Where fuel prices drive airline profits, all operational efficiency measures available to airlines should be implemented. Sander de Moor, director of operational efficiency at Aircraft Commerce Consulting, examines the benefits and challenges of a Cost Index programme.

Exploiting the full potential of Cost Index (CI) in operations

Cost Index (CI) shows how time- and fuel-related costs interact with, and offset, each other during aircraft operation, to enable the ratio between time-related costs and fuel burn to be optimised to suit specific flight profile requirements. Although CI first emerged in the 1970s, it is still not universally applied by airlines, which often do not fully understand or correctly implement it.

This article aims to give an overview of CI as a tool for flight profile and network performance optimisation, bringing together source material from publications by the International Air Transport Association (IATA), Airbus, Boeing and other contributors. It is based on years of experience by the author in managing and supporting fuel efficiency programmes.

By way of background, jet aircraft operate at Mach numbers at high altitudes. The speed capability of a jet aircraft has a minimum and a maximum Mach value for any given combination of altitude and temperature. The basic method of setting a speed for jet aircraft is to use a value called Long-Range Cruise (LRC). This is the speed at which the aircraft will achieve 99% of the maximum possible range (the distance that would be flown at Maximum Range Cruise (MRC), with the last 1% of range being traded for typically 3-5% higher cruise velocity.

- An aircraft burns more fuel the faster it flies, and per unit of ground distance covered.
- Conversely, flying faster lowers other time-sensitive operating costs, such as those associated with a delayed arrival.

It is important to find the right balance between the major cost inputs of fuel and time, so that time-sensitive flight operational costs are balanced against incremental fuel burn to achieve minimum overall trip cost. Aircraft using CI operate with variable, more efficient Mach speeds that are optimised for given cost, atmospheric and aircraft conditions. These are called ECON speeds.

A significant aspect of CI operations is that the amount of time spent in headwinds is decreased by accelerating the flight, while the amount of time spent in tailwinds is increased by slowing it down. A headwind will result in a slower ground speed, and so a longer flight time and, therefore, higher time-related costs. Costs will be optimised by flying at a faster cruise speed. A tailwind will result in a faster ground speed, so flight time and time-related costs will be reduced. The aircraft can be slowed down without incurring additional time-related costs, while lowering fuel burn for the trip.

CI optimisation, therefore, takes into account aircraft weight, ambient temperature, wind speed and altitude.

When an aircraft is stuck at a lower flight level (FL) and is unable to operate at its optimum altitude, the most efficient use of fuel will be achieved with CI managing the aircraft speed. Often, short-range flights are operated at lower FLs due to restrictions or company policy. In such cases CI keeps the aircraft operating at the most efficient speed under any range of operating circumstances.

Once a CI programme has been implemented, route-specific CI values should form the basis for both seasonal schedule creation (using assumed seasonal fuel prices) and day-to-day operations (using actual, updated station-specific fuel prices).

Potential savings from CI operations versus fixed-Mach flying vary and depend on several factors, but a 1-3% reduction is a realistic expectation. The largest savings will be achieved by airlines that have implemented a well designed CI programme that uses continuous CI optimisation, both while preparing for flight and proactively during flight (avoiding 'just going faster').

In CI-based mission management the total cost of a delay is included in the flight profile optimisation calculations. The aircraft's performance capability ('speed elasticity' or the ability to slow down or speed up) can be used to reduce or extend flight time to maintain network on-time performance (OTP) and to offset costs associated with late or early arrivals. These costs can result from passenger and freight misconnections, delayed baggage delivery, crew and aircraft rotation, overtime for ground staff, curfew penalties, additional fuel, overflight fees and, if necessary, sacrificed payload.

The CI Model

CI is a number that is used in both ground-based flight planning systems (FPS) and aircraft Flight Management Systems (FMS) to let these systems know what specific cost balancing is expected in planning and executing a flight.

The two main cost inputs are called 'Cost of Time' (CoT) and 'Cost of Fuel' (CoF), with the first one divided by the second one: CI = CoT/CoF. CI is

Cost Index (CI) is the ratio between the cost of time (CoT) and cost of fuel (CoF). CIs have to be recalculated periodically to reflect constant changes in fuel price.

expressed as a number without dimension, since both numerator and denominator are expressed in similar units (US dollars). That is, CI is a ratio of the two cost factors.

The classic explanation of CI numbers is to look at the extremes in cost-balancing; time-dependent costs are either very low or very high. These extremes then result in CI values close to minimum (zero, when time-related costs are close to zero, or when the focus is on using the minimum amount of fuel to complete a flight), or close to maximum (200, 500, 999 or even 9,999 depending on aircraft and FMS type, when time-related costs are deemed to be huge or when the focus is on completing a flight in the shortest time). These CI numbers in turn have the aircraft operate at low speed for maximum range and lowest trip fuel, or close to velocity maximum operating (VMO)/Mach maximum operating (MMO) speeds for a minimum time speed schedule.

Different manufacturers of aircraft and FMSs accept CI inputs to the FMS in different ways. Two well-known CI models are:

- Metric CI model (Airbus): Flight Cost in US$/min / Fuel Cost in US$/kg.
- English CI model (Boeing): Flight Cost in US$/Hr / Fuel Cost in US$/100lb.

The difference in these models means that non-metric CI values (Boeing) are about 30% higher than metric CI values (Airbus) given the same basic input. In an airline with a mixed fleet this can cause confusion, so some airlines use the same CI model across the entire mixed fleet. This in turn brings a common approach and understanding of the range of CI values used in day-to-day planning and Operations Control.

In the case of an expected delay, the assumed cost of such a delay must be integrated with the normal input costs of the specific flight:

- Metric CI model (Airbus): Flight Cost + Delay Cost in US$/min / Fuel Cost in US$/kg.
- English CI model (Boeing): Flight Cost + Delay Cost in US$/Hr / Fuel Cost in US$/100lb.

Aircraft types that do not have FMS speed-optimisation capabilities typically cruise at a fixed-Mach regime (MRC or LRC) or a choice of set speeds (normal cruise, and high-speed cruise). Because these fixed-Mach speed profiles do not vary with wind components they can cost an airline 2-4% in additional operating costs, and as much as 10% in conditions, such as low altitude or unusually strong winds.

For such aircraft, CI operation can be facilitated by software on Electronic Flight Bags (EFB), or via an aircraft addressing, communications and reporting system (ACARS) trigger-receive setup, or even as a booklet-based system. Such CI emulation systems can be of great value for tactical flight management in some conditions.

CI Calculations

With CI values being the result of a 'CoT' / 'CoF' ratio, all time-related costs need to be analysed and evaluated and in turn used as an input to determine correct CI values for each flight.

CI has been described as 'an accounting innovation that has been largely developed by non-accountants', with the occasionally resulting confusion unfortunately resulting in airlines failing to exploit the full economic potential of CI-managed operations.

'CoF' is the best understood component of the CI equation. Fuel prices are communicated to those managing the production of CI values, both listing station-specific fuel cost per unit (total cost of product plus any into-plane costs), and whenever a new fuel price takes effect. This practice is known as dynamic CI, and ensures that all fuel price-related data and the produced CI values are current and accurate.

In many airlines, however, the cost of fuel is a closely guarded secret and there are documented cases of financial departments refusing to give full access to this data. Instead they provide a network-wide average number, or even a published (IATA) figure.

Another issue involves fuel-price hedging, which is a financial instrument used to bring price stability and budget predictability to managing fuel requirements. The argument runs in favour of or against including additional hedging costs in the communicated cost of fuel when the hedging practice has turned a negative corner and the total cost of fuel, including the hedging hit, is higher than it would have been on the spot market.

In an optimum solution, an FPS will accept all relevant cost inputs directly and generate CI values as and when a flight plan is created. A lesser solution will see a department, such as Flight Support or Performance, produce a document that is regularly updated and communicates route- and aircraft-specific CI values to flight operations and flight dispatch to be used in normal planning. A separate (or even integrated) document will specify amended, condition-specific CI values or planning procedures to provide tactical guidance during delay management.

Last, fuel tankering is included in fuel cost calculations, both in using a specific

CI value and using tankering to offset associated extra burn by using a much higher CI value to recover a delay in a short-haul return operation, depending on whether the tankering is done for economic or operational reasons.

CoT is the tricky beast in the CI equation. It is vital that CoT is fully understood and calculated correctly. CoT items are those related to operating the aircraft that are sensitive to flight time, and break down into two components: Time-Dependent Maintenance Costs (TDMC) and Time-Dependent Crew Costs (TDCC). Engines, auxiliary power units (APUs) and aircraft can be owned or leased per month on a flight or block hour basis, while maintenance costs can be charged by the flight or block hour (BH), or by calendar or flight cycles. Crew salaries can have an element of hourly associated or overtime cost. These variations mean that each of these items can have a varying impact on hourly operating costs, so they can be considered as time-sensitive costs. It is, therefore, vital that these numbers are correctly identified and applied.

TDMC

Accurate TDMC values are fundamental to determining the correct CI for a flight. TDMC values should only include costs associated with, or related to, operating the aircraft. They should not include any costs related to flight cycles (FC) or fixed items, and should only be related to operating the aircraft for a few minutes shorter or longer. TDMC values are aircraft-specific in a fleet, due to different in-service dates (ageing, lease components, such as power by the hour (PBH)) and specific maintenance contracts.

When major aircraft checks are fully based on a calendar schedule, regardless of the actual FH logged, it can be argued that there is no TDMC component. This is only when there is no incremental maintenance cost, for example, due to higher than predicted aircraft utilisation. When maintenance is contracted out and a fixed rate per FH for airframe and/or engine maintenance is charged, these costs then form part of TDMC, as would also be the case when items like APU maintenance are based on FH or when an engine is temporarily leased in.

Aircraft ownership or lease costs are significant, however, since most airlines pay a fixed monthly fee or apply a fixed monthly cost of financing and depreciation independent of FH flown. These costs are not considered to be time-dependent. Where aircraft are leased based on PBH or any other construction where a fixed amount per hour is paid for each operated BH, these costs are time-dependent, and can of course be quite high. This results in possibly high to very high flight speeds and associated fuel burns. In these cases, a re-evaluation of such a contract may be necessary.

TDCC

A flight schedule brings crew-related costs. Each block time has an associated cost per flightcrew (directly per FH compensation, additional crew required due to FTL regulations). The entire schedule and planned service delivery, however, will drive additional costs such as crew overnights, crew type requirements, staffing levels, and so on. Here, time-related crew costs vary widely between single-type, short- and medium-haul airlines, low-cost carriers (LCCs), and multi-type, long- and ultra-long-haul full-service carriers.

An advanced flight schedule management tool will take into consideration these and other variables, such as slots, available assets, maintenance requirements, and load factors, to present a range of optimised solutions. The finally selected (seasonal) flight schedule will have an anticipated baseline cost to operate, which can then be used to budget for staffing and purchasing in all departments.

Once CI has been calculated by the flight operations department, it is ultimately used by flightcrew by inputting it into the aircraft's FMS

It is here that the impact of CI can be seen, especially on long- and ultra-long-haul sectors. For example, where the difference between a baseline CI50 profile and an evaluated CI200 profile is 12 minutes shorter flight time and 1,600kg additional fuel burn at a total additional cost (cost of additional fuel minus cost of less time-related cost) of $500, the TDCC element of the TDC is solely based on per FH compensation cost. Depending on FTL regulations for this flight, however, these 12 minutes could mean the difference between needing two or three pilots. This has a significant impact on annual staffing, analysed in advance in the Flight Schedule Management tool.

Different schools of thought exist regarding the inclusion of parts of crew costs and how to deal with any time-sensitive cost breakdown. Answers depend on whether the seasonal flight schedule was built using: the traditional method of fixed Mach values (LRC) and seasonal wind factors; historic flight performance (including or excluding delayed or late flights, and/or flights that were operated faster to maintain network integrity); or a combination or variation of these two examples.

Should crew costs be considered if crews are paid flat salaries? If they are not, this means that flights will operate at a lower CI value, which may require adding flight crew at the end of the year if the seasonal flight schedule was not built on these lower speeds. If they are, this means considering crew costs in calculating TDCC, except when it is obvious that during periods of low flight crew productivity, no TDCC will be incurred if flights are slowed down and will not result in additional flight crew requirements at the end of the year.

Regarding the inclusion of parts of crew costs, if the seasonal flight schedule was built properly using realistic block times, TDCC should only include incremental crew costs (compensation for additional flight time or block time, or compensation for vacation days worked). This is because the baseline total real cost that flight crew and cabin crew members represent to the airline has already been accounted for, and is a required fixed cost to operate the baseline schedule. Acquisition of additional crew at the end of the year is not foreseen. If, on the other hand, the seasonal flight schedule was based on inaccurate inputs, the TDCC should include some costs towards additional crew acquisition and training (new hires, type changes, upgrades), preferably based on data and experience from the previous relevant season.

CI and delay cost management

In daily use, CI is as much embedded in all normal actions related to producing flight plans and operating aircraft as maintaining the databases of the flight planning system and the FMSs, or maintaining performance degradation factors of the aircraft in both FPS and FMS. In an advanced FPS, the correct CI value for a flight is automatically produced by the FPS, based on data in its tables. For a less advanced FPS, it will be necessary to manually enter a CI value for a flight, which would be taken from a specifically produced document.

Where CI really comes into its own is when a flight encounters a delay or an early arrival, and a decision needs to be made on whether to change its speed profile, and then by how much. By using CI, rather than simply increasing speed, any additional fuel burn generated will always be a best balance between needs and costs.

OTP is critical to both customer satisfaction and airline financial health. While departing on time is important, arriving on schedule is even more so.

During day-to-day operations additional time-related costs can occur that justify the use of a CI value other than the normal route/aircraft-specific CI value. Most delay-related issues (such as strong headwinds and departure delays) impact on connecting passengers, subsequent flights, missed curfews or slots, gate occupancy conflicts, and crew legalities or crew connections. Where a delay is expected, late arrival costs should be analysed to determine whether an attempt to recover all or some of the delay should be made.

It should be noted here that different delay costs have different impacts on the overall cost of delay. Flight-related costs (more fuel burn and more expensive airspace when taking a different route) are one-offs, while delay costs associated with passengers or cargo (connectivity) may not start from the first minute of delay, and will change or accumulate as the delay increases. This is both in absolute terms, as more and more passengers are affected; and in relative terms, as the cost per passenger may rise from a simple rebooking to a night spent in a hotel, and so on.

In this respect there are significant differences between short- and medium-range operations and longer-range operations due to the nature of scheduling, and operational abilities of the aircraft used.

Short-range operations are characterised by relatively short flights and short turn-arounds, where planned flight time is sometimes not more than half of planned block time. Time is of the essence in these operations, and the speed-elasticity using CI managed operations is very limited (a few minutes at most at significant additional fuel cost). Delay recovery in this operational environment is best done on the ground, supported by flight crew in cooperation with air traffic control (ATC) in expediting ground and flight operations (taxi-ing, shortcuts, 'free' speeds). On the other hand, incurred costs of delay may be limited because onward connections can more easily be arranged through more frequent flights between city-pairs.

As sectors get longer, the scheduled block time starts to show a bit more leeway, as schedulers need to accommodate more variation in planned wind components during a season. This may give an opportunity to recover a delay in-flight through CI-managed options as well as the ones mentioned above. These schedules can, however, give rise to early arrivals at destination, which may come with additional costs as well.

Flights arriving early can incur additional costs (gate holds or longer gate utilisation, ramp congestion, additional ground staff and ground support requirements, and increased APU use). In such cases these flights can be operated at a lower CI value to reduce fuel consumption and offset expected costs associated with an early arrival against a slightly increased CoT.

Flights arriving late will incur some or all of the above-mentioned costs and have a serious impact on passenger, baggage and cargo connections, as well as operational considerations. Real costs of misconnections are difficult to assess and greatly depend on flight-specific circumstances. Fully recovering a delay may not always be possible through CI management alone, but the aircraft may have sufficient speed elasticity to offset a significant portion of the anticipated cost of delay, resulting in a minimum cost of arrival operation.

Flight delays often occur at a very late stage in the departure process when decisions must be made about speed management to minimise foreseen disruption cost. When using a proper cost-analysis tool, OCC and Flight Dispatch are in a good position to evaluate these costs and determine the correct response in revising the operating plan. Many variables will drive expected cost impact, and flight crews are simply not able to correctly assess these situations as they lack much of the required information. OCC should decide on a course of action that will best minimise delay cost and other impacts of the delay and provide the flight crew with a revised, optimised flight profile and associated fuel. Effective coordination and communications between OCC, Flight Dispatch, Station Operations and flight crews is vital.

CI and speed optimisation processes must be well understood, defined, managed and fully integrated in several areas of an airline (flight operations, flight dispatch, flight dispatch support, scheduling and OCC). Staff who deal with, or input to, CIs need proper training. A well-formulated performance optimisation programme has a measurable and significant impact on operational efficiency.

Airline management often assumes that the cost of operating aircraft is simply 'the cost of doing business' when dedicated tools can used to improve cost-efficiency. The means of doing this include: developing a suitable system; identifying priority flights where a delay will have a significant impact on cost and service; defining a process to evaluate the cost impact of each item related to a delay; and inputs to calculate a revised CI value that will completely or partially minimise any cost of delay.

CI theory & application

CI management plays a vital role in managing flight operational cost, and, more to the point, how such a programme should be implemented.

Once firmly on the road to CI-managed operations, airlines, however, risk implementing CI theory wrongly. This is caused by lack of understanding or training, or both, in key decision areas. Some examples of these implementation variations include:

- Using CI to approximate LRC.
- Use of CI only between Maximum Range Cruise (MRC) and LRC.
- Higher CI value if necessary for

Correct use of a CI will generate savings of 2-4% in cash operating costs versus cruising at a fixed Mach number.

scheduling irrespective of fuel consumption issues.

- CI variation according to fuel prices, irrespective of time considerations (transparent/not considered).
- Use of CI to approximate LRC, except using CI = 0 for fuel-critical routes.
- Use of CI to meet schedule requirements route-by-route (hard STA).
- Use of CI route-by-route differentiating by fuel price only (disregarding CoT).
- Adoption of CI values by copying from other aircraft models/ manufacturers.
- Adoption of CI values by adapting for speed requirements only.
- Changing CI values for sector fuel price variations only after an initial rigorous fuel and time calculation.

Airbus, which is a big supporter of CI-managed operations, and a publisher of some excellent work on this topic, produced a study some years ago that concluded that 'the mere fact that fuel costs can vary significantly from one sector to another throughout the year should prompt airlines to consider adopting different cost indices for their various routes. However, they appear not to do so.'

By way of illustration, the example below shows the difference in operational cost for an A330-300 operating at different CI values.

Inputs were TDC at $1,685 per FH, and fuel cost at $500 per tonne. This will result in an optimum CI value of 56 (CI56), producing the lowest cost flight profile ((1685/60)/0.50). Operating this aircraft at the company-published CI75 consumes an extra 200kg of fuel (+0.4%) and speeds up the flight by one minute, which has the effect of changing the time cost by -0.2%. Overall, this causes the total cost for this flight to increase by $72, which, at 1,000 flights annually, is equivalent to wasting $72,000 and 200 tonnes of fuel.

It is, therefore, clear that incorrect CI values can have a significant impact on flight operational costs. Other examples based on average routes, payloads and conditions show similar deviations and impacts:

- An A320-200 operating CI50 vs OPT CI26 shows +0.21% fuel cost and -0.33% time cost.
- A 747-400 operating CI150 vs OPT CI94 shows +0.33% fuel cost and -0.67% time cost.
- A 777-200ER operating CI100 vs OPT CI80 shows +0.19% fuel cost and -0.11% time cost.
- A 737-700 operating CI65 vs OPT CI30 shows +1.78% fuel cost and -1.46% time cost.

These deviations are usually caused because many airlines do not have an active CI values-monitoring programme in place. CI values used in day-to-day operations may have been determined months or even years ago, and may not have been changed. Since the cost of fuel has increased by more than 50% over the course of past year (May 2017 to May 2018) alone, CI values across the fleets should be more than 50% lower than a year ago.

It is therefore not uncommon for airline operations departments to struggle with correctly implementing CI-based operations, while at the same time trying to persuade financial analysts and controllers to correctly assess TDC inputs. These difficulties are most likely to be caused by non-operational staff who are failing to fully appreciate the importance of operational cost optimisation through CI management. This concept may still be largely unknown to key airline financial decision-makers.

Summary

Jet fuel today costs at least 50% more than it did a year ago, and is once again likely to take over from labour as the largest cost item in running an airline. Rising fuel costs and increasing concerns about emissions-related climate change mean that optimisation of CI-managed flight operations is vital.

Airlines cannot afford to not operate flights in the most cost-efficient way. A correctly designed and managed CI programme is a cornerstone of fuel and operational efficiency.

A number of airlines, unfortunately, do not fully understand CI theory, resulting in misuse of CI or miscalculation of CI values. This in turn leads to sub-optimum CI values being used.

Many airlines have expressed interest in correcting this situation as they begin to appreciate the value of CI in optimising operational costs. Adopting a well-designed CI management programme as the primary means of planning a seasonal flight schedule and operating aircraft on a daily basis ensures that all flight operations are planned and executed based on current economic conditions. This in turn results in the lowest possible trip cost that will meet mission requirements.

Aircraft Commerce Consulting (ACC) is a provider of fuel-efficiency consulting services, and can support airlines with designing or improving a CI management programme through assessment, training and implementation as part of a larger fuel-efficiency support programme. AC