

Fuel Conservation For Short-Haul Operators

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Flight Data Services' Briefing Note 4 explains how flight data can augment engine and airframe monitoring to minimise fuel consumption. This case study looks at one short-haul airline and how FDS provided ideas they could put into practice immediately.

This fuel saving assessment started from examination of the climb profile, as this is typically where many gains may be made. Data from a number of flights was condensed by taking average values of key parameters over 1,000ft bands.

On a given flight there are certain things a pilot can alter and some they cannot. For example, the aircraft weight, external cleanliness, aerodynamics and air temperature are clearly outside a pilot's control. However, they can determine the rate of climb and airspeed, and as a consequence the power and fuel burn. We therefore start by examining the airspeed and rate of climb to see what the pilot is doing in the climb. The ideal climb profile may also be affected by ATC restrictions.

Climb Airspeed

The chart below shows for each 1,000ft altitude (from take-off to 39,000ft) the airspeed achieved. Each point is the average airspeed from one flight as the aircraft climbs from 500ft below the altitude to 500ft above the altitude.

This airframe has a 250kts birdstrike limit up to 10,000ft and clearly this is being observed by most crews. At 10,000ft they accelerate sharply towards 290kts. Above 25,000ft (depending upon atmospheric conditions) the aircraft becomes Mach limited. The diagram also shows that some crews continue to climb at 250kts, while others climb above 10,000ft at 280kts - 300kts.

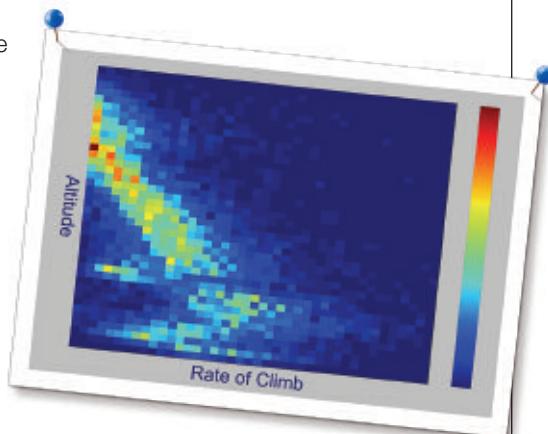
These variations may depend on company/cost index requirements, but this does allow us to quickly assess the performance over a range of flights.

Climb Rate of Climb

As a result of the variations in aircraft weight, engine performance, and atmospheric conditions, there is a much wider variation in climb performance:

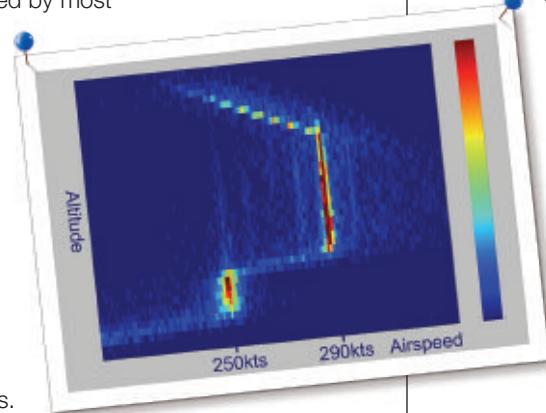
Immediately apparent is the wide range of rates of climb which may be dependent on weight, speed, and ATC.

The reduced rate of climb as the aircraft is accelerated above 10,000ft can be seen in this diagram. This is a direct result of acceleration to optimum climb speed.



There are also a few exceptional flights with much higher than normal rates of climb. These were found to relate to aircraft at light weight or that were trading speed for rate of climb over short "zoom" climbs, possibly for ATC or weather reasons.

One consequence is that more fuel is consumed in the 10,000ft band than at any other altitude, because the rate of climb is reduced and traded for increase in airspeed.



To look at the data in more detail, it is convenient to slice the charts at one level. For this case study, we illustrate the data at 20,000ft, chosen because at this altitude:

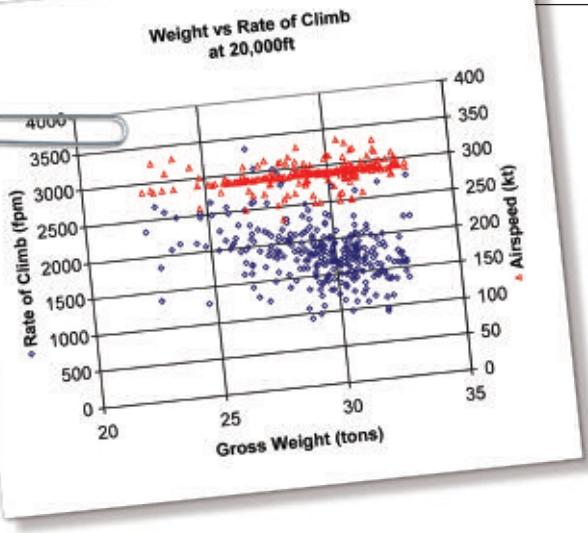
- the acceleration phase has been completed,
- the aircraft is not Mach limited, and
- all the flights were in steady climb (i.e. all the initial cruise altitudes were well above 20,000ft).

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At this altitude the N1 is close to 86.5% on all flights, and the autopilot is commanding 290kt on most flights. There is a weak correlation between the aircraft weight and the airspeed or rate of climb.

The question arises whether 290kts is the optimal speed on climbing through 20,000ft. To answer this we can use the fact that there is some scatter in the data and use regression algorithms to compute the effect of varying one parameter at a time. For example, in this case we were able to show that the climb efficiency (feet climbed per kg of fuel consumed) increased by 0.5% for each knot reduction in airspeed.

It is not surprising that the fuel consumed during climb reduces with airspeed. Reducing the airspeed will allow the aircraft to reach its cruising altitude, having used less fuel, although not having traveled so far.

Examination of the cruise data shows that in 20% of the flights the aircraft cruised at a lower airspeed than it climbed, with an average speed reduction of over 8kts. It was therefore clear that not exceeding the cruise speed during the climb would save fuel, and provide a quantitative estimate of the savings possible.

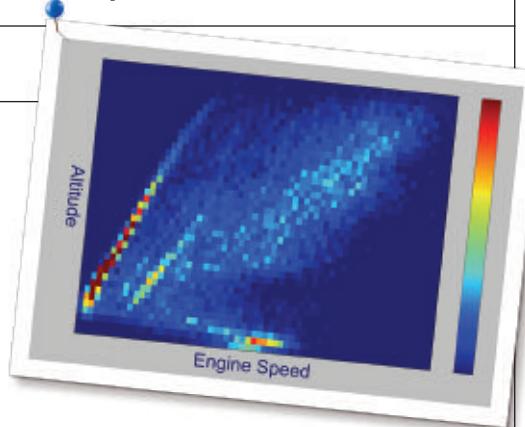
Descent

Similar diagrams to those of the climb show how the aircraft is being operated, and for brevity the engine speed is monitored.

The minimum power/engine speed can be seen as the high density line along the left side of the diagram. Higher powers during level flight can be seen as a yellow band in the 5,000 –

15,000ft range. A low altitude high power area relates to landing conditions.

Most significant from a fuel conservation perspective is the dominant area to the top right of the diagram, which shows that the majority of crews for this airline are powering down the descent rather than flying minimum power descents.



Summary

These techniques can only point to possible areas of fuel savings, and without active participation of the airline and crews nothing will happen. However, they do emphasize areas for examination. Since all the data comes from flight recordings, there is no reliance upon manufacturer's test data. The operator can be sure that the changes made will have the predicted effect.

FDS helps customers to identify fuel inefficiencies and safety issues within their operations, and achieve measurable reductions in event rates.

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