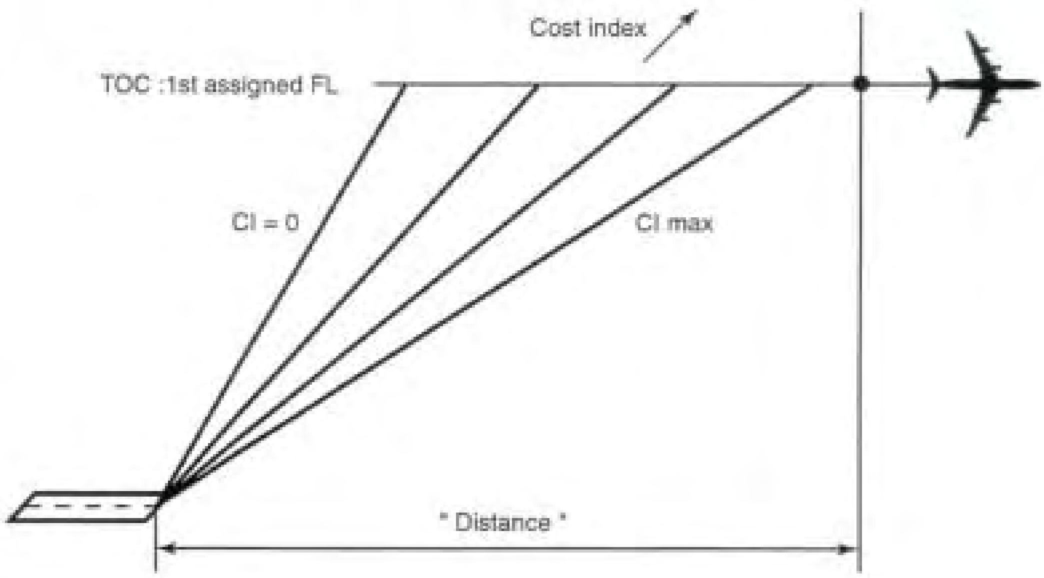
To sum up, and considering average time-related cost for each aircraft type, we can say that fuel prices are indeed rather influential in cost index determination especially when their value exceeds 1 US$/USG (see preceding graphs).

5. CLIMB PERFORMANCE VERSUS COST INDEX

5.1 Cost index - climb profile relationships

Let us consider the influence of the cost index on the climb profiles shown in the following graph. We can readily appreciate how the FMS computes the Top of Climb (TOC) as a function of the cost index.

Figure 11. Climb profiles



Fuel and Time to "Distance" (e.g. 150 or 200nm) is also a good indicator

We notice that the higher the cost index :

- **the shallower the climb path (the higher the speed),**
- **the longer the climb distance,**
- **the farther the Top of Climb (TOC),**

In order to be more accurate, we have to review the cost index influence on climb for each aircraft type, and this is done in the following two sections.

5.2 Variation of climb parameters with the cost index

The following Table 6 shows the different relevant accurate climb parameters (time, speed, fuel, distance...) computed by in-flight performance software (not FMS computation) for the A300, A310, A320, A330 and A340. The A340 case is considered more particularly in the next section because its climb CAS is not a cost index function.

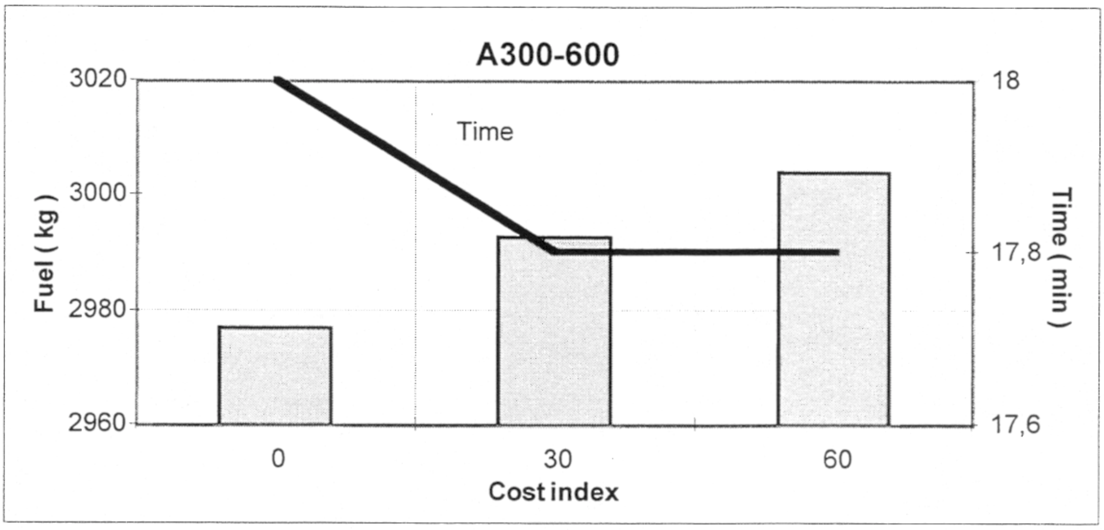
Table 6. Climb parameters to FL330
(ISA conditions, no wind)
(250kt up to FL 100)

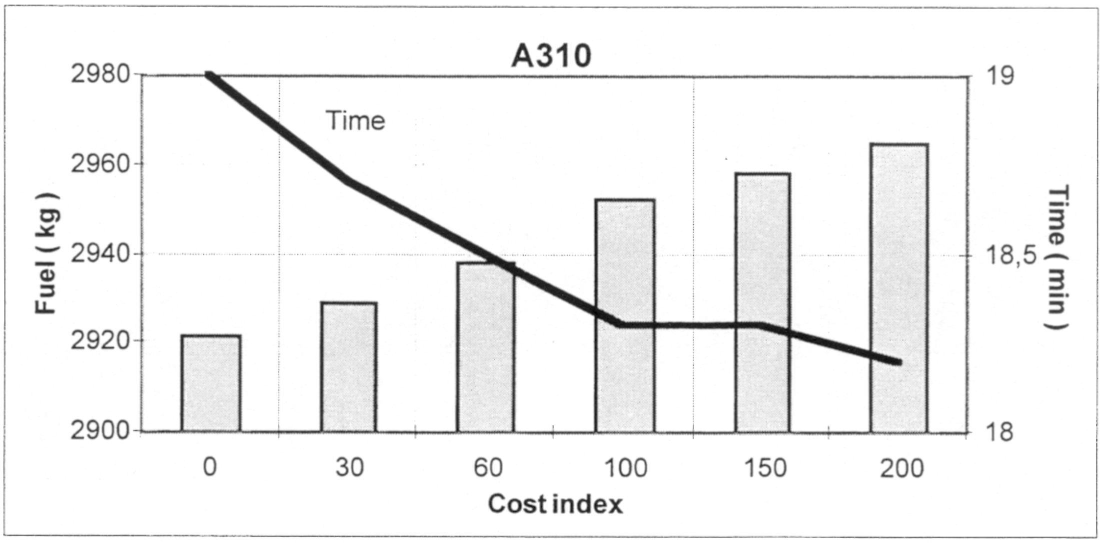
Climb parameter to FL 330 (ISA condition, no wind, 250kt up to FL 100)

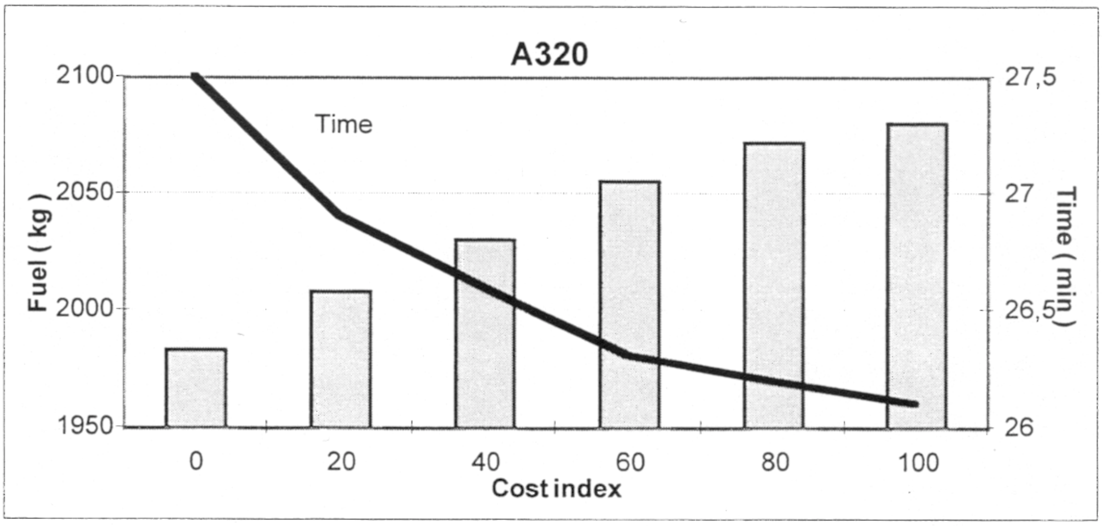
AIRCRAFT TYPE (T/OFF weight)	COST INDEX (Kg/min)	ONLY CLIMB SEGMENT			CLIMB WITH CRUISE SEGMENT		CAS/MACH	RATE at TOC (ft/min)
		FUEL (Kg)	TIME (min)	DISTANCE (NM)	FUEL (Kg)	TIME (min)		
A 300-600	0	2891	17	115	2977	18	320 / .777	869
(PW 4158)	30	2959	17,5	119	2993	17,8	325 / .791	842
(150 000 Kg)	60	3004	17,8	122	3004	17,8	325 / .800	810
A 310	0	2787	17,4	114	2922	19	302 / .791	1037
(CF6-80)	30	2833	17,6	118	2929	18,7	311 / .800	1024
(140 000 Kg)	60	2870	17,7	121	2938	18,5	320 / .803	1009
	100	2920	17,9	124	2952	18,3	330 / .807	991
	150	2942	18,1	125	2958	18,3	330 / .811	968
	200	2965	18,2	127	2965	18,2	330 / .814	936
A 320	0	1757	22,4	150	1984	27,5	308 / .765	584
(CFM 56)	20	1838	23,1	159	2009	26,9	321 / .779	566
(75 000 Kg)	40	1897	23,7	165	2030	26,6	333 / .783	550
	60	1980	24,7	175	2056	26,3	340 / .791	506
	80	2044	25,6	183	2072	26,2	340 / .797	461
	100	2080	26,1	187	2080	26,1	340 / .800	439
A 330	0	3568	19,07	122,3	3927	23	293 / .761	963
(PW 4168)	50	3773	20,02	134,6	3984	22,2	309 / .800	943
(200 000 Kg)	80	3886	20,5	141	4018	21,8	320 / .812	917
	100	3927	20,74	143,3	4031	21,8	320 / .818	896
	150	4005	21,25	147,8	4053	21,7	320 / .827	837
	200	4068	21,68	151,5	4068	21,7	320 / .833	786
A 340	0	5363	25,4	168	5532	26,8	298 / .793	503
(CFM56)	50	5450	26	172	5551	26,7	298 / .805	485
(250 000 Kg)	80	5492	26,2	174	5560	26,7	298 / .810	475
	100	5510	26,3	175	5563	26,7	298 / .812	469
	150	5547	26,5	177	5570	26,7	298 / .816	457
	200	5574	26,7	178	5574	26,7	298 / .819	447

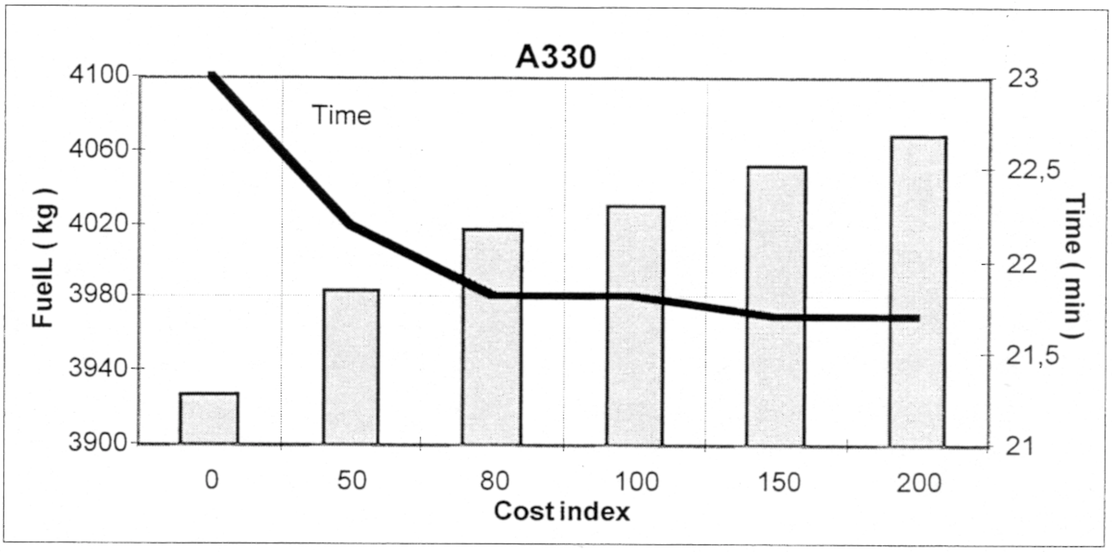
Since these values vary very much with flight conditions (first assigned flight level, takeoff weight, temperature, wind...) the most representative values are the delta time, delta distance values between different cost indices and these are almost invariable even with different external conditions.

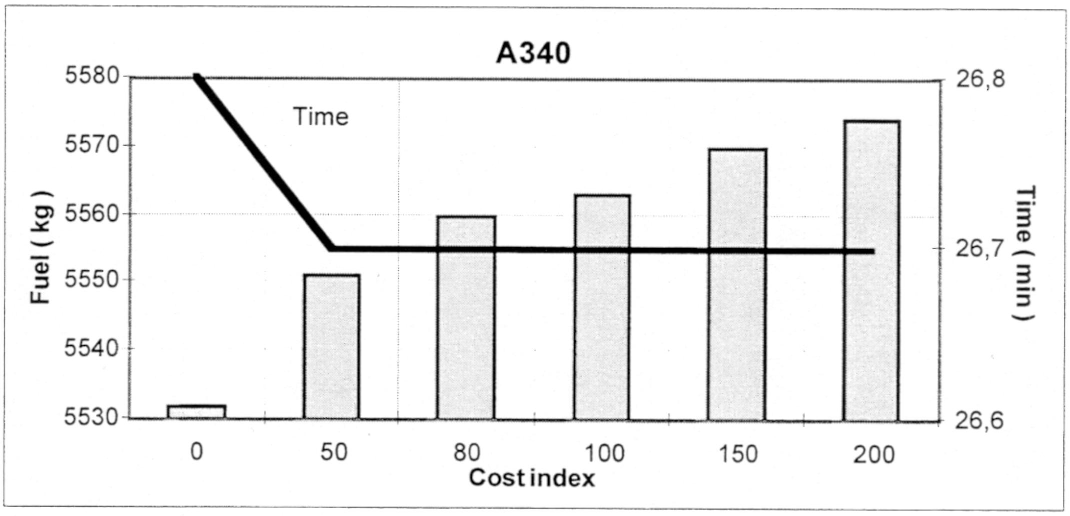
Figure 12. Climb parameter to the same point in cruise (FL 330, ISA conditions, no wind, 250kt up to FL 100)








A330
Time
4100
4060
4020
3980
3940
3900
FuelL (kg)
23
22,5
22
21,5
21
Time (min)
0
50
80
100
150
200
Cost index


A340
Time
5580
5570
5560
5550
5540
5530
Fuel (kg)
26,8
26,7
26,6
Time (min)
0
50
80
100
150
200
Cost index

First of all, we note that time to climb is only slightly affected by the cost index (less than 1 minute) for the A300 and A310 (whatever the engine) between low and high cost indices.

This time difference is higher, however, for the A330 and especially for the A320 (up to 3 minutes) since both the range of climb CAS and climb Mach are rather larger for these two aircraft.

However, to have a representative comparison of these different climb strategies, we have to include the short cruise segments between the "low cost index TOC" and the "high cost index TOC" (see climb profile graph).

The following Table 7 provides parameters and differences in terms of time and fuel at the same geographical point (corresponding to the furthest TOC) thereby summarizing the array of possible climb laws between CI=0 and high cost indices.

Table 7. Climb to FL 330

	Time (min) / Fuel (kg) at farther TOC				**Difference between low and high cost index**	
	CI = 0		High cost index		**Time gain**	**Fuel increment**
A300-600	18.0	2977	17.8	3004	**10 s**	**30 kg**
A310	19.0	2922	18.2	2965	**50 s**	**40 kg**
A320	27.5	1984	26.1	2080	**1 min 30 s**	**100 kg**
A330	23.0	3927	21.7	4068	**1 min 20 s**	**140 kg**
A340	26.8	5532	26.7	5574	**10 s**	**40 kg**

As a general conclusion, we can say that climbing at low cost index is only worthwhile if time to climb is really essential (FL competition, ATC requirement...) since the difference in terms of costs between low and high cost index climbs is very small.

5.3 A340 practical case

Contrary to the A300, A310, A320 and A330, the A340's cost index is only influential on ECON climb Mach but not on ECON climb IAS; the ECON climb Mach corresponding to the ECON cruise Mach at TOC.

The ECON climb IAS is also a function of take-off weight and inserted FL only :

- **the higher the FL, the lower the speed,**
- **the higher the aircraft gross weight, the higher the speed.**

As shown in Figure 13 and in Table 8 for managed climb at high cost indices, time to climb may be affected when the first requested FL is rather high (higher than optimum) and especially in hot conditions.

Figure 13. Time to climb to FL 350 versus CI

A340-311/CFM56-5C2

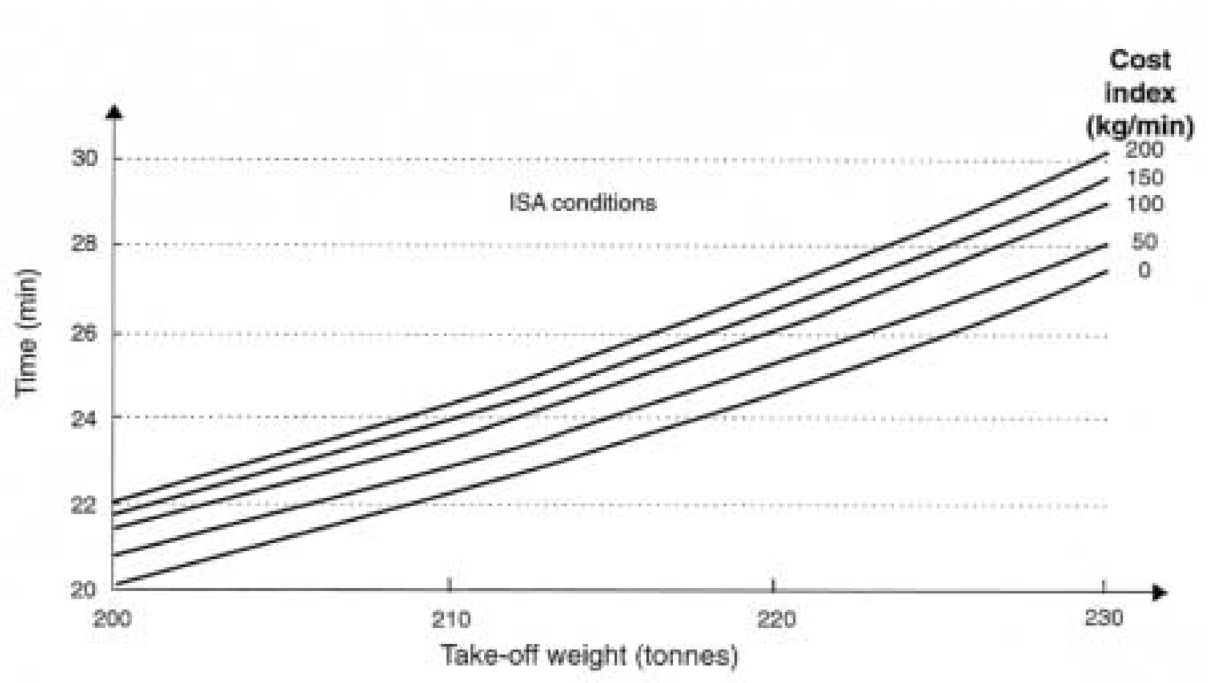


Table 8. Climb to FL 350 according to CI (Load 6)
A340-311 /CFM56-5C2
TOW : 230 tonnes
ISA conditions

COST INDEX (kg/min)	TIME (min)	DISTANCE (nm)	FINAL MACH (MN)	FUEL (kg)	FINAL RATE at TOC (ft/min)
0	27.4	181	0.783	5200	470
50	28	187	0.800	5300	460
80	28.6	192	0.808	5400	440
100	29	195	0.812	5450	430
150	29.5	200	0.818	5530	400
200	30	205	0.823	5620	360

- In order to be as close as possible to the **minimum time to climb** without compromising distance to climb, nor reaching too low a Mach Number, **IAS/MACH CLIMB schedules, corresponding to the best rate of climb, were defined as shown in the tables of Appendix 4.**

  The three tables shown in Appendix 4 for respectively the A340-311, -312, -211, and -212, for the A340-313 and A340-313E, indicate the preselected climb IAS to be entered and the resulting Climb MACH, corresponding to the FMS output displayed in small font on MCDU PERF CLIMB page.

- The preselected climb speed mode allows the introduction of a IAS only, the climb Mach then being computed against this IAS. With these tables it is therefore possible to choose the preselected IAS and ECON CLIMB MACH before these are to be part of FMGEC Load 7 when available later in 1997.
- The Tables of Appendix 4 are limited by the Max Altitude in ISA conditions. However, the speeds provided are available for any temperature. In ISA deviation conditions, Cruise Altitude has to be limited by the FMGS predicted Max Altitude.
- **In order to perform strict <u>minimum distance to climb</u>, green dot should be selected or an altitude constraint should be inserted on a waypoint in the FMS.**

6. OPTIMUM ALTITUDE FOLLOW-UP

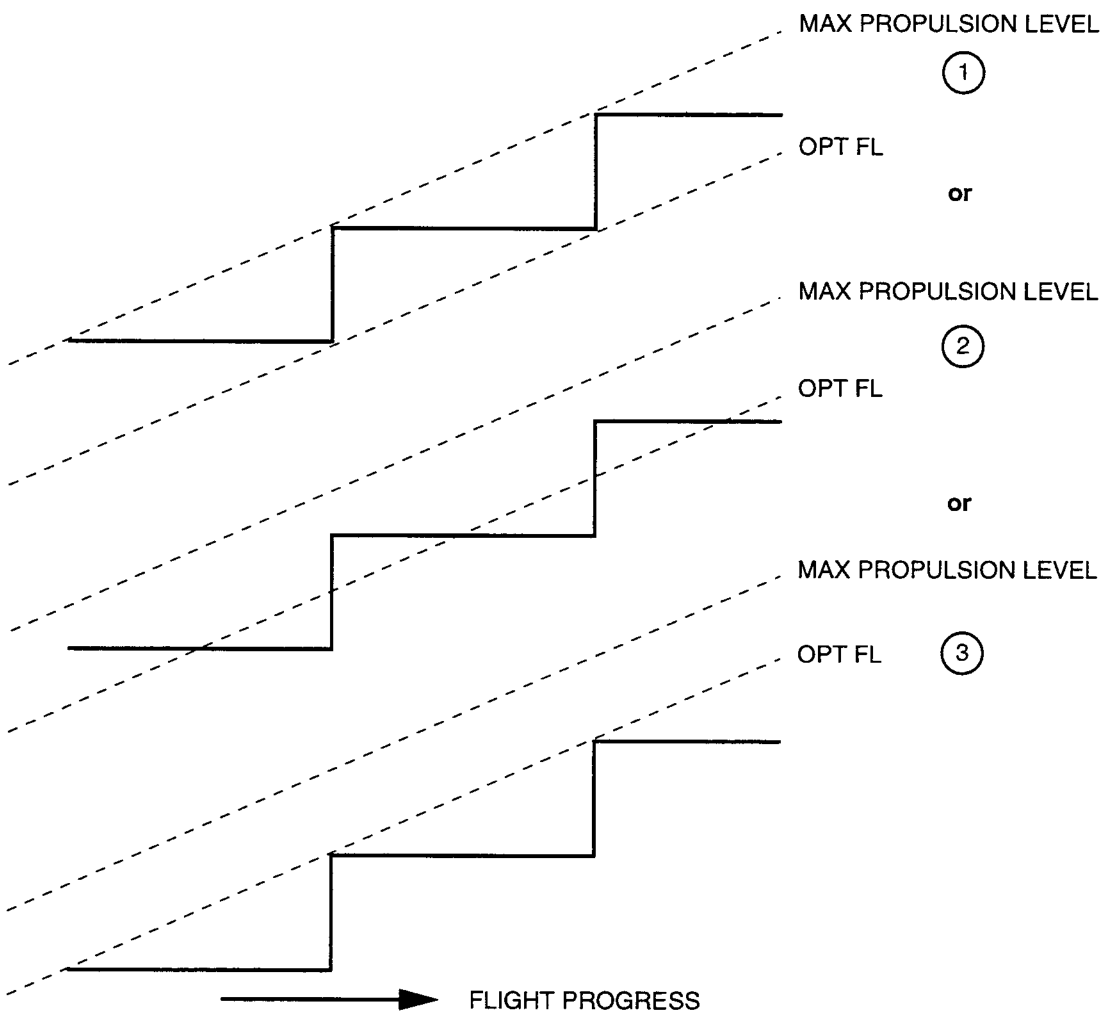
6.1 Trade-off between manoeuvrability and economy

In general, numerous parameters such as weather conditions or ATC requirements could influence any decision made by the crew, with regard to three fundamental priorities :

- manoeuvrability
- comfort
- money saving economy

This pertains to the choice of the cruise FL which can be made according to the following three climb profiles between optimum and maximum altitude

Figure 14.



- **best order for improved manoeuvrability margins : 3, 2, 1**
- **best order for money saving economy : 2, 3, 1**

Contrary to some opinions, solution ① is neither worthwhile for comfort nor for economy. Other considerations could lead to a higher FL being chosen for meteorological or operational reasons but, in any case, flying above optimum altitude commands particular attention.

On all Airbus FMS-equipped aircraft, OPT FL (taking into consideration aircraft gross weight, cost index (i.e speed), wind...) and MAX FL are displayed in the MCDU progress page. The recommended MAX FL in the FMGC ensures a 0.3 g buffet margin, a minimum rate of climb of 300 ft/min at MAX CLIMB thrust as well as level flight at MAX CRZ thrust. The 1.3 g maximum altitude is always above maximum propulsion altitude.

The pilot has to manage step climbs according to traffic, ATC requirements and values of OPT and MAX FL which differ according to the following values for each Airbus type :

Table 8 bis. OPTIMUM and MAXIMUM altitude

Types	**Approximate difference between OPT and Max FL**
A300/A310	4000 ft
A319	4000 ft
A320	3000 ft
A321	3500 ft
A330 GE	3500 ft
A330 PW	3500 ft
A330 RR	3000 ft
A340	2500 ft

Furthermore, a 4000ft step climb between OPT -2000ft and OPT+2000ft is to be performed when possible, when to minimize fuel consumption by choosing cruise FL segments as close as possible to the OPT FL.

Since step climbs are performed in 4000ft altitude increments and since we aim to follow solution ② (average between OPT and MAX FL), respective margins to 1.3g buffet limits are as for the various models.

By way of example, the best compromise between comfort and economy for the A340 is to step climb when reaching OPT FL -3000ft in order to level off at OPT FL +1000ft.

This step climb scenario is obviously not always feasible due to ATC traffic constraints and external environment such as turbulence.

With the advent of FANS (Future Air Navigation System), the lateral track clearance will greatly facilitate using this optimization possibility by means of the offset option available on every FMS.

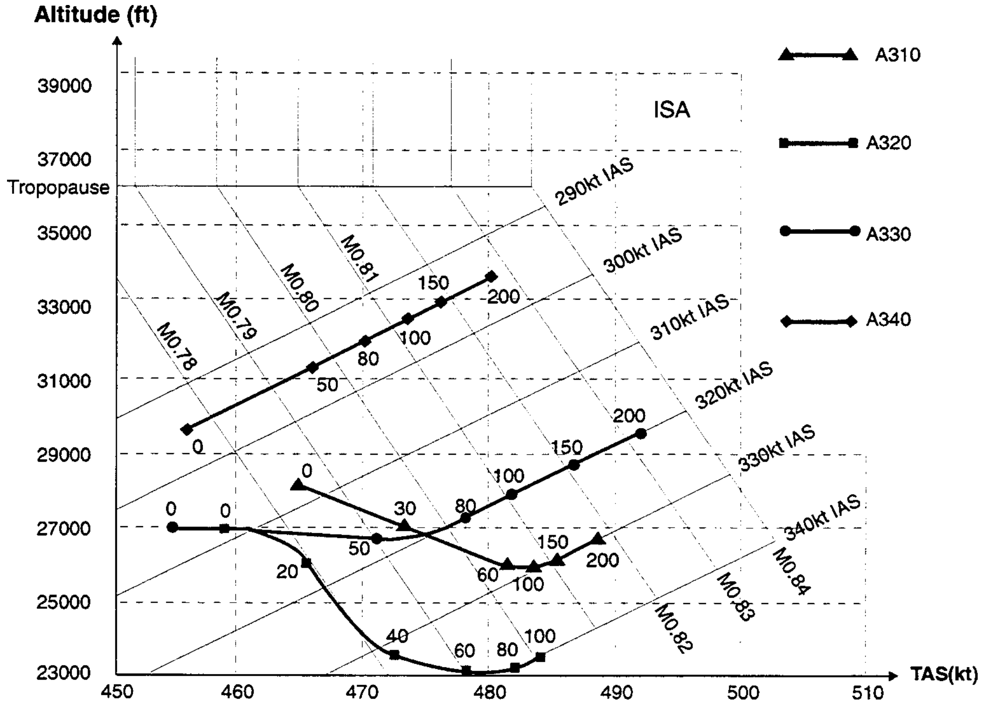
6.2 Cross-over altitude versus optimum altitude

As per definition, the cross-over altitude is the altitude at which the climb law switches from Indicated Air Speed (IAS) to Mach speed (MACH).

For managed climbs on A320, A330, A340, the cross-over altitude varies with the cost index because of its influence on climb speeds.

The following Figure 15 is based on high take-off weights (MTOW -10t < TOW < MTOW). It illustrates the evolution of the cross-over altitude with the cost index for each Airbus type, summarizing climb laws with regard to IAS/MACH and True Air Speed (TAS).

Figure 15. Cross-over altitude = f (cost index)



For ISA deviations the following can be observed

* Temperature correction :
For Upper Information Region (UIR) flight levels and TAS ranges (between 400 and 500kt), the TAS varies according to a simple rule :
- plus 1 kt per degree Celsius above ISA
- minus 1 kt per degree Celsius below ISA.

* Tropopause correction :
- In case of "high tropopause" (above FL 360), the figure shown above remains principally the same in terms of TAS advantage at cross-over altitude.
- In case of "low tropopause" (below FL 360), the TAS advantage, especially on A340, is no more advantageous if the tropopause altitude is below cross-over altitude since TAS will be constant (and much lower) from there on.

As per definition the Optimum Mach Number is a MN which remains greater than MRC and lower than LRC over the entire range of a typical cruise operation in terms of gross weight and altitude. The Optimum FL, for this Optimum MN, is the flight level which provides the greatest specific range (nm/kg) at a given gross weight. The Optimum FL increases with decreasing gross weight, as illustrated in the FCOM.

By design choice, and contrary to the rest of the Airbus fleet, the cost index has no influence on the climb IAS for the A340.

We also notice that, at cross-over altitudes, all aircraft demonstrate the best TAS since thereafter TAS decreases (up to the tropopause and is constant from there on) and since climb speed then becomes ECON MACH.

Let us now compare this cross-over altitude (taking into account an average altitude for the practical range of cost indices) to the first optimum altitude (considering a take-off weight close to the maximum authorized : i.e. between MTOW -10 tonnes and MTOW).

Types	CROSS-OVER altitude (average)	1st OPTIMUM FL (≤ ISA+10)	1st OPTIMUM FL (ISA+20)
A300	26000 ft	300	280
A310	27000 ft	330	310
A319	29000 ft	370	340
A320	29000 ft	360	340
A321	29000 ft	340	310
A330 GE	31000 ft	370	340
A330 PW	31000 ft	370	360
A330 RR	31000 ft	370	370
A340	32000 ft	330	320

Due to its particular climb speeds, the A340 cross-over altitude (well above the others) corresponds exactly to the first optimum FL for high take-off weights, whereas the optimum altitude is well above the cross-over altitude for all the other aircraft.

This leads us to consider the cost strategy case of the A340 in Section 6.3 herebelow because of its pre-eminent TAS advantage at cross-over altitude (around FL320).

On the other Airbus models this TAS advantage is never predominant compared to the accompanying fuel increment. This is due to the significant altitude difference (from 6000ft up to 9000ft) between optimum and cross-over altitude. By way of example we can indicate respectively the A320 and A330 families as consuming some 1000kg extra for a time gain of 5 to 8 minutes when climbing straight to the crossover altitude on typical and respective stage lenghts of 2000 and 3000 Nm.

In short, there is every reason for us to take the time factor into account in initial step climb management. The concern for fuel will receive priority thereafter.

To summarize this we can say that :

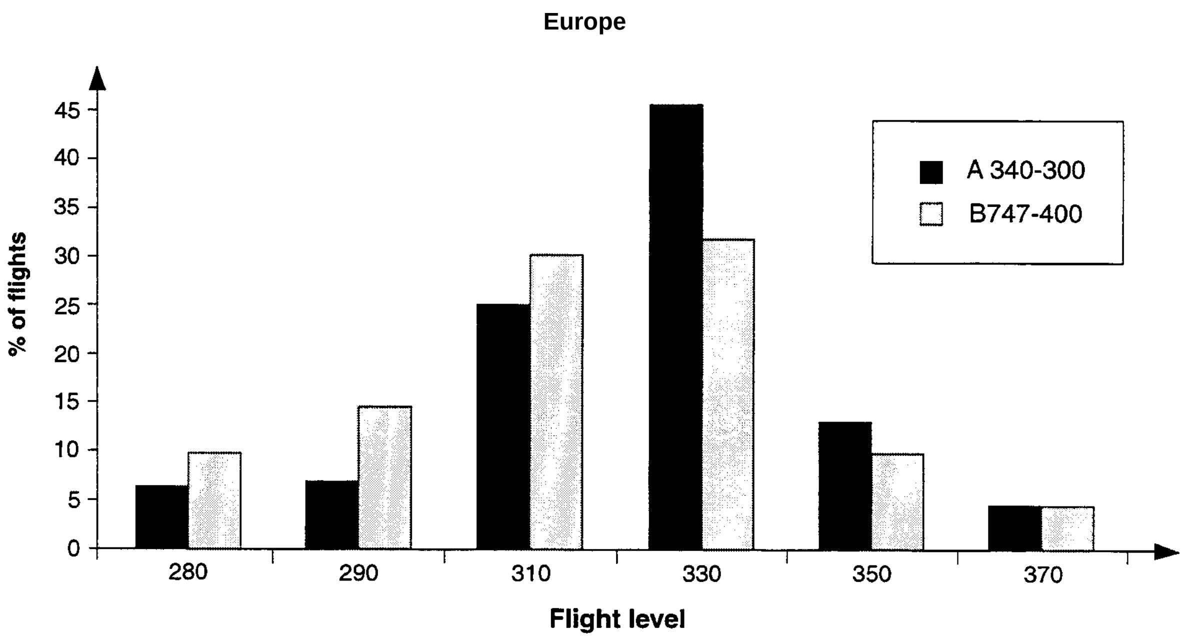
- On models other than the A340, the OPT altitude being higher than the cross-over altitude, the emphasis must immediately be placed on fuel economy (i.e, following scenario ② from the outset even for the very first cruise flight level).
- On the A340 models the OPT altitude being the same as the cross-over altitude, the emphasis should rather be placed on time economy as no real advantage can be gained from fuel economy until further into the flight.

6.3 Best cost strategy : A340 application

(a) Climb capability

In practice and contrary to some opinions, the A340 does climb straight to higher levels than its immediate competitor.

Figure 16. First assigned FL



Source : EUROCONTROL

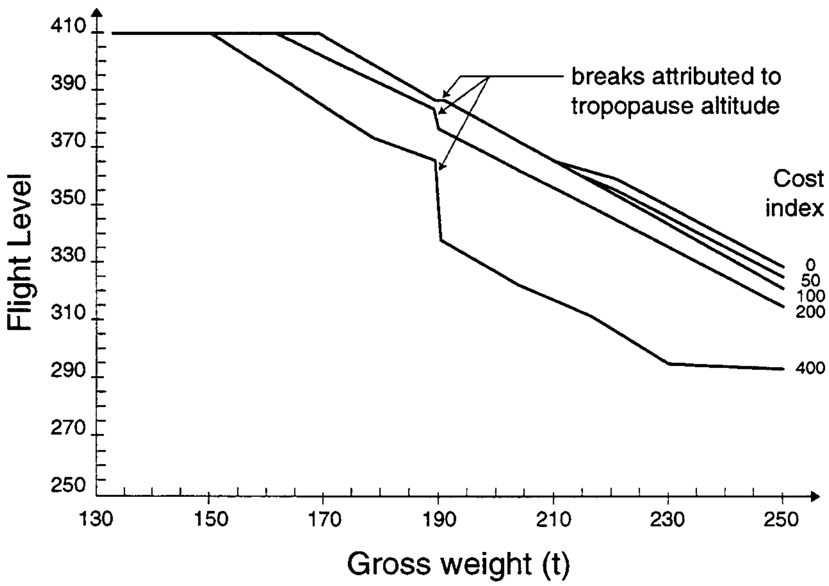
The following Table 9 provides a good approximation of optimum and maximum flight level for a Mach Number of 0.82 (< ISA +10).

Table 9. A340-311/CFM56-5C2

GROSS WEIGHT (t)	OPT FL	MAX FL (FMS)
250	310	330
230	330	350
220	350	370
200	370	390
180	390	410
170	410	410 (max certified)

Optimum altitude is also a function of the cost index but its influence will only be significant for values in excess of 200 (see Figure 17).

Figure 17. A340 OPT FL = f(CI)



For high TOW (above 230t) it is not worth climbing direct to max flight levels (e.g. FL 350 or 370), especially in hot conditions due to or because of :

- increased time of climb (above OPT FL)
- higher fuel consumption (above OPT FL)
- lower TAS.

If we consider still air or constant wind conditions, whatever the level, fuel consumption increases approximately as shown in Table 10.

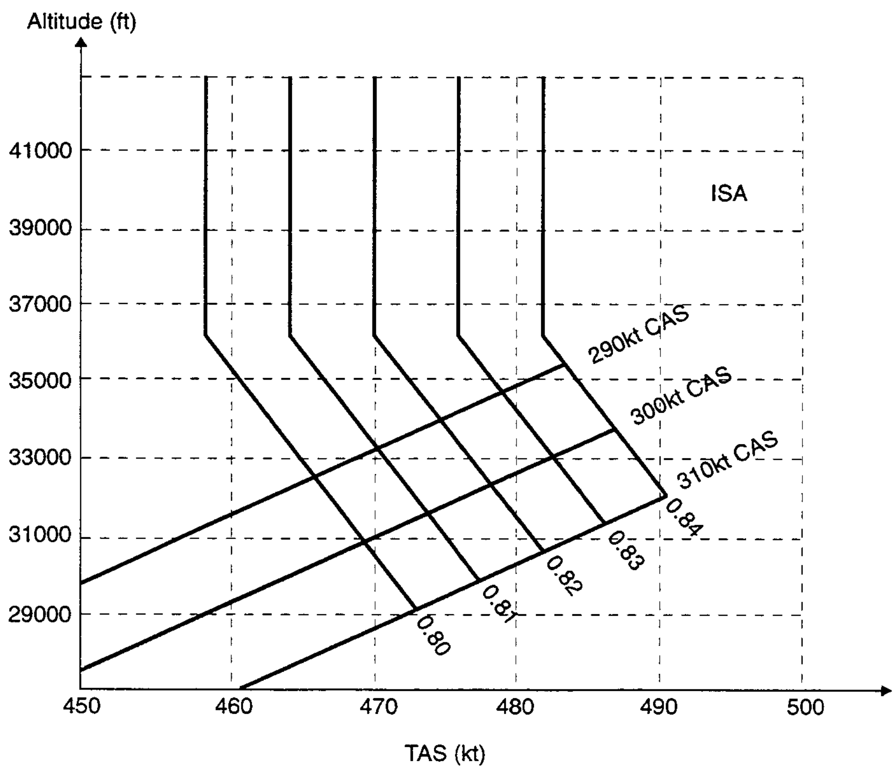
Table 10. A340-311/CFM56-5C2

FLIGHT LEVEL	FUEL INCREMENT
OPT + 2000ft	+ 1.5 %
OPT FL	-
OPT - 2000ft	+ 1.5 %
OPT - 4000ft	+ 3 %

(b) Cost factor in the choice of optimum altitude

Moreover, at the beginning of the flight it is also more interesting to stay at lower flight levels to take profit of better true airspeeds as indicated in Figure 18.

Figure 18. CAS/TAS/MACH profiles



This can amount to some 10 to 15kt (or approximately 2 minutes per hour) depending on Climb Mach Number and Climb CAS. This assumes that there is no FL competition or no subsequent risk of being restricted to the first assigned flight level.

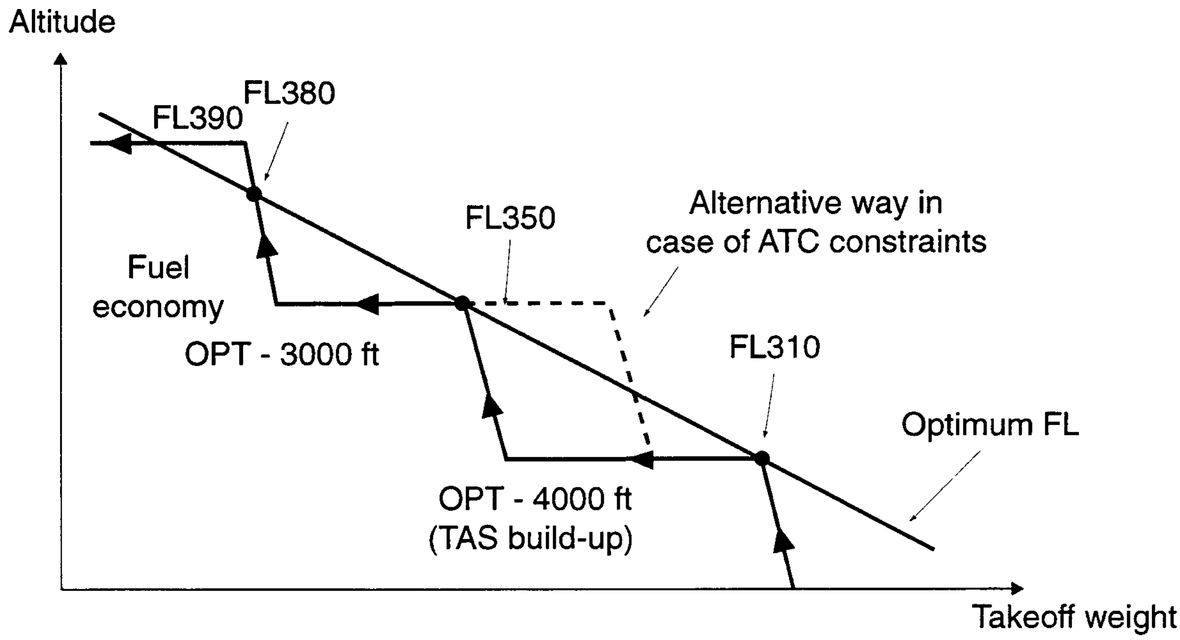
Practically, the following can be said to summarize :

- There is no gain in climbing above OPT FL +2000 ft, either in terms of fuel consumption or time, except in case of subsequent ATC flight level constraints.
- As already shown in Table 9, one should avoid staying below OPT FL -3000 ft but rather choose OPT FL +1000 ft, especially in case of heavy traffic.
- The best strategy is to perform :

  (a) a 4000 ft step climb when reaching OPT FL -4000 ft at low FL (290, 310, 330), which will help make TAS and mileage, taking about 4 hours to save about 8 to 10 minutes flight time in the process.

  (b) a 4000 ft step climb when reaching OPT FL -3000 ft as graphically shown in Figure 18, to rejoin OPT FL +1000 ft for a higher FL at the end of the flight.

Figure 19. FCOM-type view for optimum altitude follow-up



To give a practical example of the impact of step climbing, we compare below the two flight profiles depicted in Figure 20 with time/fuel calculations shown in Tables 11 and 12.

Figure 20. Comparison of flight profiles

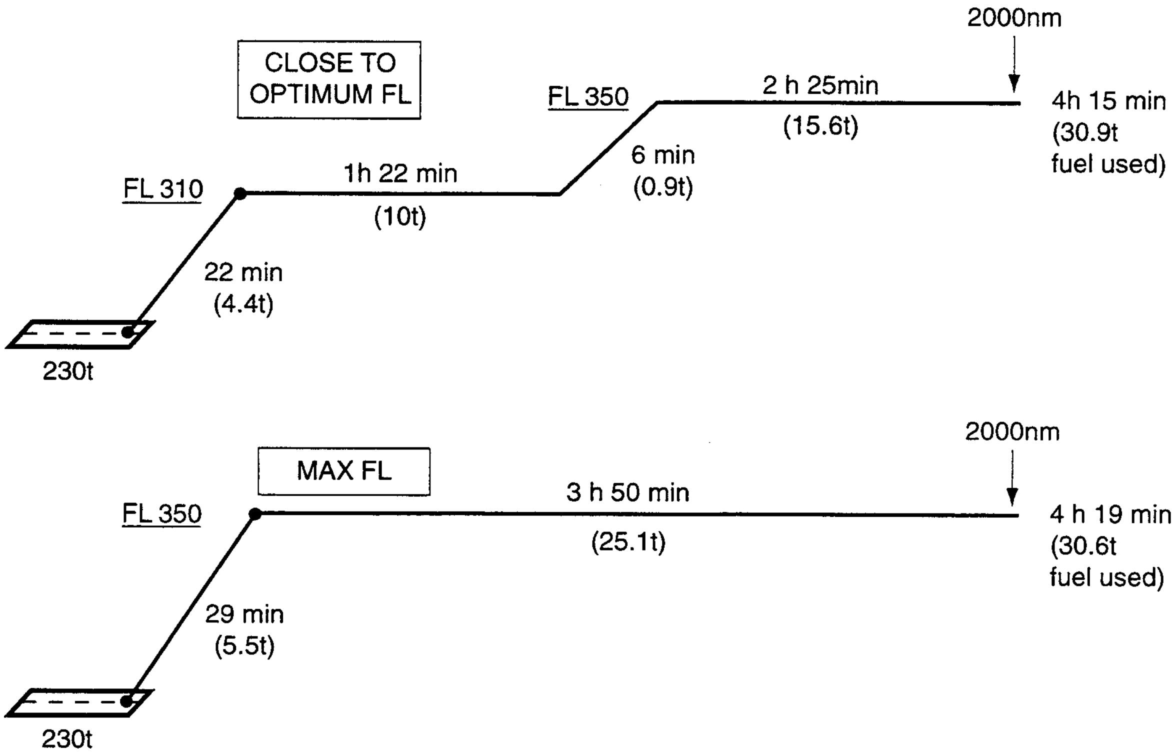


Table 11. Close to optimal FL profile

TOW (t)	Time at FL 310	Time gain at FL 310 (min)	Fuel increment at FL 310 (kg)
230	1 h 30	- 4	+ 300
240	2 h 45	- 7	+ 500
250	4 h 00	- 10	+ 700

Table 12. Maximum FL profile

TOW (t)	Time at FL 310	Time gain at FL 310 (min)	Fuel increment at FL 310 (kg)
230	3 h 00	- 6	+ 800
240	5 h 30	- 11	+ 1400
250	8 h 00	- 18	+ 2000

- Saving 7 minutes but spending 500kg to stay 2 h 45 at FL 310 after taking off at 240t results in :
  - saving 7 x 20 $/min (average CT) = 140$
  - spending 500kg x 0.24$/kg (average CF) = 120$

  → a benefit in time and money, however small.
- Saving 11 minutes but spending 1400kg to stay 5 h 30 at FL 310 after taking off at 240t results in :
  - saving 11 x 20$/min = 220$
  - spending 1400kg x 0.24$/kg = 336$

  → a cost.

To sum up, spending too much time below optimum altitude results in a fuel used/time saved ratio not profitable in terms of costs, but spending the right time (see Table 11) below optimum altitude results in a fuel used/time saved ratio profitable in terms of both time and costs.

If applied for "raw operational judgement" the cost index can be instrumental in facilitating cost-beneficial fuel-time evaluations. This should come as no surprise for a concept that balances time and fuel-related costs.

- Returning to the above example for cases below 230t (240t for models fitted with CFM56-5C4 engine) there is, however, no gain in staying at lower flight levels (FL 310 or 330) because time savings are not worthwhile compared to the fuel increment.

  The best strategy is therefore to climb initially to FL 350 or FL 370 (whether it is a westbound or eastbound flight) to avoid congested flight levels (FL 310 and especially FL 330 when referring to paragraph 6.3.a and figure 16).

7. COST INDEX AND CRUISE MANAGEMENT

The FMS manages cruise speed according to the aircraft gross weight, flight level, wind and of course the cost index. In this chapter we will review the influence of these four parameters on the ECON speed including differences between "selected" and "managed" cruise mode with a view towards adapting the flight towards external conditions.

7.1 Cost index - cruise speed relationship

In general, we can say that, at a given cost index :

- **the higher the flight level, the higher the ECON Mach,**
- **the higher the aircraft gross weight, the higher the ECON Mach.**

The following graphs (ECON Mach=f(CI)) as adapted to each Airbus model will illustrate this point best.

(a) At a given gross weight

On the following figures, we can duly appreciate ECON Mach variation at different cost indices for a range of flight levels.

Figure 21. ECON cruise Mach = f(CI)

A310-324/PW4152

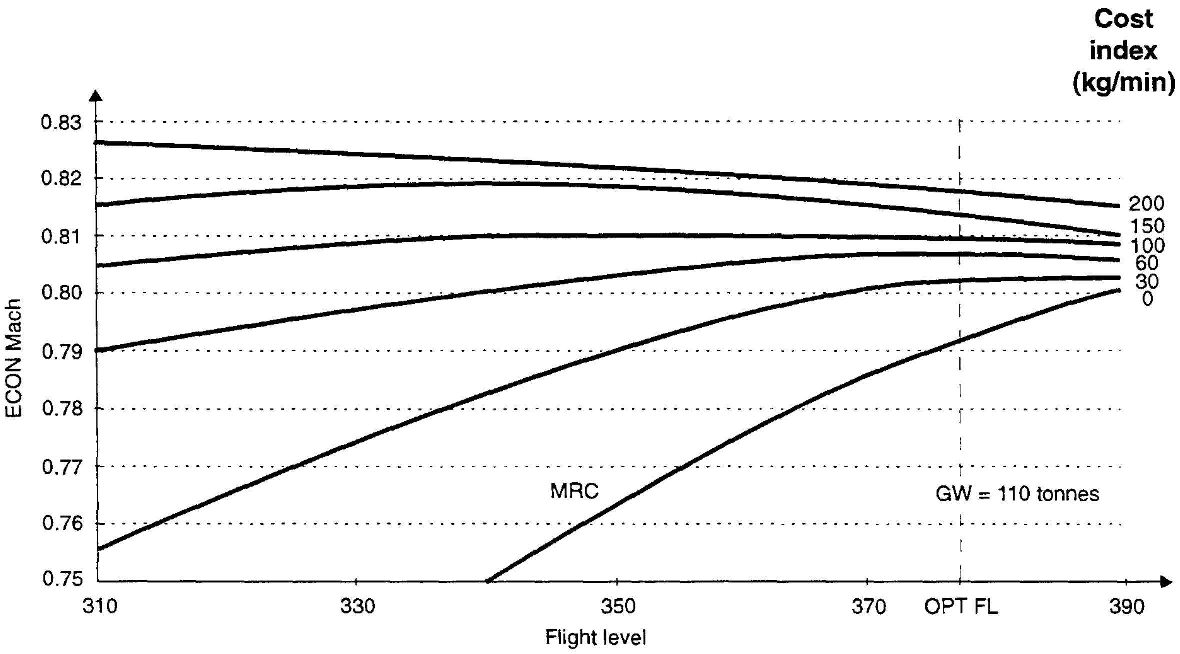


Figure 22. ECON cruise Mach = f(CI)

A320/V2500

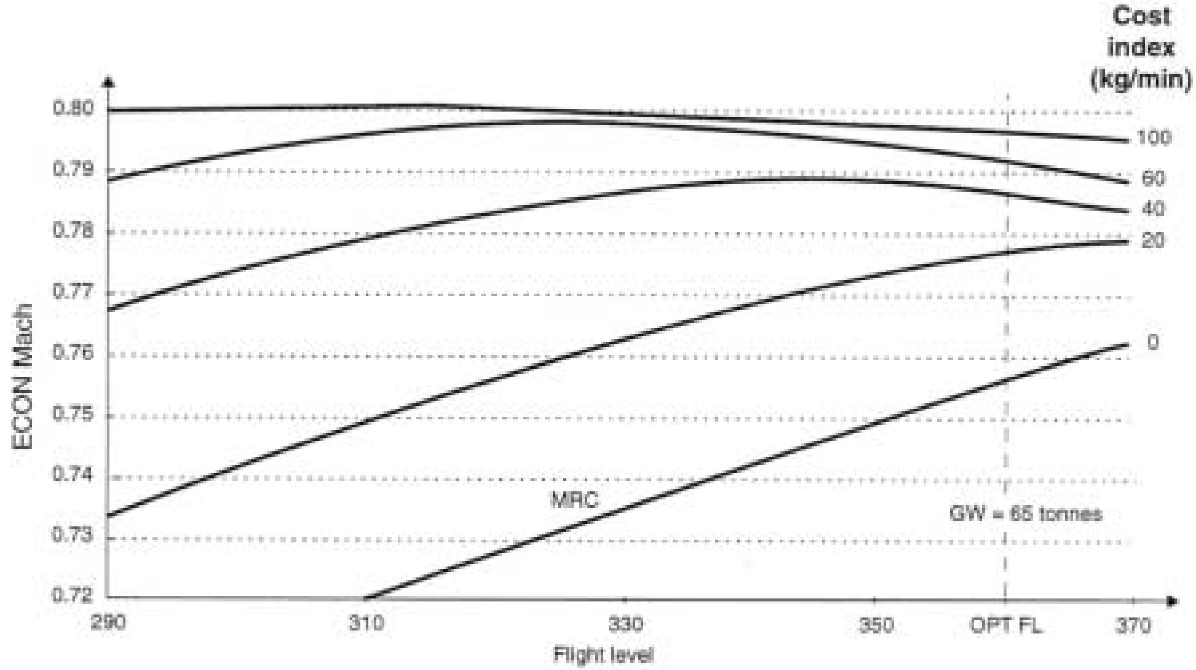


Figure 23. ECON cruise Mach = f(CI)

A330-322/PW4158

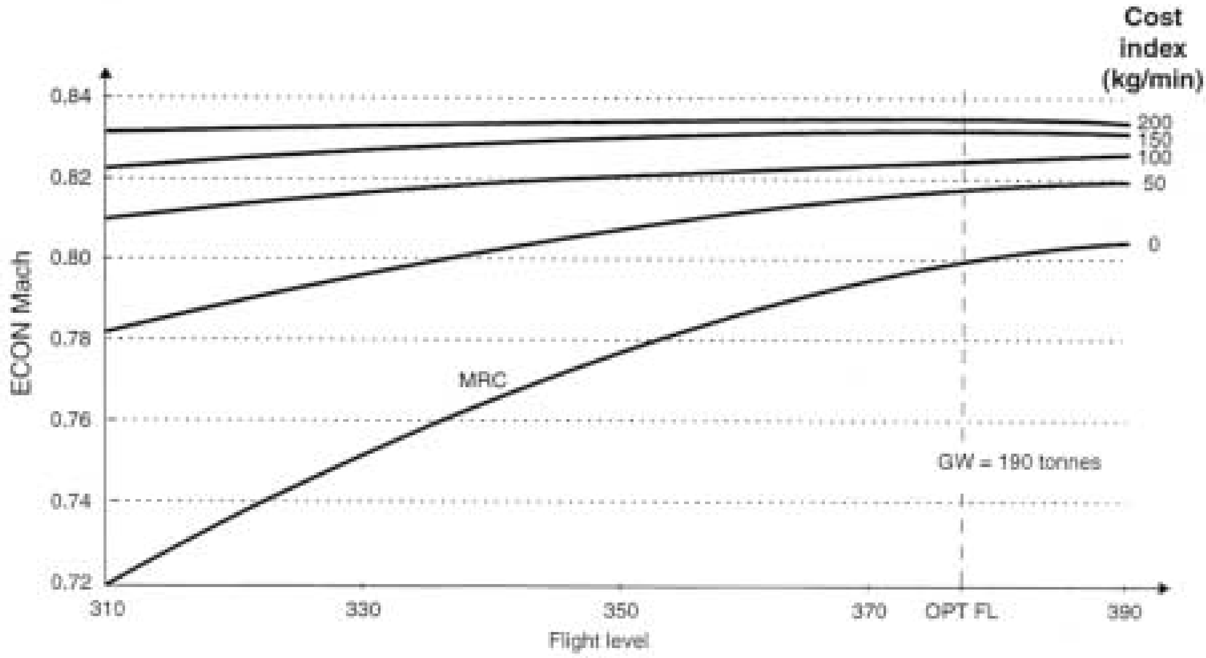


Figure 24. ECON cruise Mach = f(CI)

A340-311/CFM56-5C2

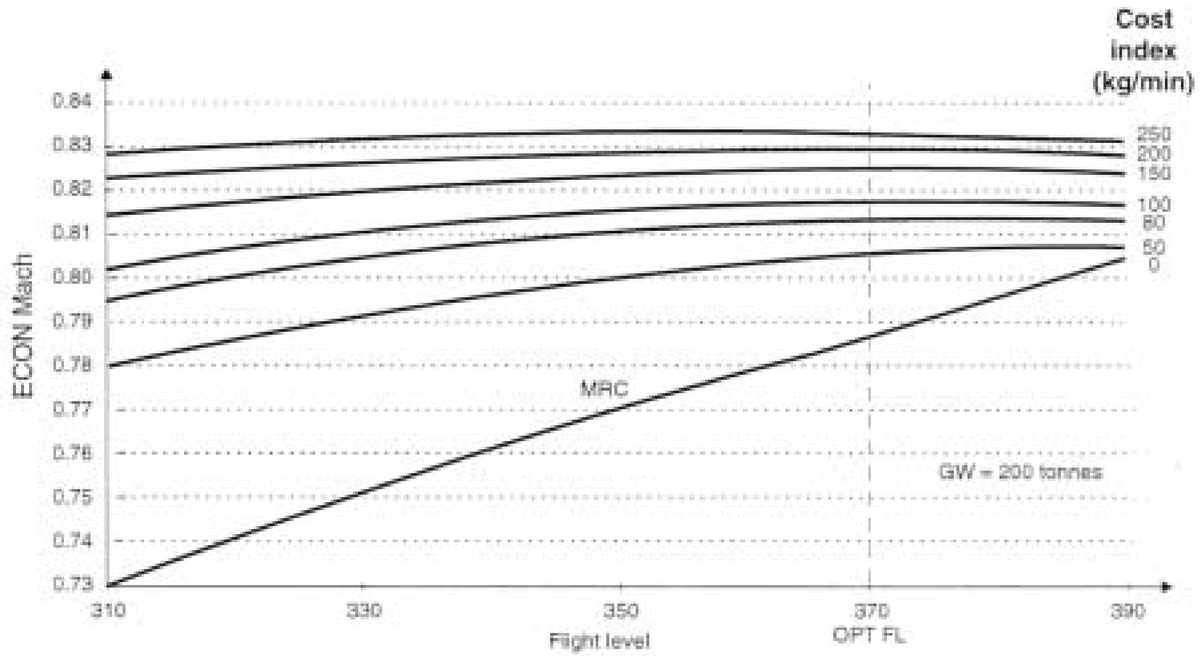
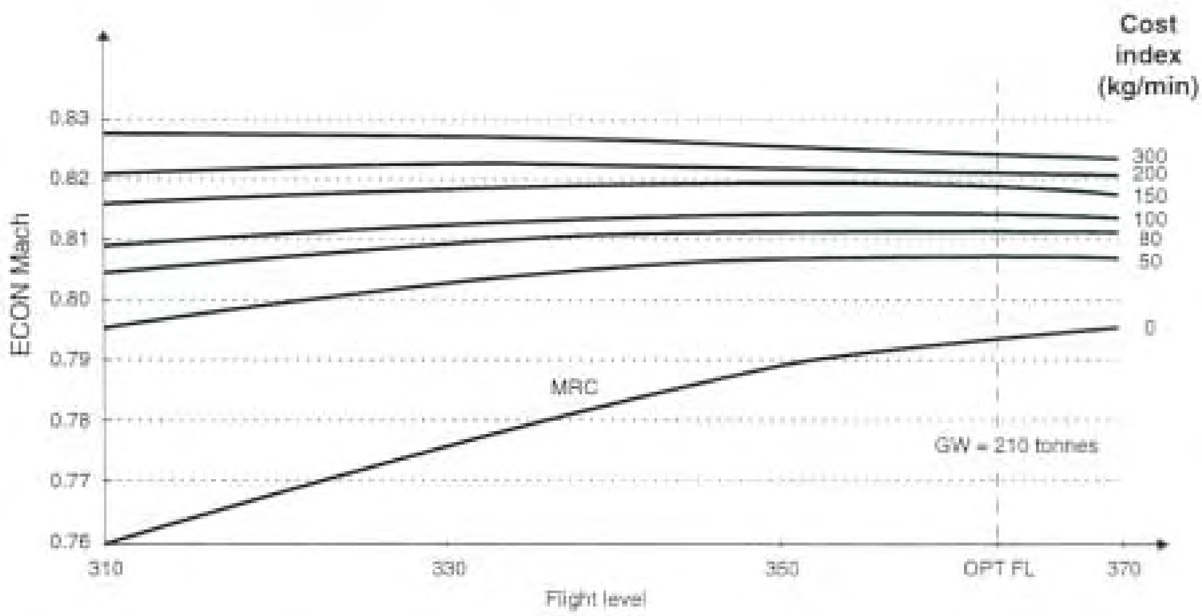


Figure 25. ECON cruise Mach = f(CI)

A340-313E/CFM56-5C4



These figures clearly depict the importance of the optimum altitude follow-up. We can indeed notice that **ECON speed is very sensitive to the cost index when flying below optimum altitude especially for low cost indices,** a sensitivity effect which is rather reduced around and above optimum flight level .

Moreover, optimum speed slowly increases with flight level for higher cost indices resulting in linear Mach variations when performing step climbs.

(b) At a given flight level

The curves below show cruise speed variations at different cost indices as a function of aircraft gross weight. They give a useful indication of ECON Mach variation at a fixed flight level and for a range of gross weights.

Figure 26. ECON cruise Mach = f(CI)

A310-304/CF6-80

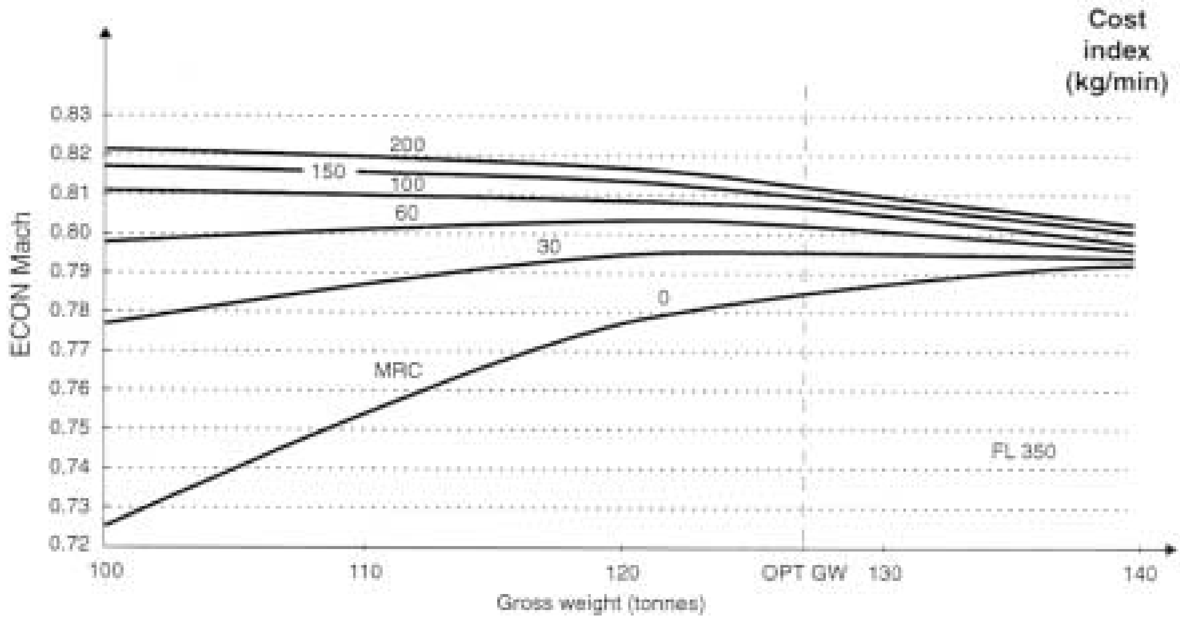


Figure 27. ECON cruise Mach = f(CI)

A320/CFM56

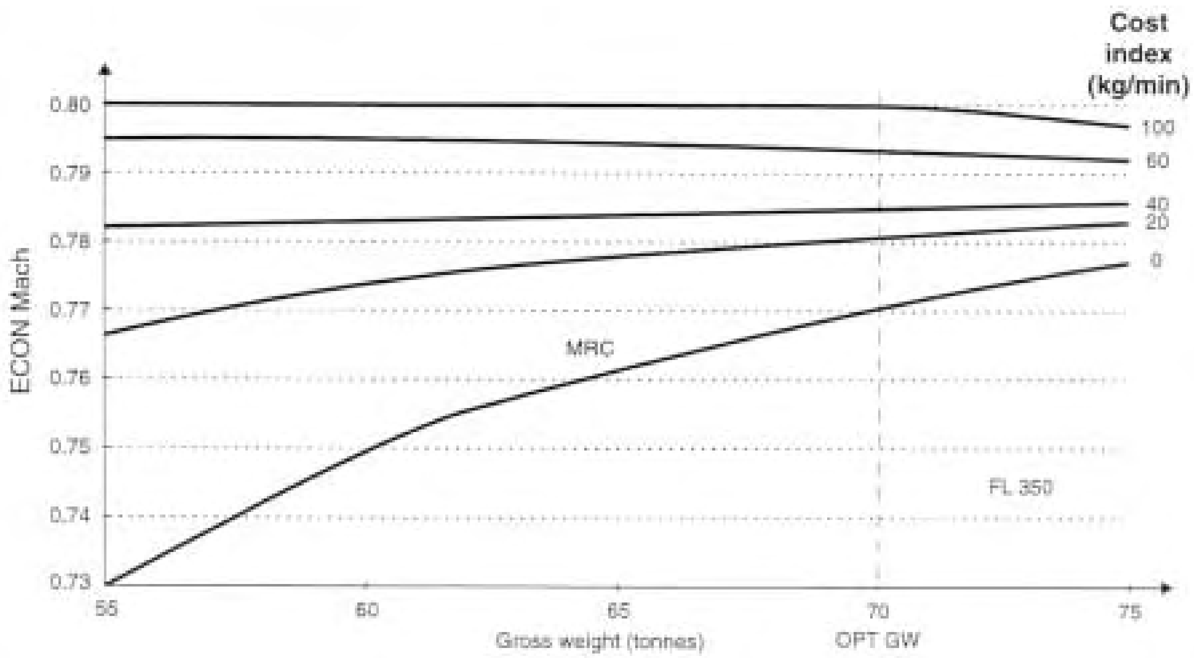


Figure 28. ECON cruise Mach = f(CI)

A330-342/RR772

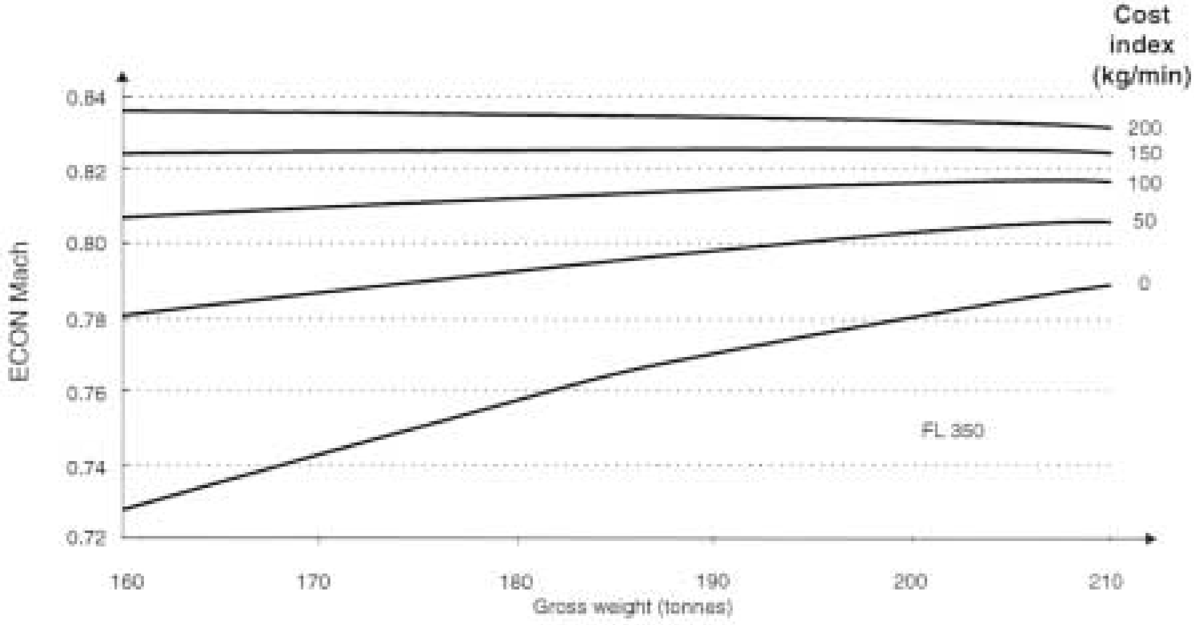
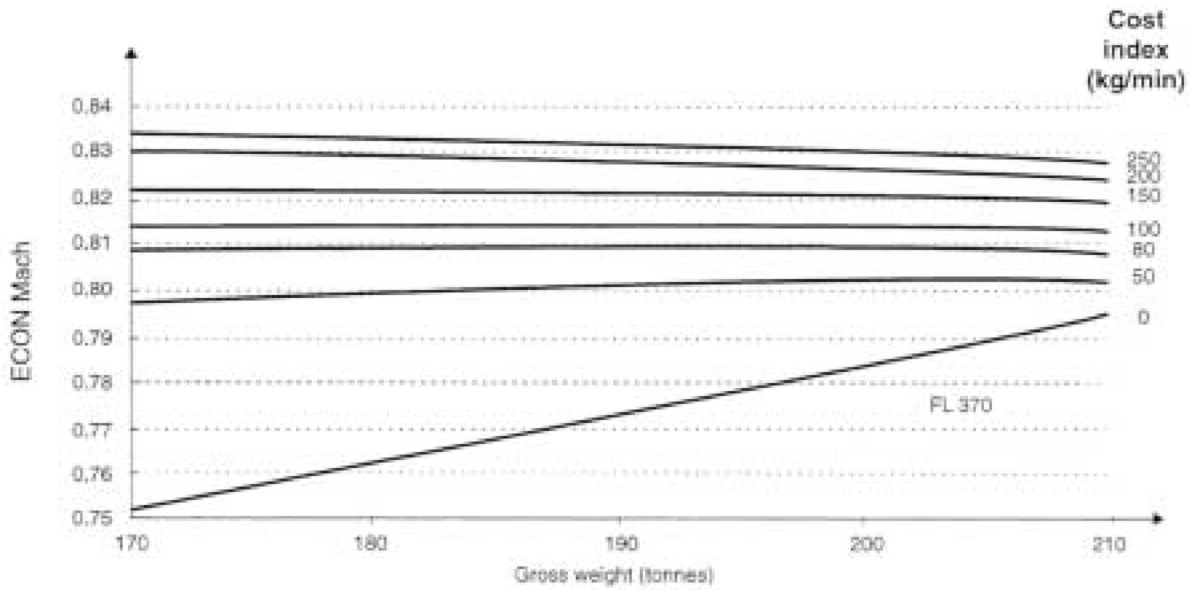


Figure 29. ECON cruise Mach = f(CI)

A340-313/CFM56-5C4



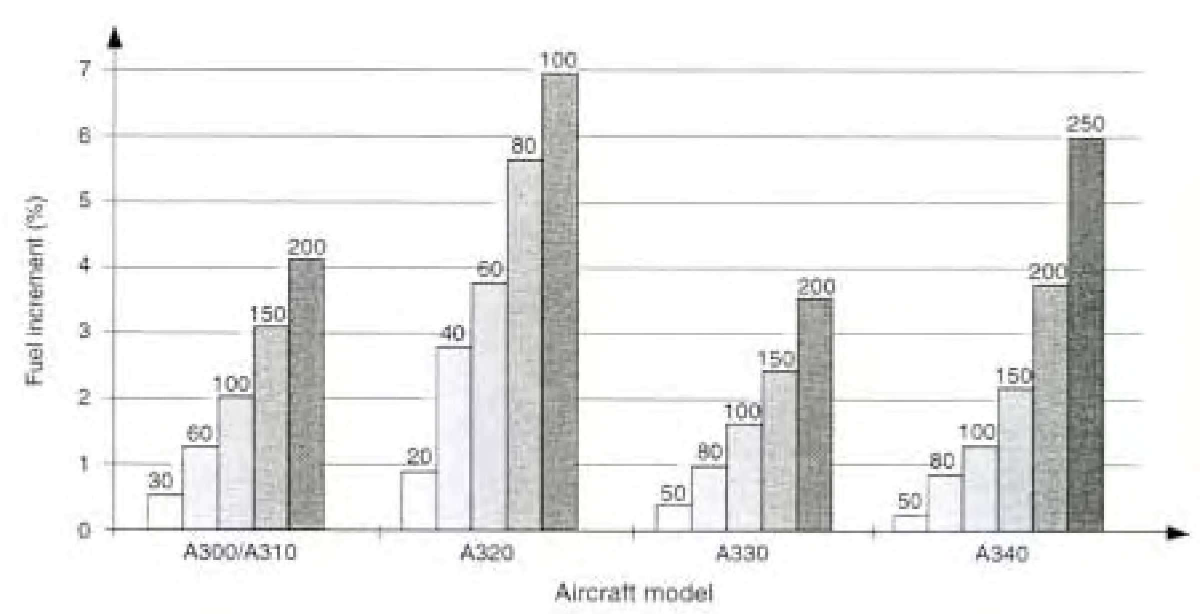
These figures clearly show that **ECON cruise Mach stays fairly constant** throughout the flight for representative cost indices as discussed in Section 3, as well as for representative weights and flight levels.

Moreover, one should notice that, for low cost indices, a small cost index; increment has a far-reaching influence on ECON Mach (2 or 3 points) and hence on flight time, especially for the A340 as can be confirmed by means of specific range curves in Section 3.3.b.

7.2 Cost Index - fuel consumption relationship

The following figure illustrates the block fuel increment for a range of practical cost index values for each Airbus model. Increment levels are approximate and it is considered that engine type has no influence on the Δ trip fuel.

Figure 30. Δ Trip fuel = f(CI) compared to CI = 0



To summarize, we can say that there is no advantage whatsoever gained by flying at low cost indices (i.e below LRC cost indices) since fuel gains are not at all meaningful when traded far time, especially for the A340.

This finding will be more precisely highlighted in section 10.2.b with Δ time/Δ fuel tables facilitating trade-off appreciations.

7.3 Cruise "managed" versus cruise "selected"

(a) **Flying at a given cost index rather than at a given Mach Number** provides the added advantage of always benefiting from the optimum Mach Number as a function of aircraft gross weight, flight level and head/tailwind component.

This means ECON Mode ("managed" speed) can save fuel relative to fixed Mach schedules ("selected" speed) and for an identical block time.

By way of example, the following table points to potential fuel savings in "managed" speed versus "selected" speed. It applies to all Airbus models and may be used to interpolate to the trip length at least for a rough operational assessment.

Table 13. Potential fuel savings

Aircraft type (Takeoff weight)	**Range (nm)**	**Type of cruise**	Trip fuel (kg)	Flight lime	**Fuel economy (k9)**
A310-324 (130 t)	**2000**	**CI = 50**	19560	4h 26 min	**70**
		MACH 0.81	19630		
A320-211 (65 t)	**1000**	**CI = 30**	5830	2h 22 min	**30**
		MACH 0.78	5860		
A330-342 (190 t)	**4000**	**CI = 80**	45750	8h 42 min	**100**
		MACH 0.82	45850		
A340-311 (250 t)	**6000**	**CI = 150**	84000	12h 56 min	**500**
		MACH 0.82	84500		

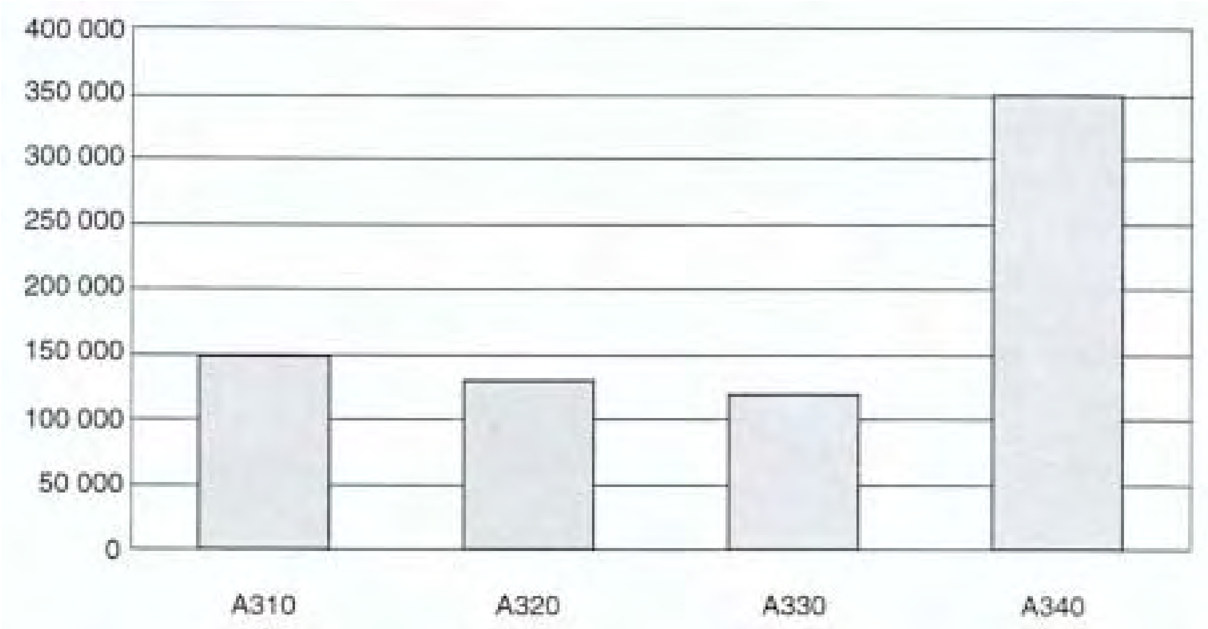
Albeit possibly negligible on a single flight, this can be rather meaningful on a yearly basis when extended to a whole fleet (see Figure 31 on the following page).

(b) **Contrary to the common belief of many pilots, the variation of ECON Mach with gross weight variation (due to fuel burn) at a given flight level is very small** (see graphs in Chapter 7.1.b). It is hence always possible to fly at a fixed cost index which results in a negligible speed variation.

However, since use of the cost index as a speed control is not recommended, pilots should select the necessary Mach Number via the FCU, in case of ATC speed request prior to recovering "managed" speed if constraints are subsequently released.

Figure 31. Potential fuel economy/year ($)

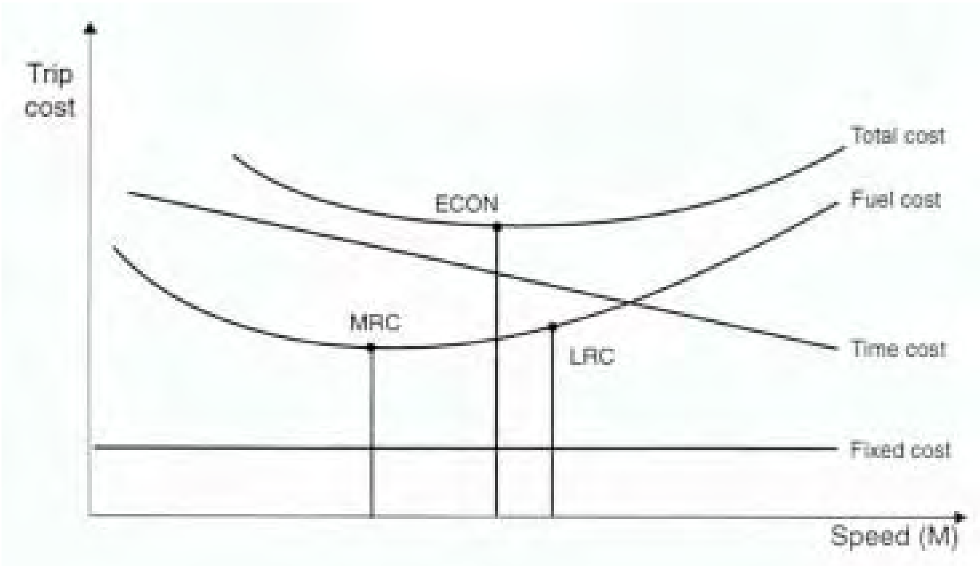
10 aircraft fleet (10 hours/day)



(c) **For many people, the term ECON Mach (for a flight managed at a given cost index) is synonymous with slower speeds solely for the sake of fuel economy. This is totally wrong as we know :** hourly costs referred to earlier on, when combined with today's low fuel colts, will systematically lead to cost indices that are over and above long-range cruise cost indices.

More clarification of this point will be given in Figure 32 below.

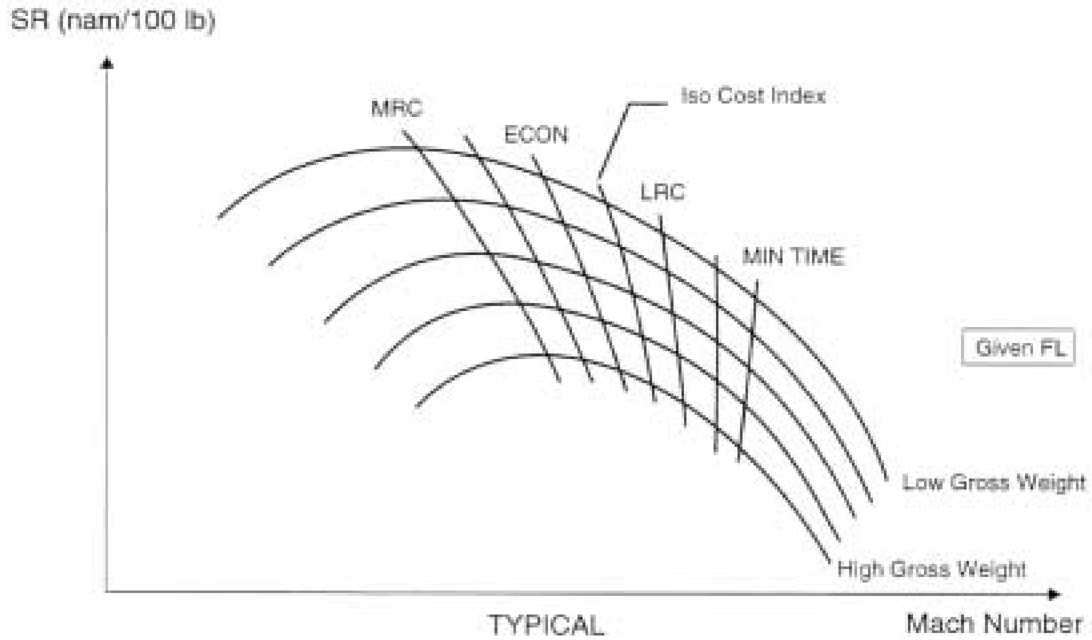
Figure 32.



7.4 Airbus family Long-Range Cruise (LRC) cost indices

LRC speeds (that give a specific range equating to 99% of Maximum Range Cruise (MRC)) being a function of aircraft gross weight and flight level, the corresponding cost index is also variable as shown in Figure 33.

Figure 33. LRC speeds as a function of aircraft GW and FL



However, assuming that the aircraft should always be flying at about its optimum flight level (between OPT FL -2000ft and OPT FL +2000ft), calculations confirmed that the cost index values in the following table should systematically return a Mach Number close to long-range cruise Mach and for each aircraft type.

As a summary, it can be recalled that the **Optimum Mach Number** is a MN which remains greater than MRC and lower than LRC over the entire range of a typical cruise operation in terms of gross weight and altitude. The **Optimum Flight Level** for this Optimum MN is the FL which provides the greatest specific range at given gross weight. The optimum FL increases with decreasing gross weights, as illustrated in the FCOM.

On the A300-600/A310 family the Optimum Mach Number is set at 0.79 (GE) or at 0.80 (PW) and the Optimum Flight Level (all temperatures) as a function of Max. Altitude (ISA + 10/ISA + 20, n=1.3/1.4g) is provided in FCOM 2.17.30.

On the A320/A330/A340 Families Optimum Mach Number is presented in FCOM tables as ECON Mach versus cost index, altitude and wind as calculated by the FMG(E)C and to be found in FCOM 3.05.15. Appendix 5 shows an example for the A340-313E.

Table 14. LRC cost Index

		Cost Index (kg/min)	Cost Index (100 lbs/hr)
A300/A310		**70 SPERRY FMS 60 SMITHS FMS**	**150 SPERRY FMS 130 SMITHS FMS**
A320		**f(GW, FL) refer to Appendix 6**	
A330	GE1A2	**40**	**53**
	PW4168/4164	**30**	**40**
	RR772	**40**	**53**
A340-200/300			
	CFM 5C4	**90**	**120**
	5C3	**80**	**106**
	5C2	**80**	**106**
A340-300E (High Gross Weight)			
	CFM 5C4	**80**	**106**
A340 FMGC L7			
	CFM 5C4	**50**	**67**
	5C3	**50**	**67**
	5C2	**50**	**67**

Important : All these values are available whatever the model or engine type, but pilots should bear in mind that cost indices will not correspond to LRC speed if the aircraft is far from its optimum FL (as may be the case because of ATC constraints or if encountered winds are significant (see following section).

7.5 Wind effect on ECON speeds

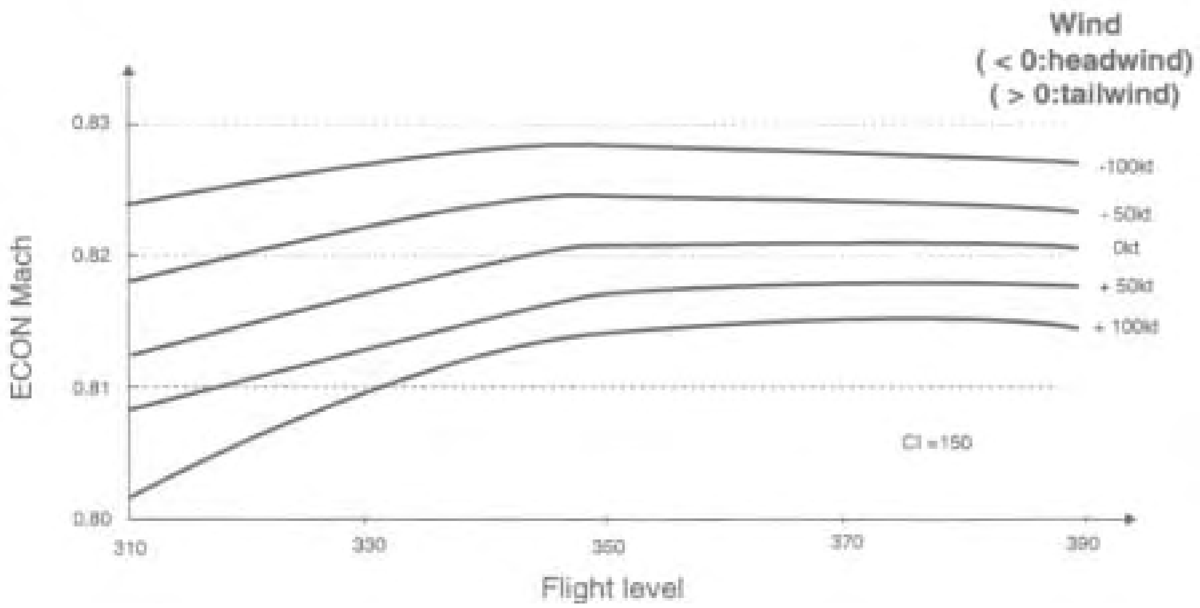
(a) Cost index purpose being a compromise between trip fuel and trip time, the resulting ECON Mach Number accounts for the actual wind component encountered in order to integrate ground speed.

This was already reviewed in Section 2 and is the result of the cost index definition itself and not of any particular FMS mechanization whatsoever.

The following figure (example for the A340) explains this point best :

Figure 34. ECON Mach = f(wind)

A340-311 /CFM56
(200 tonnes)



We notice that :

- **headwinds command higher ECON speeds (less exposure time to higher winds)**
- **tailwinds command lower ECON speeds (let winds work).**

Indeed, in the case of headwind, the fuel increment (due to higher speeds) is compensated for by the reduced trip time in terms of cost and vice versa (see next section).

Moreover, the following rule results from the preceding graph :

The ECON Mach wind correction being referred to herebelow is (for all Airbus models) of the order of :

+1/2 point of Mach per 50kt headwind
-1/2 point of Mach per 50kt tailwind.

Important : in case of "managed" cruise, pilots should pay particular attention to the Mach Number in case of strong headwinds, especially with high inserted cost indices, since this could lead to significant cruise speeds.

Whatever the aircraft model and external conditions, the ECON Mach is always limited by MMO-0.02.

(b) To illustrate this point, let us compare the difference between a flight managed (with ECON Mach wind correction) and a flight selected (without Mach wind correction) in case of headwind :

A340-311 (6000nm)
Headwind : 50kt

TYPE OF CRUISE	TRIP TIME	TRIP FUEL
Cost index -150	**14 h 20**	**90 500 kg**
Mach 0.82	**14 h 30**	**89 500 kg**

Indeed, considering a time cost of 25US$/min and a fuel cost of 0.25US$/kg, the **fuel cost increment** (1000 x 0.167=**167$**) **is compensated for by** the **time cost gain** (10 x 25=**250$**).

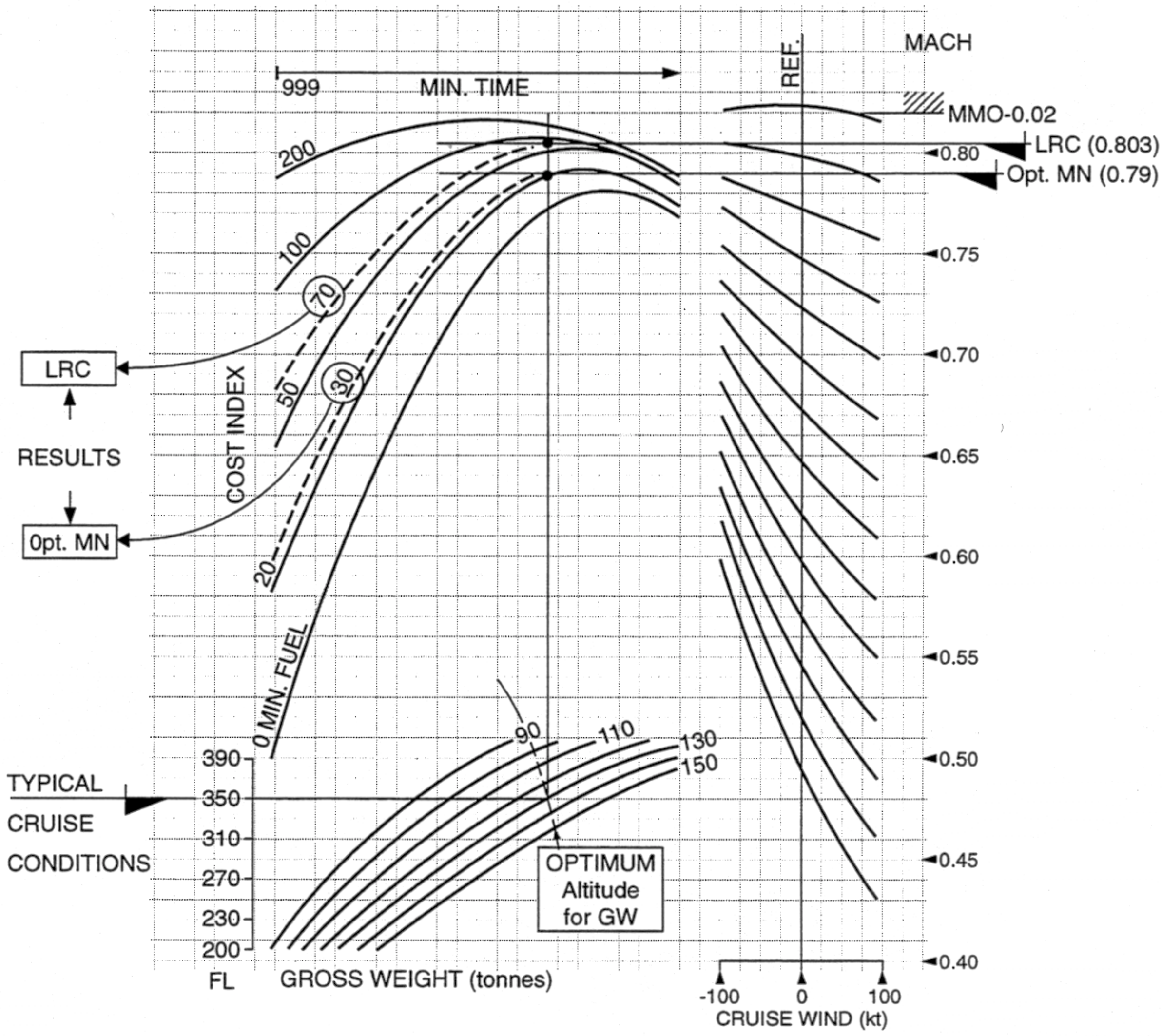
Moreover, this Mach wind correction allows the airline to maintain its schedule in case of unexpected winds.

7.6 Summary

The following figure (specific example for the A310-304) summarizes the influence of all the preceding parameters on the ECON Mach computation as performed by the FMS.

Figure 35. A310 ECON Mach

Final climb, cruise and initial descent Mach for strategic mode



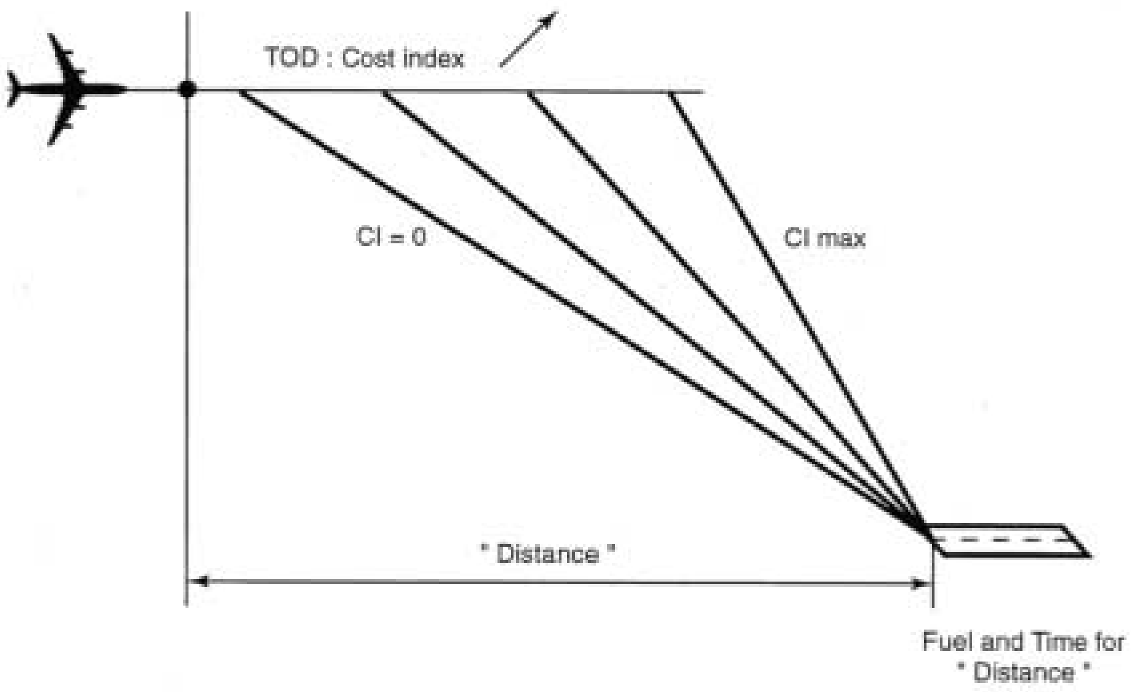
USE ONLY FOR CRUISE FLIGHT > 5mn

8. DESCENT PERFORMANCE VERSUS COST INDEX

8.1 Cost index - descent profile relationships

Let us now look at the influence of the cost index on the descent profiles depicted in the following figure. We can readily appreciate how the FMS computes the Top of Descent (TOD) as a function of the cost index.

Figure 36. Descent profiles



We notice that the higher the cost index :

- **the steeper the descent path (the higher the speed) ,**
- **the shorter the descent distance,**
- **the later the top of descent (TOD).**

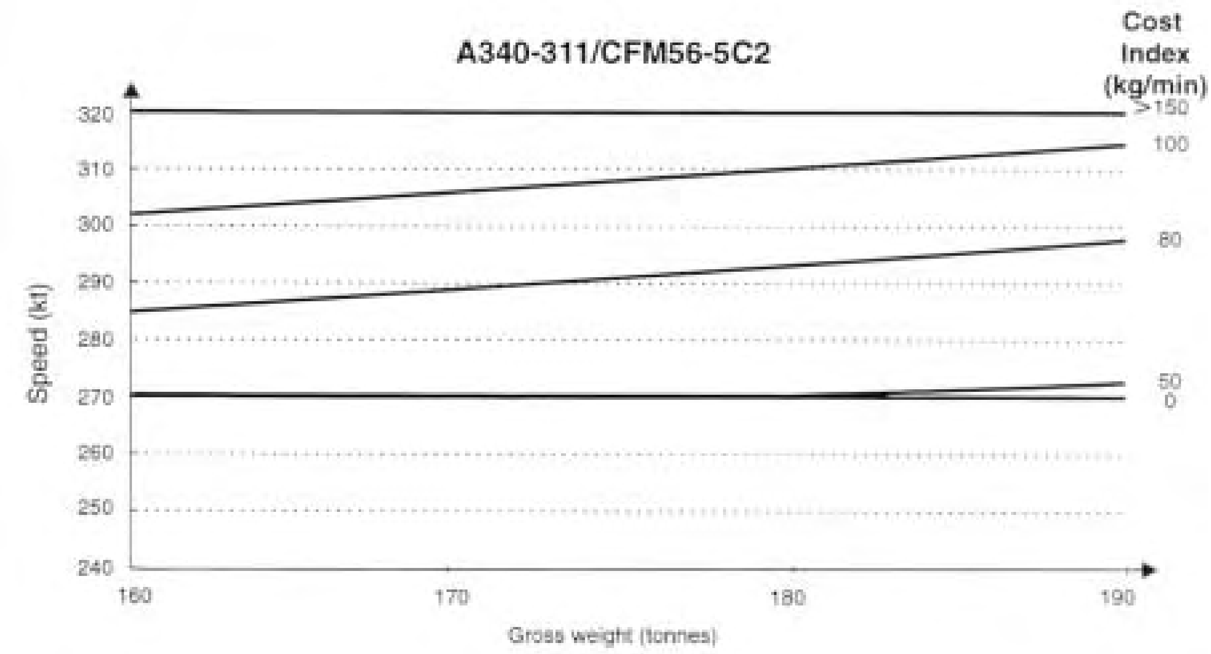
In order to be more accurate, we have to examine the influence of the cost index on descent for each aircraft type and this is done in the following section.

In order to be more accurate, we have to examine the influence of the cost index on descent for each aircraft type and this is done in the following section.

8.2 Variation of descent parameters with the cost index

As for the climb, descent performance is a function of the cost index; indeed, the higher the cost index, the higher the descent speed. But contrary to the climb, the aircraft gross weight (as shown in Figure 37 below by means of an A340-300 example) and the TOD flight level appear to have a negligible effect on the descent speed computation.

Figure 37. ECON descent speed - F(CI)



The following Table 15 shows the different relevant accurate descent parameters (time, speed, distance, fuel,...) computed by in-flight performance software (not FMS computation) for the entire Airbus family. The above figure should convince us that reducing the cost index before descent (as practiced by some airlines) to avoid unlikely overspeed warnings is unjustified. The limit of VMO - 10kt (320kt for the A330/A340, 330kt for the A300/A310, 340kt for the A320 family) is reached with a ceiling cost index depending on the aircraft and is not bound to vary with even higher values.

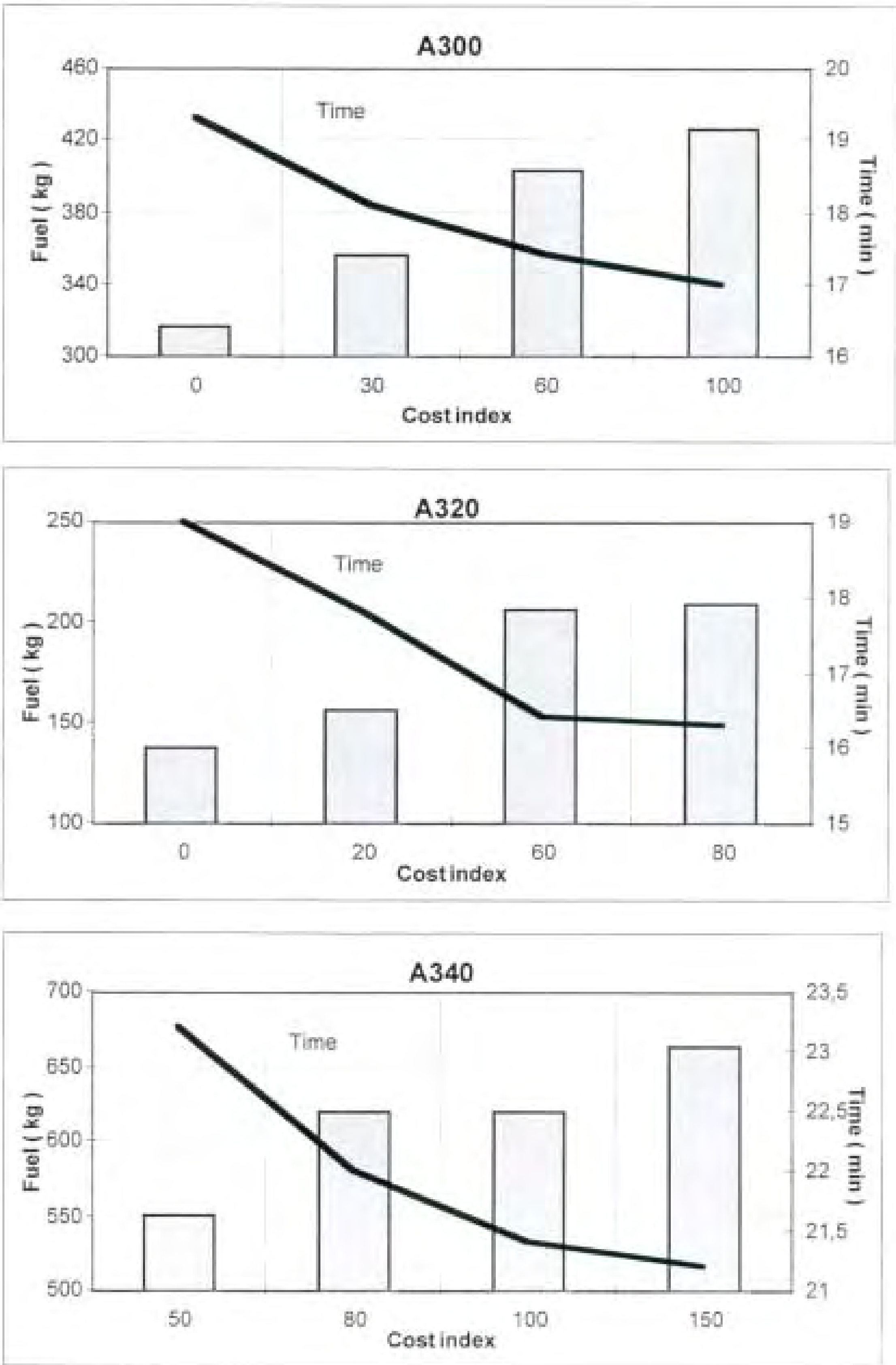
Table 15. Descent parameters from FL 370 (ISA conditions, no wind) (250kt below FL 100)

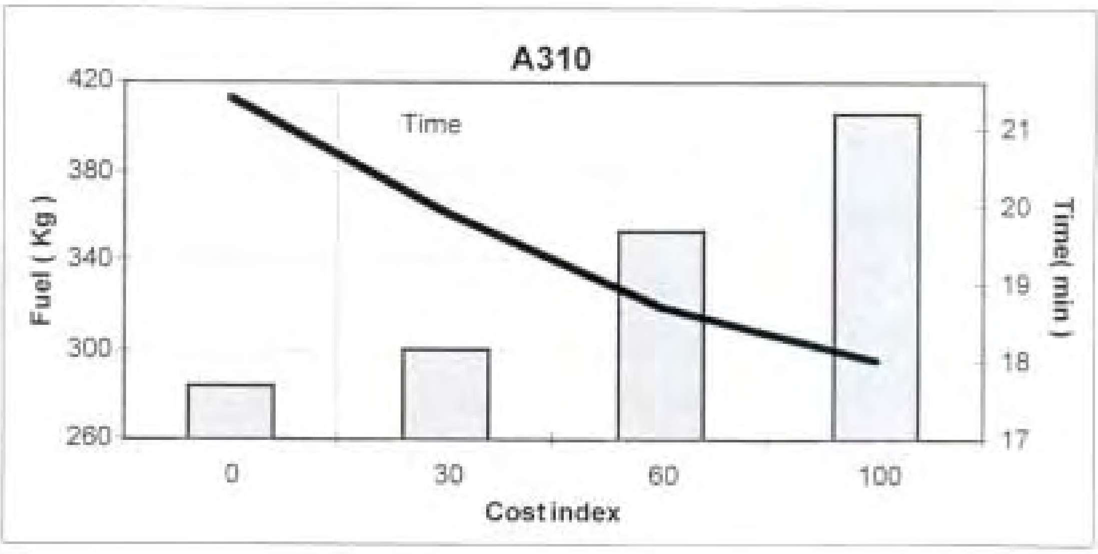
AIRCRAFT TYPE (T/OFF weight)	COSTINDEX (Kg/min)	ONLY DESCENT SEGMENT			DESCENT WITH CRUISE SEGMENT		MACH/CAS
		FUEL (Kg)	TIME (min)	DISTANCE (NM)	FUEL (Kg)	TIME (min)	
A 300-600	0	317	19,3	108	317	19,3	.790 / 258
(PW 4158)	30	298	17,3	102	357	18,1	.793 / 285
(120 000 Kg)	60	282	15,8	96	403	17,4	.800 / 310
	100	276	15	93	427	17	.800 / 325
A 310	0	284	21,4	116	284	21,4	.756 / 246
(CF6-80)	30	263	19,3	111	301	19,9	.801 / 269
(110 000 Kg)	60	239	17	103	353	18,7	.806 / 300
	100	218	15,3	95	406	18	.810 / 332
A 320	0	138	19	105	138	19	.764 / 252
(CFM 56)	20	125	17	99	157	17,8	.779 / 278
(60 000 Kg)	40	112	14,9	90	187	16,8	.786 / 311
	60	137	14,6	92	207	16,4	.796 / 339
	80	142	14,6	92	210	16,3	.800 / 342
A 330	0	449	23,5	135	449	23,5	.774 / 270
(PW 4168)	50	444	22,7	134	463	22,9	.809 / 281
(170 000 Kg)	80	427	20,5	125	540	21,9	.819 / 307
	v100	420	19,6	121	580	21,4	.823 / 320
A 340	≤50	550	23,2	133	550	23,2	.767 / 273
(CFM56)	80	524	21	125	620	22	.799 / 301
(180 000 Kg)	100	509	19,7	120	620	21,4	.811 / 323
	v150	501	19,1	117	663	21,2	.817 / 323

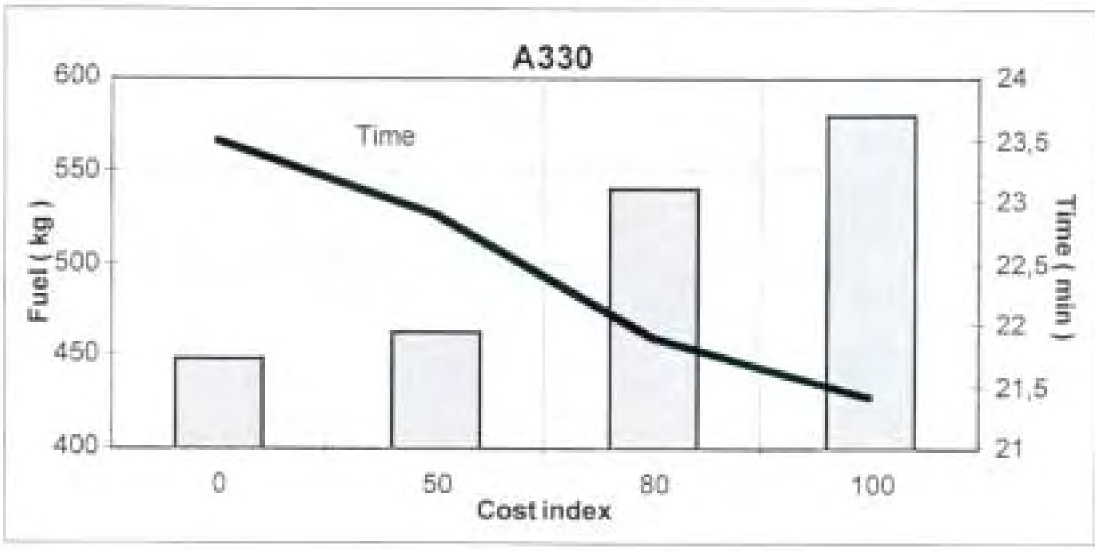
Values for time, distance, Mach, fuel consumption do vary much with flight conditions such as TOD flight level temperature and wind but are less variable with respect to gross weight.

Similar to the climb, delta values with regard to time and distance are largely the same whatever the initial flight conditions.

Figure 38. Descent parameters from the same point in cruise (FL 370, ISA conditions, no wind, 250kt from FL 100)




A310
420
380
340
300
260
Fuel (Kg)
Time
21
20
19
18
17
Time(min)
0
30
60
100
Cost index


A330
600
550
500
450
400
Fuel (kg)
Time
24
23,5
23
22,5
22
21,5
21
Time (min)
0
50
80
100
Cost index

First of all, we note that time to descent between low and high cost indices is more sensitive than for the climb varying from 4 minutes (A300, A330 and A340) up to 7 minutes for the A310.

However, in order to have a representative comparison of these different types of descent, we have to take into consideration the short cruise segments between the "low cost index TOD" and the "high cost index TOD" (see descent profiles in Section 8.1)

The following table provides parameters and differences in terms of time and fuel from a similar geographical point (TOD corresponding to cost index=0) to summarize descent laws between CI=0 (0 to 50 for the A340) and high cost indices (i.e. cost indices from which descent laws are the same : >60 for A320, >100 for A300, A310 and A330, >150 for A340).

Table 16. Descent from FL 370

	Time (min) / Fuel (kg) from 1st TOD (CI = 0)				**Difference between low and high cost index**	
	CI = 0		High cost index		**Time gain**	**Fuel increment**
A300-600	19.3	317	17.0	427	**2 min 20 s**	**110**
A310	21.4	284	18.0	406	**3 min 20 s**	**120**
A320	19.0	138	16.3	210	**2 min 40 s**	**70**
A330	23.5	449	21.4	580	**2 min 10 s**	**130**
A340	23.2	550	21.2	663	**2 min**	**110**

However, in order to obtain the best TOD computation by the FMS and in order to avoid a nominal flight path overshoot (embarassing especially with high cost indices), a good insertion of descent winds is of vital importance even if the FMS adjusts the descent speed in a 20kt range according to the winds encountered.

9. PRACTICAL USE OF THE CI - OPERATIONAL RECOMMENDATIONS

9.1 Cost index revisions

Correct use of the cost index requires a dedicated estimation for each route considering both time- and fuel-related costs involved on outbound as well as inbound sectors. **Periodic revisions** by means of **monthly reviews** should keep track of fluctuations if the airline wants to be really cost-conscious.

After analysis, adapted **cost index values** should be rounded values possibly aggregated in a small matrix of values corresponding to several routes with similar cost structure or cost combinations (fuel- and time-related). The low, medium, high assortments proposed in Section 3 may be a good start to setting up such a system.

Airbus has proposed already such an approach in the course of many fuel burn audits and operational liaison visits.

In this context and for consistent fuel predictions, the correct **performance factor** should also be inserted in the FMS and in the computerized flight plan (CFP). This factor takes into account specific range deterioration figures of individual aircraft by periodically running the performance monitoring program or resulting from dedicated performance audits.

The importance of using the same performance factor in pre-flight planning (CFP) and in the FMS cannot be over emphasized. In the past updating the FMS Performance Factor was restricted to maintenance staff, but now some of our customers have adapted this policy. Some airlines have defined company policy to allow the crew to check and enter the Performance Factor. This factor is communicated to the crew via the flight planning document for the specific aircraft tail number concerned.

9.2 Changing the cost index at departure / on ground

The cost index can, if necessary, be changed on ground to avoid a delay at arrival in case of late departure and in order to prevent important cost repercussions such as passenger dissatisfaction, missed connections, diversions due to curfews, etc.

The tables in Appendix 1 respectively provide default to new cost index repercussions with regard to Δ time and Δ fuel for the A300/A310, A320, A330 and A340 (delta values with regard to time and fuel are largely the same whatever the temperature and wind conditions). Trading fuel for time as tabulated is what really matters here.

9.3 Changing the cost index in flight

(a) Changing the cost index in the case of different en-route winds is irrelevant.

Indeed, it is not even necessary to vary cost indices with seasonal wind fluctuations. This is because the FMS integrates ground speed (i.e. wind) when computing ECON Mach corresponding to a given cost index. This has already been reviewed in Section 2.

As a reminder of Section 7.5, the Mach correction referred to hereabove, for all Airbus models, is of the order of :

Mach + 0.005 MN for 50kt headwind
Mach - 0.005 MN for 50kt tailwind.

In addition, the wind model accounted for by the FMS in its ECON Mach calculation results from :

- from current position up to 150nm ahead : actual encountered wind,
- further up, a wind evolving linearly towards the wind inserted by the pilot into the FMS at that flight level.

However, the cost index would have to be changed in flight if the encountered winds were becoming so great that it could result in a missed hub connection upon arrival. It should be done after checking the fuel predictions on the secondary flight plan in the FMS with the new cost index value.

By iteration on the A300, A310 and A320, this recommendation could be followed on the A330 and A340 via the time constraint option.

(b) Changing the cost index in the case of fuel problems should be done as follows

The objective is to avoid having to make a refueling stop. Select a lower cost index than the actual one in case of negative or pessimistic fuel predictions **(extra fuel/extra time <0 in the FUEL PRED page in the FMS)** due to strong winds encountered or ATC rerouting, restrictions or expected holding at arrival.

Important : this should be done first on the secondary flight plan and after checking fuel predictions before entering the **adapted value (found by iteration until obtaining extra time/extra fuel>0 in the FUEL PRED page in the FMS)** in the primary flight plan to avoid unnecessary thrust variations.

That is why the quickest strategy is to check the fuel predictions first with the LRC cost index (see Section 7.4) and select CI=0 only if there is a fuel concern.

(c) Changing the cost index for speed control should never be done except in the case of fuel problems (LRC or MRC) as just explained.

(d) For a fuel-critical route, setting a zero cost index may be envisaged exceptionally provided all mandatory route reserves can then be maintained.

10. CONCLUSION

The cost index is a simple and effective tool when it is appropriately used by an airline. This means airlines should have a thorough knowledge of costs in order to optimize operating economics. This is the single and only purpose of the cost index, keeping in mind that wrong utilization and/or wrong calculation of it leads inevitably to cost penalties. These penalties pertain to overall costs and not just to fuel costs ; apparent overconsumption caused by the cost index may sometimes be attributed to the need to save expensive flying time.

Therefore, one should always bear in mind that the cost index trades off both fuel and time provided they are properly assessed.

All of the above should not hide the fact that aircraft performance is rather variable when depending on the cost index : speed and rate of climb, Mach as a function of gross weight, flight level and cruise winds. Its output performance may also lead to incompatibilities with ATC constraints. The development of FANS (Future Air Navigation System) with CNS - ATM and new FMS avionics should prompt a more appropriate utilization of the cost index and certainly a more dedicated optimization of flight economics. Lateral track clearances and improved altitude allocation should certainly enable better use to be made of the cost index concept.

Airbus is both willing and able to support airlines by providing direct assistance in costing and operational matters. As it runs dedicated departments for maintenance cost (AI/SE-M2) and for operational performance (AI/ST F), coordinated projects can be launched with the objective of consulting with customers and establishing cost index policies adapted to specific airline settings (fleet composition, type of network, economics, route and ATC constraints).

To accomplish this, information should be exchanged to enable proper and precise evaluations to be made based on the best possible assumptions. As said earlier in this brochure, much progress could be achieved by having airline accountants involved.

In practice, however, it has been hard for flight operation departments and airline financial analysts to come to synergistic teamwork in this matter. Some airline managements convinced of the potential of airline econometrics - have nonetheless succeeded in coming to grips with the cost index much to the success of their operating economics, let alone their balance sheets.

APPENDIX 1

CHANGING THE COST INDEX AT DEPARTURE/ON GROUND

The following tables show the repercussions with regard to ∆ time and ∆ fuel for the A300/A310, A320, A330 and A340 when **changing the cost index at departure/on ground.**

Table 17. A300-600 / A310 ∆ Time / ∆ Fuel
Distance : 1000nm

(including takeoff, step climb, cruise, descent)

(Honeywell FMS)

		New cost index (kg/min)					
		0	30	60	100	150	200
Initial cost index (kg/min)	0	min kg	-5 100	-6 250	-9 450	-9 550	-10 600
	20	5 -100		-2 150	-4 300	-4 400	-5 450
	40	6 -250	2 -150		-2 150	-2 250	-3 300
	60	9 -450	4 -300	2 -150		-1 100	-1 150
	80	9 -550	4 -400	2 -250	1 -100		-1 50
	100	10 -600	5 -450	3 -300	1 -150	1 -50	

Table 18. A300-600 / A310 Δ Time / Δ Fuel
Distance : 2000nm

(including takeoff, step climb, cruise, descent)

(Honeywell FMS)

Initial cost index (kg/min)		New cost index (kg/min)					
		0	30	60	100	150	200
	0	min kg	-8 200	-13 400	-15 650	-17 850	-17 1050
	30	8 -200		-4 250	-7 500	-9 700	-9 800
	60	13 -400	4 -25		-2 250	-5 450	-5 600
	100	15 -650	7 -500	2 -250		-2 200	-2 350
	150	17 -850	9 -700	5 -450	2 -200		0 100
	200	17 -1050	9 -800	5 -600	2 -350	0 -100	

Table 19. A300-600 / A310 Δ Time / Δ Fuel
Distance : 3000nm

(including takeoff, step climb, cruise, descent)

(Honeywell FMS)

		New cost index (kg/min)					
		0	30	60	100	150	200
Initial cost index (kg/min)	0	min kg	-11 300	-15 600	-20 1000	-23 1200	-23 1400
	20	11 -300		-5 300	-10 600	-13 1000	-13 1200
	40	15 -600	5 -300		-5 350	-8 700	-9 900
	60	20 -1000	10 -600	5 -350		-3 300	-4 500
	80	23 -1200	13 -1000	8 -700	3 -300		-1 200
	100	23 -1400	13 -1200	9 -900	4 -500	1 -200	

Table 20. A300-600 / A310 Δ Time / Δ Fuel Distance : 4000nm

(including takeoff, step climb, cruise, descent)

(Honeywell FMS)

		New cost index (kg/min)					
		0	30	60	100	150	200
Initial cost index (kg/min)	0	min kg	-12 300	-19 700	-24 1200	-27 1500	-30 1900
	20	12 -300		-7 400	-12 900	-16 1200	-18 1600
	40	19 -700	7 -400		-6 400	-10 900	-11 1200
	60	24 -1200	12 -900	6 -400		-4 450	-6 750
	80	27 -1500	16 -1200	10 -900	4 -450		-1 300
	100	30 -1900	18 -1600	11 -1200	6 -750	1 -300	

Table 21. A319 / A320 / A321 ∆ Time / ∆ Fuel
Distance : 1000nm

(including takeoff, step climb FL 350, 390, cruise, descent)

(Honeywell FMS)

		New cost index (kg/min)					
		0	20	40	60	80	100
Initial cost index (kg/min)	0	min kg	-3 50	-5 150	-7 250	-8 350	-9 400
	20	3 -50		-2 100	-4 200	-5 300	-5 350
	40	5 -150	2 -100		-2 100	-3 200	-3 250
	60	7 -250	4 -200	2 -100		-1 100	-2 150
	80	8 -350	5 -300	3 -200	1 -100		-1 50
	100	9 -400	5 -350	3 -250	2 -150	1 -50	

Table 22. A319 / A320 / A321 Δ Time / Δ Fuel
Distance : 2000nm

(including takeoff, step climb FL 350, 390, cruise, descent)

(Honeywell FMS)

Initial cost index (kg/min)		New cost index (kg/min)					
		0	20	40	60	80	100
	0	min kg	-5 50	-8 200	-11 350	-13 500	-13 650
	20	5 -50		-4 150	-7 300	-8 350	-9 600
	40	8 -200	4 -150		-3 200	-5 300	-5 450
	60	11 -350	7 -300	3 -200		-2 150	-2 300
	80	13 -500	8 -350	5 -300	2 -150		0 150
	100	13 -650	9 -600	5 -450	2 -300	0 -150	

Table 23. A319 / A320 / A321 Δ Time / Δ Fuel
Distance : 3000nm

(including takeoff, step climb FL 350, 390, cruise, descent)

(Honeywell FMS)

		New cost index (kg/min)					
		0	20	40	60	80	100
Initial cost index (kg/min)	0	min kg	-7 650	-11 820	-15 1040	-17 1270	-19 1440
	20	7 -650		-5 170	-8 390	-10 620	-12 790
	40	11 -820	5 -170		-4 220	-6 450	-8 620
	60	15 -1040	8 -390	4 -220		-2 230	-4 400
	80	17 -1270	10 -620	6 -460	2 -230		-2 160
	100	19 -1440	12 -790	8 -620	4 -400	2 -160	

Table 24. A330 PW Δ Time / Δ Fuel
Distance : 1000nm
Takeoff weight : 180 000 kg

(including takeoff, step climb FL 350, 390, cruise, descent)

(Honeywell FMS)

		New cost index (kg/min)					
		0	50	80	100	150	200
Initial cost index (kg/min)	0	min kg	-5 200	-7 430	-8 550	-9 690	-10 830
	50	5 -200		-2 230	-3 350	-4 490	-5 630
	80	7 -430	2 -230		-1 110	-2 260	-3 400
	100	8 -550	3 -350	1 -110		-1 150	-2 280
	150	9 -690	4 -490	2 -260	1 -150		-1 140
	200	10 -830	5 -630	3 -400	2 -280	1 -140	

Table 25. A330 PW Δ Time / Δ Fuel
Distance : 2000nm
Takeoff weight : 190 000 kg

(including takeoff, step climb FL 350, 390, cruise, descent)

(Honeywell FMS)

Initial cost index (kg/min)		New cost index (kg/min)					
		0	50	80	100	150	200
	0	min kg	-7 210	-11 500	-12 650	-14 900	-16 1150
	50	7 -210		-4 280	-5 440	-7 690	-9 940
	80	11 -500	4 -280		-1 160	-3 410	-5 660
	100	12 -650	5 -440	1 -160		-2 250	-4 500
	150	14 -900	7 -690	3 -410	2 -250		-2 250
	200	16 -1150	9 -940	5 -660	4 -500	2 -250	

Table 26. A330 PW Δ Time / Δ Fuel
Distance : 3000nm
Takeoff weight : 200 000 kg

(including takeoff, step climb FL 350, 390, cruise, descent)

(Honeywell FMS)

		New cost index (kg/min)					
		0	50	80	100	150	200
Initial cost index (kg/min)	0	min kg	-9 220	-13 550	-15 720	-18 1100	-20 1750
	50	9 -220		-4 330	-6 500	-9 870	-11 1530
	80	13 -550	4 -330		-2 170	-5 540	-7 1200
	100	15 -720	6 -500	2 -170		-3 380	-5 1040
	150	409 -1100	400 -870	396 -540	394 -380		389 660
	200	20 -1750	11 -1530	7 -1200	5 -1040	2 -660	

Table 27. A330 PW ∆ Time / ∆ Fuel
Distance : 4000nm
Takeoff weight : 210 000 kg

(including takeoff, step climb FL 350, 390, cruise, descent)

(Honeywell FMS)

Initial cost index (kg/min)		New cost index (kg/min)					
		0	50	80	100	150	200
	0	min kg	-13 280	-18 680	-21 910	-25 1450	-28 2090
	50	13 -280		-5 400	-8 640	-12 1180	-15 1810
	80	18 -680	5 -400		-3 230	-7 770	-10 1410
	100	21 -910	8 -640	3 -230		-4 540	-7 1180
	150	25 -1450	12 -1180	7 -770	4 -540		-3 640
	200	28 -2090	15 -1810	10 -1410	7 -1180	3 -640	

Table 28. A330 PW Δ Time / Δ Fuel
Distance : 5000nm
Takeoff weight : 210 000 kg

(including takeoff, step climb FL 350, 390, cruise, descent)

(Honeywell FMS)

Initial cost index (kg/min)		New cost index (kg/min)					
		0	50	80	100	150	200
	0	min kg	-17 600	-24 1220	-27 1750	-32 2980	-35 3770
	50	17 -600		-7 610	-10 1150	-15 2380	-18 3170
	80	24 -1220	7 -610		-3 540	-8 1770	-11 2550
	100	27 -1750	10 -1150	3 -540		-5 1230	-8 2020
	150	32 -2980	15 -2380	8 -1770	5 -1230		-3 790
	200	35 -3770	18 -3170	11 -2550	8 -2020	3 -790	

Table 29. A340-311 CFM Δ Time / Δ Fuel
Distance : 3000nm
Takeoff weight : 210 000 kg

(including takeoff, step climb FL 350, 390, cruise, descent)

(Honeywell FMS)

		New cost index (kg/min)					
		0	50	80	100	150	200
Initial cost index (kg/min)	0	min kg	-11 140	-17 480	-19 670	-23 1110	-26 1810
	50	11 -140		-6 340	-8 540	-12 970	-15 1670
	80	17 -480	6 -340		-2 200	-6 630	-9 1330
	100	19 -670	8 -540	2 -200		-4 430	-7 1140
	150	23 -1110	12 -970	6 -630	4 -430		-3 700
	200	26 -1810	15 -1670	9 -1330	7 -1140	3 -700	

Table 30. A340-311 CFM Δ Time / Δ Fuel
Distance : 4000nm
Takeoff weight : 230 000 kg

(including takeoff, step climb FL 310, 350, 390, cruise, descent)

(Honeywell FMS)

		New cost index (kg/min)					
		0	50	80	100	150	200
Initial cost index (kg/min)	0	min kg	-16 220	-23 820	-26 1140	-31 1630	-33 2230
	50	16 -220		-7 600	-10 920	-15 1410	-17 2000
	80	23 -820	7 -600		-3 320	-8 810	-10 1400
	100	26 -1140	10 -920	3 -320		-5 490	-7 1090
	150	31 -1630	15 -1410	8 -810	5 -490		-2 590
	200	33 -2230	17 -2000	10 -1400	7 -1090	2 -590	

Table 31. A340-311 CFM Δ Time / Δ Fuel
Distance : 5000nm
Takeoff weight : 240 000 kg

(including takeoff, step climb FL 310, 350, 390, cruise, descent)

(Honeywell FMS)

		New cost index (kg/min)					
		0	50	80	100	150	200
Initial cost index (kg/min)	0	min kg	-20 280	-27 870	-32 1160	-36 1760	-41 2750
	50	20 -280		-7 590	-12 880	-16 1480	-21 2470
	80	27 -870	7 -590		-5 290	-9 890	-14 1880
	100	32 -1160	12 -880	5 -290		-4 600	-9 1590
	150	36 -1760	16 -1480	9 -890	4 -600		-5 990
	200	41 -2750	21 -2470	14 -1880	9 -1590	5 -990	

Table 32. A340-311 CFM Δ Time / Δ Fuel
Distance : 6000nm
Takeoff weight : 250 000 kg

(including takeoff, step climb FL 310, 350, 390, cruise, descent)

(Honeywell FMS)

		New cost index (kg/min)					
		0	50	80	100	150	200
Initial cost index (kg/min)	0	min kg	-26 390	-34 990	-38 1370	-45 2190	-50 3300
	50	26 -390		-8 600	-12 990	-19 1810	-24 2910
	80	34 -990	8 -600		-4 390	-11 1210	-16 2310
	100	38 -1370	12 -990	4 -390		-7 820	-12 1930
	150	45 -2190	19 -1810	11 -1210	7 -820		-5 1110
	200	50 -3300	24 -2914	16 -2310	12 -1930	5 -1110	

Table 33. A340-313 CFM Δ Time / Δ Fuel
Distance : 3000nm
Takeoff weight : 210 000 kg

(including takeoff, step climb FL 350, 390, cruise, descent)

(Honeywell FMS)

		New cost index (kg/min)					
		0	50	80	100	150	200
Initial cost index (kg/min)	0	min kg	-10 240	-14 570	-16 750	-19 1130	-21 1670
	50	10 -240		-4 330	-6 500	-9 890	-11 1430
	80	14 -570	4 -330		-2 180	-5 560	-7 1100
	100	16 -750	6 -500	2 -180		-3 390	-5 930
	150	19 -1130	9 -890	5 -560	3 -390		-2 540
	200	21 -1670	11 -1430	7 -1100	5 -930	2 -540	

Table 34. A340-313 CFM Δ Time / Δ Fuel
Distance : 4000nm
Takeoff weight : 230 000 kg

(including takeoff, step climb FL 310, 350, 390, cruise, descent)

(Honeywell FMS)

		New cost index (kg/min)					
		0	50	80	100	150	200
Initial cost index (kg/min)	0	min kg	-11 290	-17 860	-16 1120	-23 1580	-26 2120
	50	11 -290		-6 570	-8 820	-12 1290	-15 1820
	80	17 -860	6 -570		-2 260	-6 720	-9 1260
	100	19 -1120	8 -820	2 -260		-4 460	-7 1000
	150	23 -1580	12 -1290	6 -720	4 -460		-3 540
	200	26 -2120	15 -1820	9 -1260	7 -1000	3 -540	

Table 35. A340-313 CFM Δ Time / Δ Fuel
Distance : 5000nm
Takeoff weight : 240 000 kg

(including takeoff, step climb FL 310, 350, 390, cruise, descent)

(Honeywell FMS)

		New cost index (kg/min)					
		0	50	80	100	150	200
Initial cost index (kg/min)	0	min kg	-14 400	-19 830	-22 1110	-26 1760	-30 2340
	50	14 -400		-5 430	-8 710	-12 1360	-16 1940
	80	19 -830	5 -430		-3 280	-7 920	-11 1500
	100	22 -1110	8 -710	3 -280		-4 650	-8 1230
	150	26 -1760	12 -1940	7 -920	4 -650		-4 580
	200	30 -2340	16 -1936	11 -1500	8 -1230	4 -580	

Table 36. A340-313 CFM Δ Time / Δ Fuel
Distance : 6000nm
Takeoff weight : 250 000 kg

(including takeoff, step climb FL 310, 350, 390, cruise, descent)

(Honeywell FMS)

		New cost index (kg/min)					
		0	50	80	100	150	200
Initial cost index (kg/min)	0	min kg	-16 460	-22 1000	-25 1370	-31 2050	-36 2770
	50	16 -460		-6 540	-9 910	-15 1590	-20 2310
	80	22 -1000	6 -540		-3 370	-9 1060	-14 1770
	100	25 -1370	9 -910	3 -370		-6 680	-11 1400
	150	31 -2050	15 -1590	9 -1060	6 -680		-5 720
	200	36 -2770	20 -2310	14 -1770	11 -1400	5 -720	

Table 37. A340-313E CFM Δ Time / Δ Fuel
Distance : 3000nm
Takeoff weight : 210 000 kg

(including takeoff, step climb FL 350, 390, cruise, descent)

(Honeywell FMS)

		New cost index (kg/min)					
		0	50	80	100	150	200
Initial cost index (kg/min)	0	min kg	-10 540	-12 920	-14 1230	-16 1640	-15 1780
	50	10 -540		-2 390	-4 690	-6 1100	-5 1250
	80	12 -920	2 -390		-2 300	-4 710	-3 860
	100	14 -1230	4 -690	2 -300		-2 410	-1 560
	150	16 -1640	6 -1100	4 -710	2 -410		-1 150
	200	15 -1790	5 -1250	3 -860	1 -560	1 -150	

Table 38. A340-313E CFM Δ Time / Δ Fuel
Distance : 4000nm
Takeoff weight : 230 000 kg

(including takeoff, step climb FL 310, 350, 390, cruise, descent)

(Honeywell FMS)

		New cost index (kg/min)					
		0	50	80	100	150	200
Initial cost index (kg/min)	0	min kg	-13 810	-15 1310	-18 1710	-20 2240	-20 2480
	50	13 -810		-2 500	-5 900	-7 1430	-7 1670
	80	15 -1310	2 -500		-3 400	-5 930	-5 1170
	100	18 -1710	5 -900	3 -400		-2 530	-2 770
	150	20 -2240	7 -1430	5 -930	2 -530		0 240
	200	20 -2480	7 -1670	5 -1170	2 -770	0 -240	

Table 39. A340-313E CFM Δ Time / Δ Fuel
Distance : 5000nm
Takeoff weight : 240 000 kg

(including takeoff, step climb FL 310, 350, 390, cruise, descent)

(Honeywell FMS)

		New cost index (kg/min)					
		0	50	80	100	150	200
Initial cost index (kg/min)	0	min kg	-12 970	-17 1780	-19 2190	-21 2820	-20 3180
	50	12 -970		-5 810	-7 1220	-9 1850	-8 2200
	80	17 -1780	5 -810		-2 410	-4 1040	-3 1400
	100	19 -2190	7 -1220	2 -410		-2 630	-1 990
	150	21 -2820	9 -1850	4 -1040	2 -630		-1 360
	200	20 -3180	8 -2200	3 -1400	1 -990	1 -360	

Table 40. A340-313E CFM Δ Time / Δ Fuel
Distance : 6000nm
Takeoff weight : 250 000 kg

(including takeoff, step climb FL 310, 350, 390, cruise, descent)

(Honeywell FMS)

		New cost index (kg/min)					
		0	50	80	100	150	200
Initial cost index (kg/min)	0	min kg	-16 1100	-20 1790	-23 2260	-25 3000	-25 3450
	50	16 -1100		-4 690	-7 1170	-9 1910	-9 2360
	80	20 -1790	4 -690		-3 480	-5 1220	-5 1670
	100	23 -2260	7 -1170	3 -480		-2 740	-2 1190
	150	25 -3000	9 -1910	5 -1220	2 -740		0 450
	200	25 -3450	9 -2360	5 -1670	2 -1190	0 -450	

Table 41. A340-313E CFM Δ Time / Δ Fuel
Distance : 7000nm
Takeoff weight : 260 000 kg

(including takeoff, step climb FL 310, 350, 390, cruise, descent)

(Honeywell FMS)

		New cost index (kg/min)					
		0	50	80	100	150	200
Initial cost index (kg/min)	0	min kg	-15 1320	-23 2100	-25 2590	-29 3430	-28 3960
	50	15 -1320		-8 780	-10 1270	-14 2120	-13 2640
	80	23 -2100	8 -780		-2 490	-6 1330	-5 1860
	100	25 -2590	10 -1270	2 -490		-4 850	-3 1370
	150	29 -3430	14 -2120	6 -1330	4 -850		-1 530
	200	28 -3960	13 -2640	5 -1860	3 -1370	1 -530	

Table 42. A340-313E CFM Δ Time / Δ Fuel
Distance : 8000nm
Takeoff weight : 271 000 kg

(including takeoff, step climb FL 310, 350, 390, cruise, descent)

(Honeywell FMS)

		New cost index (kg/min)					
		0	50	80	100	150	200
Initial cost index (kg/min)	0	min kg	-19 1550	-25 2430	-28 2940	-32 4140	-35 4830
	50	19 -1550		-6 880	-9 1390	-13 2590	-16 3280
	80	25 -2430	6 -880		-3 510	-7 1710	-10 2400
	100	28 -2940	9 -1390	3 -510		-4 1190	-7 1880
	150	32 -4140	13 -2590	7 -1710	4 -1190		-3 690
	200	35 -4830	16 -3280	10 -2400	7 -1880	3 -690	

APPENDIX 2

A300-600/A310 DEFAULT COST INDEX OPTION

If the company cost index is not known or if it is preferred to refrain from the calculated concept, a default cost index value can easily be assessed to fly in PROFILE (A300-600/A310) at any desired Mach Number compatible with an operational objective (e.g. FCOM Optimum Mach or LRC or any Mach Number).

The cost index should, however, not be manipulated as a speed control tool by varying the value on the CDU. Moreover, any overemphasis on the fuel economy side may be accompanied by costly repercussions on the time-related cost, hence jeopardizing total trip cost.

This Appendix proposes a technique for the assessment of a Default Cost Index value, using the graphs published in the FCOM :

- 2.02.19 - page 34 (Sperry - Honeywell)
- 2.02.19 - page 32 (Smiths).

Adapting a Default Cost Index can - in many cases where no calculated value is available be quite adequately defined for

- the whole flight or for a given flight phase
- for any desired speed :
    - given cruise Mach Number or LRC
    - given descent IAS (separate graphs).

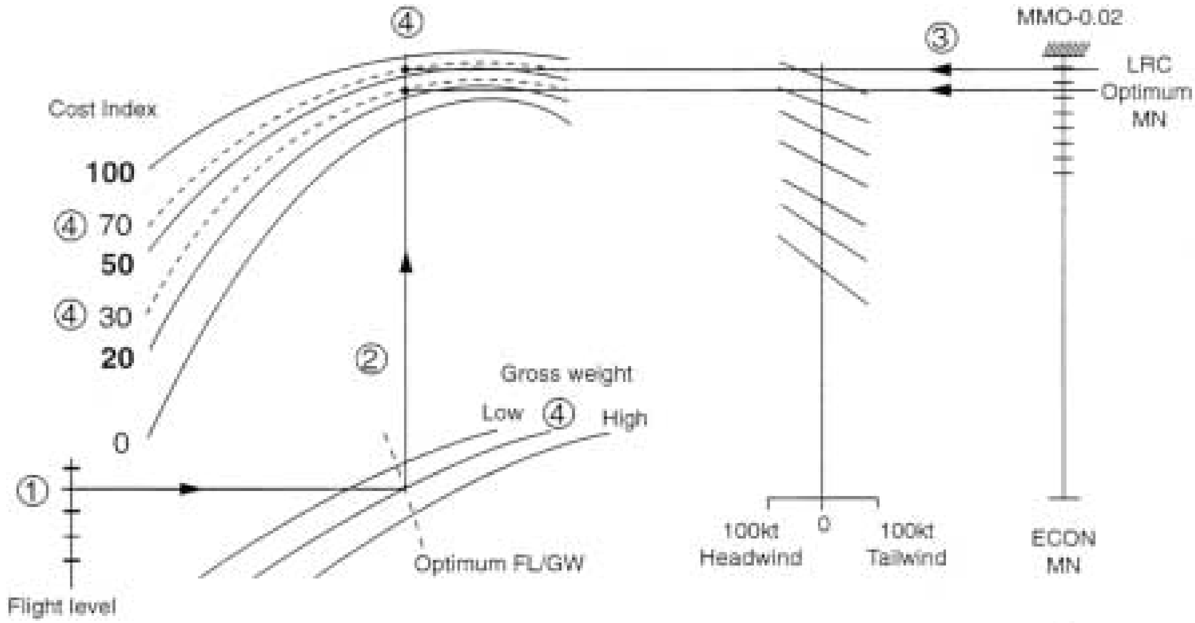
Step ①

- Determine an average cruise gross weight (e.g. weight at cruise middle point) for the route, the area of operation or for the entire network.
- Using the CRUISE ALTITUDE CHART in FCOM 2.17.30 (page 20 for A310, page 14 for A300-600), determine the optimum altitude for this gross weight.

Step ②

- Using the average cruise gross weight and corresponding optimum altitude, determined in Step ①, enter the FMS graph in 2.02.19, as follows :
    - plot the above values in the FL / GROSS WEIGHT lower graph,
    - from this point, draw a vertical line.

Figure 39. FMS ECON speed or Default Cost Index ~ Graphical assessment



Step ③

- Using the desired MN (Optimum MN, LRC or any MN) enter the graph from the right side in the ECON Mach scale and draw a horizontal line **(do not consider** any cruise wind component).

Step ④

- At the intersection between the vertical line (drawn in Step ②) and the horizontal line (drawn in Step ③), read the default cost index value, e.g. :
  - C I = 30,
    Default Cost Index resulting in an ECON MN (without wind) =
    FCOM Optimum MN,
  - CI = 70, Default Cost Index resulting in an ECON MN (without wind) = LRC MN.
- Interpolate, as required, between the cost index values of the two adjacent Cost Index curves.

APPENDIX 3

A340-200 AND -300 COST INDEX CONVERSIONS FOR LOAD 6 PENDING LOAD 7 RELEASE

1. Assessing A340 specific range variation versus Mach Number

As requested by launching customers, the A340 has been designed for a cruise Mach Number of 0.82 at 35 000ft. Even at Mach 0.83, the payload-range capability of the A340 satisfies most mission requirements. Reduction of cruise Mach to 0.81 or 0.80 brings an increase of range capability for very long stretches. It appears that the curve representing specific range variations versus Mach Number is quite flat.

Because of the flat characteristic of the Specific Range curve, assessing accurately the Maximum Range point and, hence, the MRC and LRC Mach numbers is more difficult for the FMS software. The initial software resulted in lower-than-anticipated MN values.

Figures 40 and 41 illustrate quite well the point made in this appendix for A340-300/CFM56-5C2 and A340-300E/CFM56-5C4 models respectively.

Figure 40. A340-3001CFM56-5C2, ISA

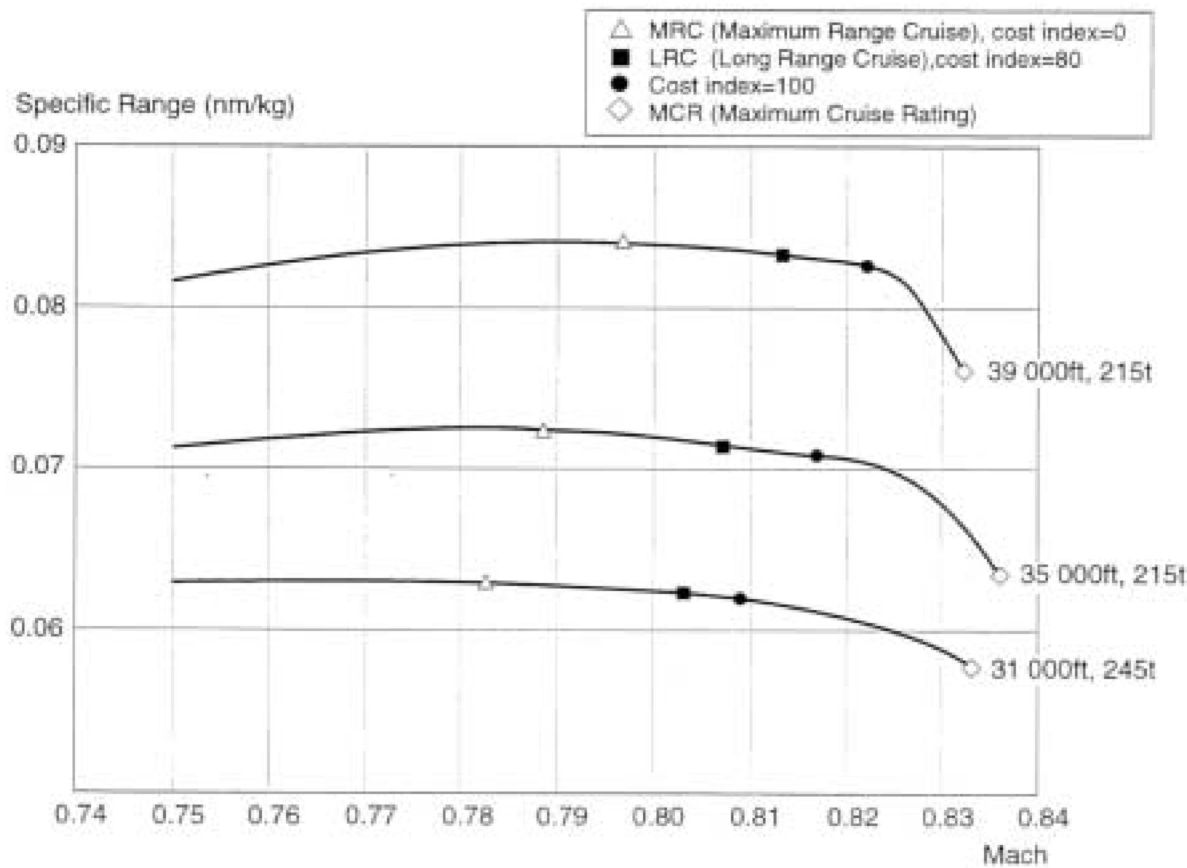
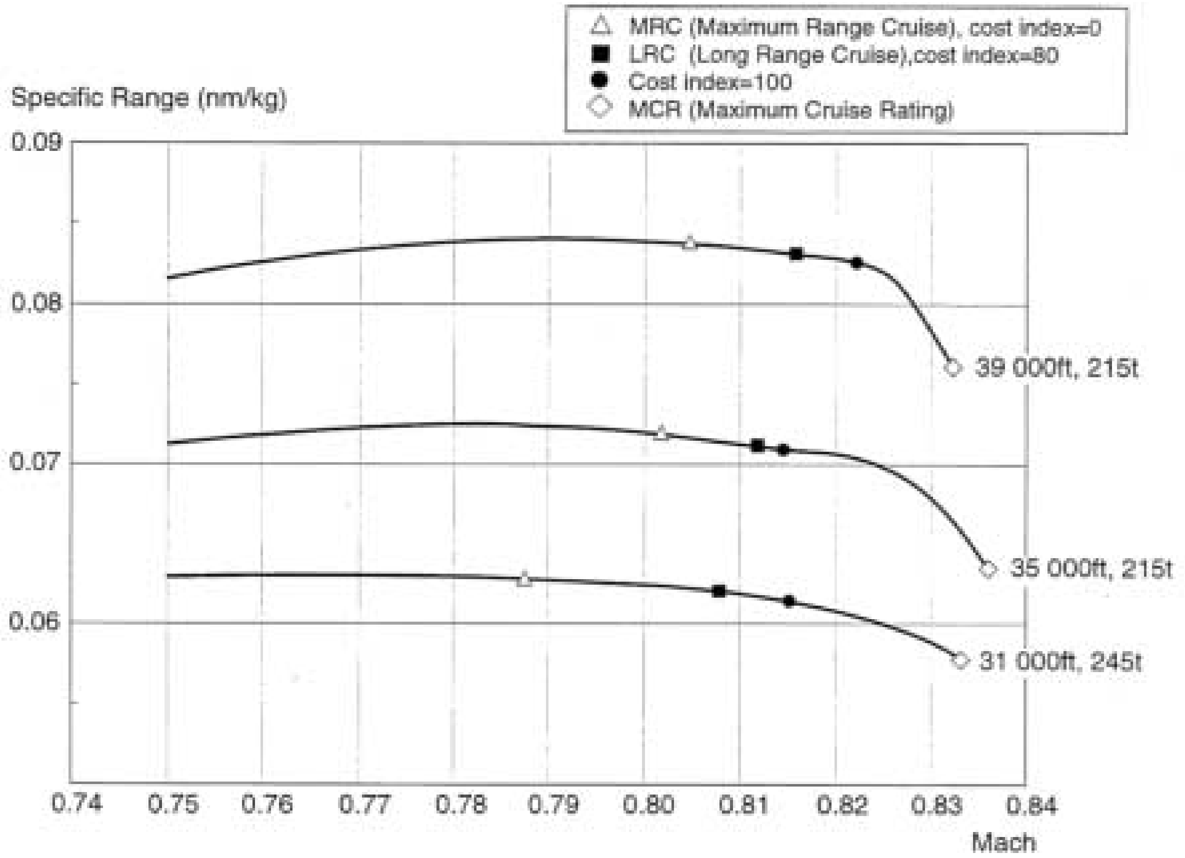


Figure 41. A340-300/CFM56-5C2, ISA



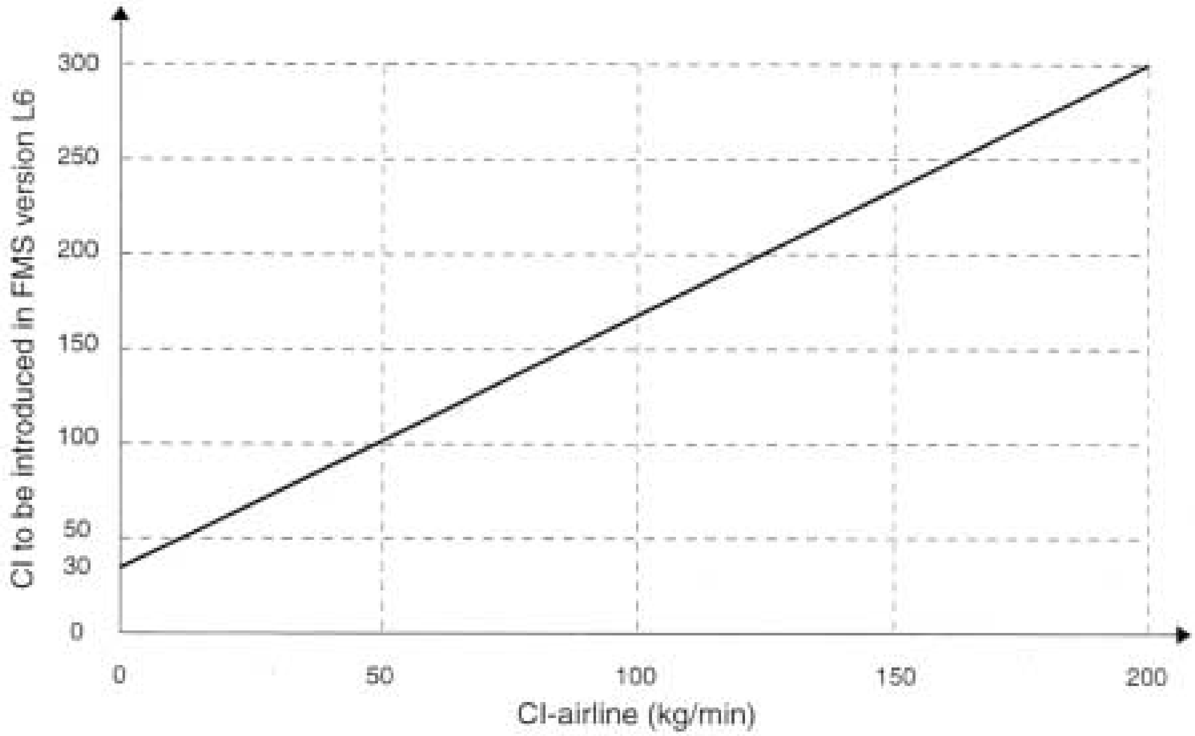
2. Recalibrating the Cost Index

Curves representating specific range variation versus Mach Number being quite flat, the original computation software of the cost index in the FMS led to the following :

- cost index 0 or MRC corresponds to slower than anticipated cruise speed ;
- the new MRC-calculation process increases the Mach Number, thus resulting in a recalibrated Cost Index ;
- when calculated for low Cost Index (see Figure 44 for CI=70), original software led to speeds that could be lower than the real Specific Range optimum ;
- a new software was defined as from April 1996, in order to achieve a result close to the real SR optimum.

Figure 42. Conversion from CI-airline to CI-FMS

A340-200 and 300/CFM56-5C2/C3/C4



In the meantime, airlines were provided with Cost Index corrective charts that were to be furnished in the form of a temporary revision of the FCOM .

Altogether, improvements are staggered as follows :

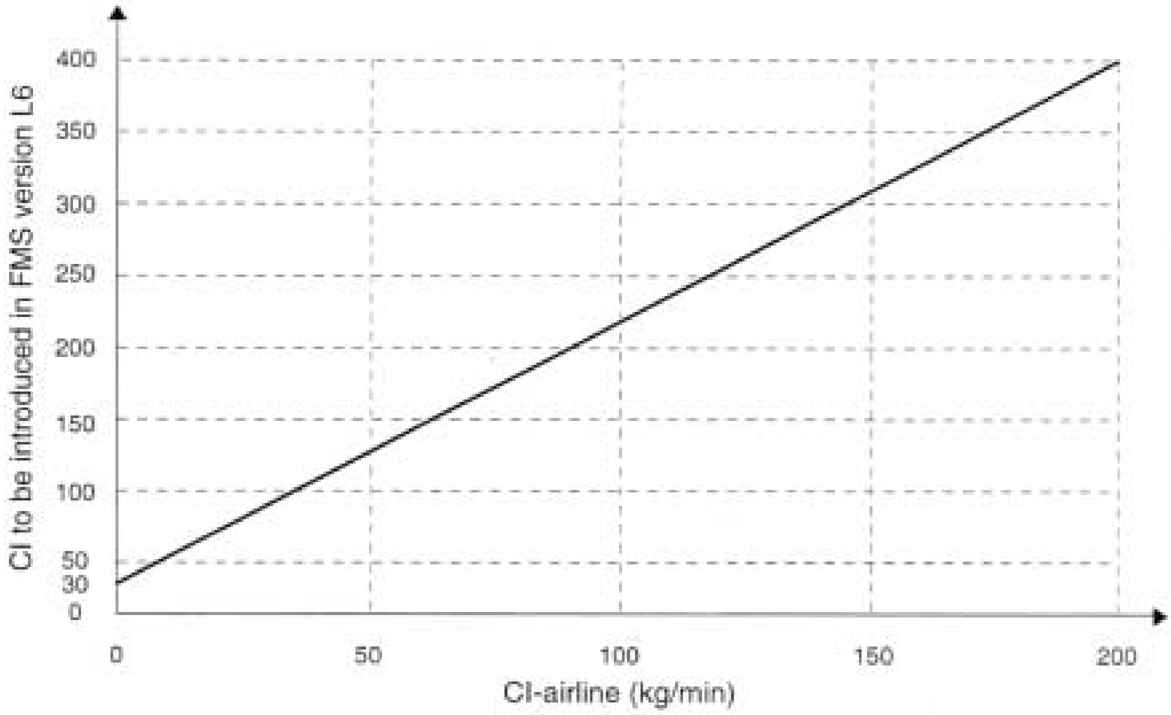
- The modified definition of MRC and hence of LRC (1% off) was to be introduced in the IFP with subsequent distribution to the airlines.

- Customers were provided with a modified table of the Cost Index, converting the old value to a new one, thereby allowing the use of higher Mach Numbers ; Figures 42 and 43 represent these correction charts for, respectively, A340-311 and -211 (CFM56-5C2) and A340-313 (E) (CFM56-5C4).

Pending Load 7, the corrections of Figures 42 and 43 are necessary. Thereafter they will be obsolete and use will then be made of the Table 3, in Section 3 of this brochure.

Figure 43. Conversion from CI-airline to CI-FMS

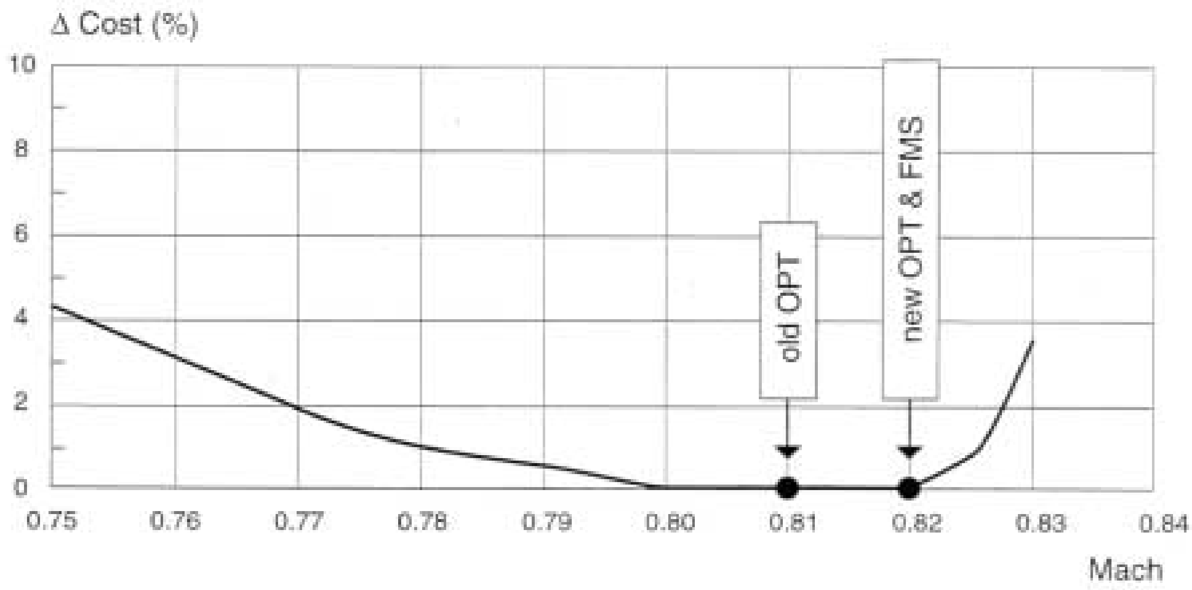
A340-313/CFM56-5C4 High Cross Weight



- The next version of the FMGEC, Load 7, will be modified so as to integrate the above modifications; the default value of the cost index will be modified accordingly, shifted from 0 to a value corresponding to a more representative cruise speed ; Figure 44 illustrates the improvement.

Figure 44. A340-300/CFM56-5C2 - cost index new definition

Example : 210t 37 000 ft CI-70kg/min



3. Transforming cost index brackets

Using Figures 42 and 43, Table 3 transforms into Tables 4 and 5 for, respectively, A340-311 (and -211), (CFM56-5C2 and C4) and A340-313(E) (CFM56-5C4).

These tables provide typical industry values covering the low to the high cost brackets for both fuel- and time-related costs.

Following integration of the above-mentioned modifications, Tables 4 and 5 will become obsolete. Use will then be made of Table 3, now also still valid for the A330.

APPENDIX 4

A340-200 AND -300 CLIMB IAS PRESELECTION PROCEDURES FOR LOAD 6 PENDING LOAD 7 RELEASE

The following are the recommended procedures pending the release of FMS Load 7, after which corrected climb speeds will be fully integrated.

1. Aircraft is not in climb phase

- The preselected CLIMB IAS may be entered on the MCDU PERF-CLIMB page on the PRESEL field. It is displayed in large font.
- The display changes to IAS/MACH and the computed Mach are displayed in small font.

2. Aircraft is in climb phase and is in speed manual control

- The selected climb IAS has to be entered on the FCU if it has not been already preselected.
- The MCDU (PERF-CLIMB page) display is a IAS/MACH in accordance with the preselected IAS entry or with the FCU selection.
- The computed MACH is then displayed in small font.
- Guidance will use the selected IAS and the computed Mach thereafter.

3. Aircraft is in climb phase and in speed auto control

- The PRESEL field of PERF-CLIMB page is blank.
- The selected IAS has to be entered on the FCU and manual mode activated.
- The MCDU (PERF-CLIMB page) display is a IAS/MACH in accordance with the FCU selection.
- The computed MACH is then displayed in small font.
- Guidance will use the selected IAS and the computed Mach thereafter.

Note :

If during climb, a CRZ FL change modifies the climb IAS to introduce (as given by the tables), the new climb IAS has to be entered on the FCU as described in 2. above.

- The following tables are limited by the Max Altitude in ISA condition. However, the speeds provided are available for any temperature. In ISA deviation conditions, Cruise Altitude has to be limited by the FMGEC MAX Altitude.
- **In order to perform minimum distance to climb, green dot should be selected or an altitude constraint should be inserted on a waypoint in the FMS.**

Table 43. Preselected climb IAS to simulate L7 ECON climb Mach

A340-311/CFM56-5C2
A340-312/CFM56-5C3

(Load 6)

TOW (t)	CRUISE FLIGHT LEVEL								
	270	280	290	310	330	350	370	390	410
260	315/.780	309/.780	302/.780	289/.780					
255	315/.780	309/.780	302/.780	289/.780	286/.780				
250	315/.780	309/.780	302/.780	289/.780	286/.780				
245	315/.780	309/.780	302/.780	289/.780	286/.780				
240	315/.780	309/.780	302/.780	289/.780	286/.780				
235	315/.780	309/.780	302/.780	289/.780	286/.780	290/.789			
230	315/.780	309/.780	302/.780	289/.780	286/.780	287/.783			
225	315/.780	309/.780	302/.780	289/.780	286/.780	286/.780			
220	314/.777	309/.780	302/.780	289/.780	286/.780	286/.780			
215	312/.773	309/.780	302/.780	289/.780	286/.780	286/.780			
210	310/.769	309/.780	302/.780	289/.780	286/.780	286/.780	289/.788		
205	309/.765	307/.776	302/.780	289/.780	286/.780	286/.780	286/.780		
200	307/.761	305/.752	302/.780	289/.780	286/.780	286/.780	286/.780		
195	305/.756	304/.769	302/.780	289/.780	286/.780	286/.780	286/.780		
190	303/.751	302/.764	300/.776	289/.780	286/.780	286/.780	286/.780	291/.793	
185	300/.746	299/.759	299/.773	289/.780	286/.780	286/.780	286/.780	287/.783	
180	298/.741	297/.753	297/.767	289/.780	286/.780	286/.780	286/.780	286/.780	
175	296/.737	295/.748	294/.761	289/.780	286/.780	286/.780	286/.780	286/.780	
170	294/.732	292/.742	291/.755	289/.780	286/.780	286/.780	286/.780	286/.780	293/.797
165	292/.727	290/.737	289/.749	289/.780	286/.780	286/.780	286/.780	286/.780	289/.787
160	290/.722	288/.731	286/.742	285/.771	286/.780	286/.780	286/.780	286/.780	286/.780

Table 44. Preselected climb IAS to simulate L7 ECON climb Mach

A340-313/CFM56-5C4

(Load 6)

TOW (t)	CRUISE FLIGHT LEVEL								
	270	280	290	310	330	350	370	390	410
260	315/.780	309/.780	302/.780	289/.780	290/.790				
255	315/.780	309/.780	302/.780	289/.780	287/.783				
250	315/.780	309/.780	302/.780	289/.780	286/.780				
245	315/.780	309/.780	302/.780	289/.780	286/.780				
240	315/.780	309/.780	302/.780	289/.780	286/.780	293/.797			
235	315/.780	309/.780	302/.780	289/.780	286/.780	290/.789			
230	315/.780	309/.780	302/.780	289/.780	286/.780	287/.781			
225	315/.780	309/.780	302/.780	289/.780	286/.780	286/.780			
220	315/.780	309/.780	302/.780	289/.780	286/.780	286/.780	295/.803		
215	315/.780	309/.780	302/.780	289/.780	286/.780	286/.780	292/.795		
210	315/.780	309/.780	302/.780	289/.780	286/.780	286/.780	289/.787		
205	315/.778	309/.780	302/.780	289/.780	286/.780	286/.780	286/.780		
200	313/.775	309/.780	302/.780	289/.780	286/.780	286/.780	286/.780	294/.800	
195	312/.773	308/.778	302/.780	289/.780	286/.780	286/.780	286/.780	291/.792	
190	311/.770	307/.776	302/.780	289/.780	286/.780	286/.780	286/.780	286/.780	
185	310/.768	306/.774	302/.780	289/.780	286/.780	286/.780	286/.780	286/.780	
180	309/.765	305/.771	301/.777	289/.780	286/.780	286/.780	286/.780	286/.780	
175	307/.761	304/.769	300/.775	289/.780	286/.780	286/.780	286/.780	286/.780	296/.805
170	305/.757	302/.766	299/.772	289/.780	286/.780	286/.780	286/.780	286/.780	292/.796
165	303/.753	301/.762	298/.770	289/.780	286/.780	286/.780	286/.780	286/.780	289/.787
160	301/.748	299/.758	296/.766	289/.780	286/.780	286/.780	286/.780	286/.780	286/.780

Table 45. Preselected climb IAS to simulate L7 ECON climb Mach

A340-313E/CFM56-5C4

(Load 6)

TOW (t)	CRUISE FLIGHT LEVEL								
	270	280	290	310	330	350	370	390	410
280	315/.780	309/.780	302/.780	291/.784					
275	315/.780	309/.780	302/.780	289/.780					
270	315/.780	309/.780	302/.780	289/.780					
265	315/.780	309/.780	302/.780	289/.780					
260	315/.780	309/.780	302/.780	289/.780	290/.790				
255	315/.780	309/.780	302/.780	289/.780	287/.783				
250	315/.780	309/.780	302/.780	289/.780	286/.780				
245	315/.780	309/.780	302/.780	289/.780	286/.780				
240	315/.780	309/.780	302/.780	289/.780	286/.780	293/.797			
235	315/.780	309/.780	302/.780	289/.780	286/.780	290/.789			
230	315/.780	309/.780	302/.780	289/.780	286/.780	287/.781			
225	315/.780	309/.780	302/.780	289/.780	286/.780	286/.780			
220	315/.780	309/.780	302/.780	289/.780	286/.780	286/.780	295/.803		
215	315/.780	309/.780	302/.780	289/.780	286/.780	286/.780	292/.795		
210	315/.780	309/.780	302/.780	289/.780	286/.780	286/.780	289/.787		
205	315/.778	309/.780	302/.780	289/.780	286/.780	286/.780	286/.780		
200	313/.775	309/.780	302/.780	289/.780	286/.780	286/.780	286/.780	294/.800	
195	312/.773	308/.778	302/.780	289/.780	286/.780	286/.780	286/.780	291/.792	
190	311/.770	307/.776	302/.780	289/.780	286/.780	286/.780	286/.780	286/.780	
185	310/.768	306/.774	302/.780	289/.780	286/.780	286/.780	286/.780	286/.780	
180	309/.765	305/.771	301/.777	289/.780	286/.780	286/.780	286/.780	286/.780	
175	307/.761	304/.769	300/.775	289/.780	286/.780	286/.780	286/.780	286/.780	296/.805
170	305/.757	302/.766	299/.772	289/.780	286/.780	286/.780	286/.780	286/.780	292/.796
165	303/.753	301 /.762	298/.770	289/.780	286/.780	286/.780	286/.780	286/.780	289/.787
160	301/.748	299/.758	296/.766	289/.780	286/.780	286/.780	286/.780	286/.780	286/.780

APPENDIX 5

A320 / A330 / A340 Families – Optimum Mach Number

The following appendix exemplifies how the Optimum Mach Number is presented in FCOM tables versus cost index (0, 100, 200, 300, 400, 500kg/min) altitude and wind as calculated by the FMGC. The examples here pertain to the A340-313E and are found in FCOM 3.05.15 pages 1 thru 5.

Cruise tables are established :

- for ISA, ISA + 10, ISA + 15 and ISA + 20
- with normal air conditioning and anti-ice off
- from FL 290 to FL 410 at M 0.80, 0.82 and 0.84
- from FL 100 to FL 410 at long range speed
- with a 30% center of gravity below 2500ft and a 37% center of gravity at higher altitudes.

Table 46. Optimum Mach Number

COST INDEX = 0 (MAXIMUM RANGE)

Weight/wind		FLIGHT LEVEL					
1000 kg/(kt)		310	330	350	370	390	410
150	**100.**	.631	.661	.693	.721	.747	.771
	50.	.649	.678	.708	.734	.757	.776
	0.	.673	.700	.726	.749	.768	.783
	-50.	.696	720	.743	.763	.779	.791
	-100.	.725	.745	.764	.779	.791	.799
170	**100.**	.673	.703	.729	.755	.776	.804
	50.	.689	.717	.741	.763	.781	.804
	0.	.709	.734	.755	.773	.787	.804
	-50.	.728	.750	.768	.783	.793	.804
	-100.	.752	.769	.783	.794	.800	.804
190	**100.**	.708	.734	.759	.779	.800	
	50. 0.	.722	.745	.766	.783	.800	
	0.	.738	.758	.776	.788	.800	
	-50.	.754	.771	.785	.794	.800	
	-100.	.771	.785	.795	.801	.801	
210	**100.**	.737	.760	.780			
	50.	.747	.768	.784			
	0.	.760	.777	.789			
	-50.	.772	.786	.795			
	-100.	.785	.795	.801			
230	**100.**	.760	.779	.790			
	50.	.767	.783	.791			
	0.	.776	.788	.793			
	-50.	.785	.794	3797			
	-100.	.795	.801	.801			
250	**100.**	.778	.790				
	50.	.782	.791				
	0.	.787	.793				
	-50.	.794	.797				
	-100.	.800	.801				
270	**100.**	.789					
	50.	.791					
	0.	.793					
	-50.	.797					
	-100.	.802					

COST INDEX = 100 KG/MIN

Weight/wind		FLIGHT LEVEL					
1000 kg/(kt)		310	330	350	370	390	410
150	**100.**	.766	.782	.795	.804	.811	.814
	50.	.777	.790	.801	.809	.814	.816
	0.	.786	.797	.807	.813	.816	.818
	-50.	.795	.804	.811	.816	.819	.821
	-100.	.802	.810	.816	.820	.823	.823
170	**100.**	.781	.794	.803	.810	.813	.812
	50.	.789	.800	.808	.813	.815	.814
	0.	.797	.805	.812	.816	.817	.815
	-50.	.804	.810	.815	.818	.819	.817
	-100.	.809	.815	.819	.822	.822	.820
190	**100.**	.792	.802	.808	.811	.809	
	50. 0.	.798	.806	.812	.814	.812	
	0.	.804	.810	.815	.816	.814	
	-50.	.809	.814	.817	.818	.816	
	-100.	.813	.818	.820	.821	.818	
210	**100.**	.799	.806	.810	.808		
	50.	.805	.810	.812	.810		
	0.	.809	.813	.815	.813		
	-50.	.813	.816	.817	.815		
	-100.	.816	.819	.819	.817		
230	**100.**	.804	.808	.807			
	50.	.808	.811	.809			
	0.	.812	.814	.812			
	-50.	.815	.816	.814			
	-100.	.818	.818	.815			
250	**100.**	.806	.806				
	50.	.810	.809				
	0.	.813	.811				
	-50.	.815	.814				
	-100.	.818	.816				
270	**100.**	.806					
	50.	.808					
	0.	.811					
	-50.	.814					
	-100.	.816					

Table 47. Optimum Mach Number

COST INDEX = 200 KG/MIN							
		FLIGHT LEVEL					
Weight/wind 1000 kg/(kt)		310	330	350	370	390	410
150	**100.**	.829	.831	.833	.833	.832	.831
	50.	.832	.834	.835	.835	.834	.832
	0.	.835	.836	.837	.836	.835	.834
	-50.	.837	.838	.839	.838	.838	.836
	-100.	.840	3840	.840	.840	.840	.839
170	**100.**	.830	.831	.832	.831	.829	.826
	50.	.832	.833	.833	.832	.830	.827
	0.	.834	.835	.834	.833	.832	.828
	-50.	.836	.837	.836	.835	.833	.830
	-100.	.839	.839	.839	.838	.836	.833
190	**100.**	.829	.830	.829	.827	.824	
	50.0.	.831	.831	.830	.828	.825	
	0.	.833	.833	.832	.830	.826	
	-50.	.835	.834	.833	.831	.828	
	-100.	.837	.837	.836	.834	.830	
210	**100.**	.829	.828	.826	.823		
	50.	.830	.829	.827	.824		
	0.	.832	.831	.829	.825		
	-50.	.833	.832	.830	.827		
	-100.	.835	.834	.832	.829		
230	**100.**	.827	.826	.822			
	50.	.828	.826	.823			
	0.	.830	.828	.824			
	-50.	.831	.829	.826			
	-100.	.833	.831	.828			
250	**100.**	.825	.822				
	50.	.826	.823				
	0.	.827	.824				
	-50.	.828	.825				
	-100.	.830	.826				
270	**100.**	.822					
	50.	.822					
	0.	.822					
	-50.	.822					
	-100.	.822					

COST INDEX = 300 KG/MIN							
		FLIGHT LEVEL					
Weight/wind 1000 kg/(kt)		310	330	350	370	390	410
150	**100.**	.835	.836	.836	.836	.835	.834
	50.	.836	.838	.838	.838	.837	.836
	0.	.838	.840	.840	.840	.839	.837
	-50.	.840	.840	.840	.840	.840	.839
	-100.	.840	.840	.840	.840	.840	3840
170	**100.**	.834	.835	.834	.833	.831	.828
	50.	.836	.836	.836	.835	.833	.830
	0.	.838	.838	.838	.837	.835	.832
	-50.	.840	.840	.840	.839	.837	.833
	-100.	.840	.840	.840	.840	.838	.834
190	**100.**	.833	3833	.832	.830	.826	
	50.0.	.834	.834	.833	.831	.828	
	0.	.836	.836	.835	.833	.829	
	-50.	.838	.838	.837	.835	.831	
	-100.	.840	.840	.839	.837	.831	
210	**100.**	.831	.830	.828	.825		
	50.	.833	.832	.830	.826		
	0.	.834	.833	.831	.828		
	-50.	.836	.835	.833	.830		
	-100.	.838	.837	.835	.830		
230	**100.**	.829	.827	.824			
	50.	.831	.829	.825			
	0.	.832	.830	.827			
	-50.	.834	.832	.829			
	-100.	.836	.834	.829			
250	**100.**	.827	.824				
	50.	.828	.825				
	0.	.829	.826				
	-50.	.831	.826				
	-100.	.833	.826				
270	**100.**	.822					
	50.	.822					
	0.	.822					
	-50.	.822					
	-100.	.822					

Table 48. Optimum Mach Number

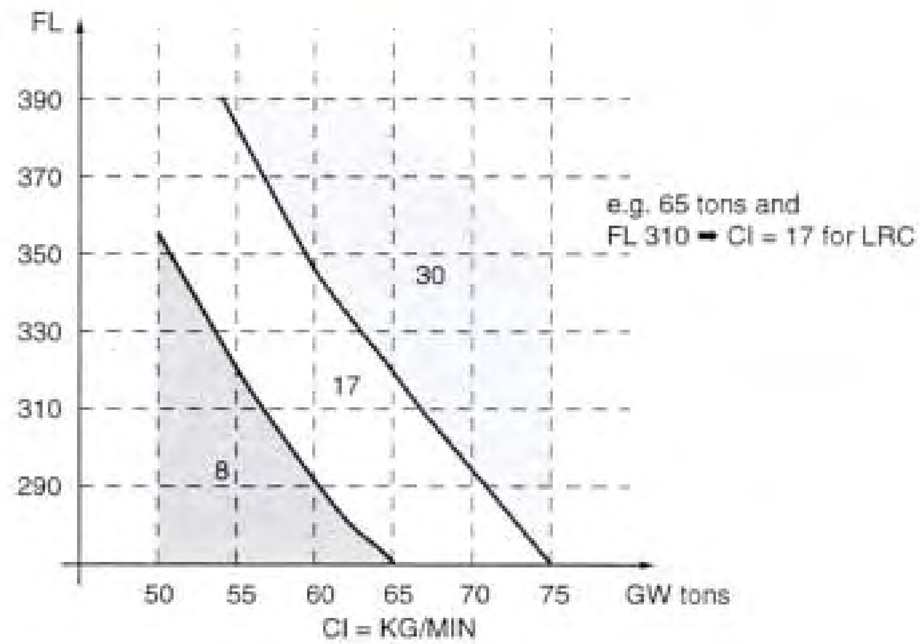
COST INDEX = 400 KG/MIN							
		FLIGHT LEVEL					
Weight/wind 1000 kg/(kt)		310	330	350	370	390	410
150	**100.**	.801	.809	.815	.820	.823	.824
	50.	.806	.813	.820	.824	.825	.825
	0.	.812	.819	.824	.827	.828	.827
	-50.	.819	.824	.828	.830	.829	.828
	-100.	.826	.829	.831	.832	.831	.829
170	**100.**	.807	.814	.818	.821	.822	.819
	50.	.811	.817	.821	.824	.823	.821
	0.	.816	.822	.825	.826	.825	.822
	-50.	.822	.826	.828	.828	.826	.823
	-100.	.827	.830	.830	.830	.828	.824
190	**100.**	.812	.816	.819	.820	.818	
	50.0.	.815	.819	.822	.822	.819	
	0.	.819	.823	.824	.824	.821	
	-50.	.823	.826	.827	.825	.822	
	-100.	.828	.829	.828	.826	.823	
210	**100.**	.815	.818	.818	.816		
	50.	.817	.820	.820	.818		
	0.	.821	.823	.822	.819		
	-50.	.824	.825	.824	.821		
	-100.	.827	.827	.826	.822		
230	**100.**	.817	.817	.815			
	50.	.818	.819	.817			
	0.	.821	.821	.819			
	-50.	.824	.823	.820			
	-100.	.826	.825	.822			
250	**100.**	.816	.815				
	50.	.818	.816				
	0.	.820	.818				
	-50.	.822	.820				
	-100.	.825	.822				
270	**100.**	.814					
	50.	.816					
	0.	.818					
	-50.	.820					
	-100.	.822					

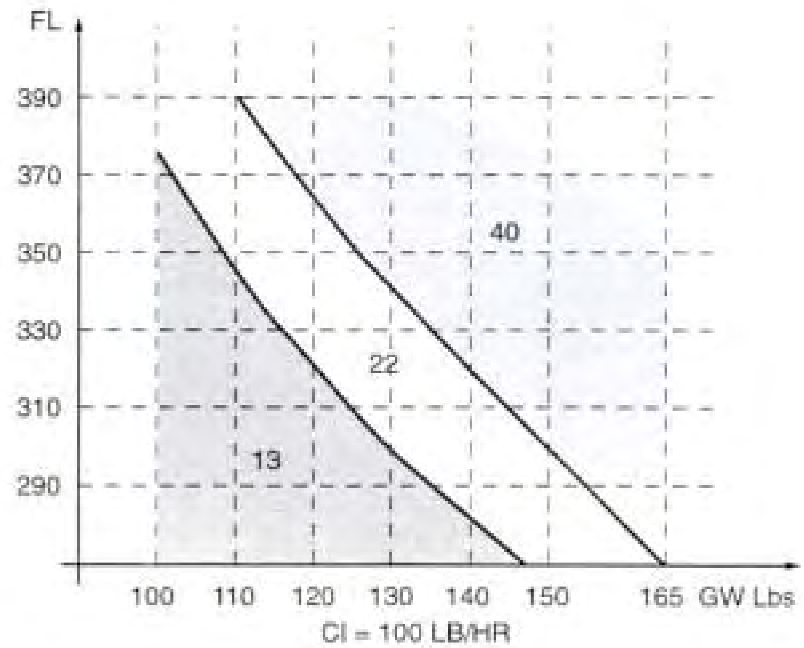
COST INDEX = 500 KG/MIN							
		FLIGHT LEVEL					
Weight/wind 1000 kg/(kt)		310	330	350	370	390	410
150	**100.**	.818	.823	.828	.829	.829	.828
	50.	.823	.828	.830	.831	.831	.829
	0.	.828	.831	.832	.833	.832	.830
	-50.	.831	.834	.835	.834	.834	.832
	-100.	.835	.836	.837	.837	.836	.834
170	**100.**	.821	.825	.827	.828	.826	.823
	50.	.825	.828	.829	.829	.827	.824
	0.	.829	.831	.831	.830	.828	.825
	-50.	.832	.833	.833	.832	.830	.827
	-100.	.835	.835	.835	.834	.832	.829
190	**100.**	.823	.825	.826	.825	.821	
	50.0.	.826	.828	.828	.826	.822	
	0.	.829	.830	.829	.827	.823	
	-50.	.831	.831	.830	.828	.825	
	-100.	.833	.833	.832	.830	.827	
210	**100.**	.823	.824	.834	.821		
	50.	.826	.826	.825	.821		
	0.	.828	.828	.826	.822		
	-50.	.830	.829	.827	.824		
	-100.	.832	.831	.829	.825		
230	**100.**	.823	.823	.820			
	50.	.825	.824	.821			
	0.	.827	.825	.822			
	-50.	.828	.826	.823			
	-100.	.830	.828	.825			
250	**100.**	.822	.819				
	50.	.823	.821				
	0.	.825	.822				
	-50.	.826	.823				
	-100.	.827	.824				
270	**100.**	.819					
	50.	.821					
	0.	.822					
	-50.	.822					
	-100.	.822					

APPENDIX 6

A319 / A320 / A321 Cost Index for LRC

A presented in FCOM 4.05.50 page 14 the Cost Index for Long Range Cruise depends on the actual gross Weight and the flight level. It can be approximated by the following graphs.





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