CFM56-7B fuel burn performance

The fuel burn performance of the four main 737NG variants are each assessed with their most popular variant of the CFM56-7B. The aircraft family has similar fuel burn efficiency to the A320 family.

The CFM56-7B series of engines powers all members of the 737-NG family, which comprises the 737-600, -700, -800 and 737-900. There are essentially two hardware-differentiated groups of the CFM56-7B: non-Tech56 modified engines; and Tech56 engines. Tech56 models all have a '/3' suffix at the end of the model designation. They incorporate an improved-emissions single-annular combustor, and a re-designed compressor and high pressure turbine (HPT) rotor. This analysis studies the performance of the most widespread of the two production standards, which is the pre-Tech56 variant, without the /3 suffix. Although there are six Federal Aviation Authority (FAA) certified thrust ratings of the CFM56-7B series *(see CFM56-7B specifications, page 10)*, this analysis examines only the following four thrust ratings: CFM56-7B22 (22,700lbs thrust), CFM56-7B24 (24,200lbs thrust), CFM56-7B26 (26,300lbs thrust), and CFM56-7B27 (27,300lbs thrust).

All engines within the pre-Tech56 subgroup have identical hardware, and the thrust capabilities are merely 'paper changes', which means that different thrust ratings depend on the operator-specific contract and certification documentation. The result is that airlines can choose from various permutations of different engine thrust ratings and different aircraft maximum take-off weights (MTOWs). Only where mission demands dictate the highest possible thrust level, such as hot-and-high departure or limited runway length profiles, will an operator be prepared to pay for the most powerful thrust option.

In this fuel burn analysis of aircraft powered by CFM56-7Bs, only one base engine for each aircraft model is studied. The reason that alternative thrust options are not included is that they would make very little difference, if any, to the sector fuel burn results, given that the aircraft and engine hardware are identical.

Sectors analysed

The route used to analyse these different aircraft is Toronto (YYZ) to Atlanta (ATL). Aircraft performance has been analysed in both directions to illustrate the effects of wind speed and direction on the actual distance flown, also referred to as equivalent still air distance (ESAD). The chosen city-pair is typical of many 737 family operations, since this sector has a block time of about one hour and 40 minutes when flying at a long-range cruise speed of Mach 0.79. In this case the diversion or alternate airports used are Nashville (BNA) when travelling to Atlanta, and Pittsburgh (PIT) when travelling to Toronto.

The flight profiles in each case are based on domestic FAR flight rules, which include standard assumptions on fuel reserves, diversion fuel (for the alternate airports mentioned above), plus contingency fuel, and a taxi time of 20 minutes for the whole sector. This is included in block time. Actual flight time is affected by wind speed and direction, and 85% reliability winds and 50% reliability temperatures for the month of June have been used in the flight plans performed by Jeppesen. The midday departure temperature at YYZ is assumed as 18°C, and 24°C at ATL. The results of these missions *(see table, page 15)* show that the YYZ-ATL route has a headwind component of 12-13 knots, while for the ATL-YYZ return sector there is no net wind component, shown by a value of zero. Therefore the 671nm ESAD distance for this ATL-YYZ sector is identical to the tracked distance. According Jeppesen, this is based on

There are many possible combinations of 737NG airframe variants and CFM56-7B variants. Higher thrusts are only required in conditions where better field performance is necessary. Fuel burn for a particular variant of the 737NG varies with actual take-off weight rather than engine variant.

FUEL BURN PERFORMANCE OF CFM56-7B SERIES

City-pair variant	Aircraft	Engine model	MTOW lbs	TOW lbs	Fuel burn USG	Block time mins	Passenger payload	ESAD nm	Fuel per seat	Wind speed
YYZ-ATL	737-600	CFM56-7B22	143,500	126,031	1,482	116	29,040	691	11.23	-13
YYZ-ATL	737-700	CFM56-7B24	154,500	132,853	1,514	116	32,780	691	10.16	-13
YYZ-ATL	737-800	CFM56-7B26	174,200	149,230	1,581	116	41,580	691	8.37	-13
YYZ-ATL	737-900	CFM56-7B27	187,700	160,284	1,637	118	47,300	691	7.62	-12
ATL-YYZ	737-600	CFM56-7B22	143,500	126,111	1,474	114	29,040	671	11.16	0
ATL-YYZ	737-700	CFM56-7B24	154,500	132,889	1,502	113	32,780	671	10.08	0
ATL-YYZ	737-800	CFM56-7B26	174,200	149,266	1,558	114	41,580	671	8.25	0
ATL-YYZ	737-900	CFM56-7B27	187,700	160,291	1,607	115	47,300	671	7.47	0

Source: Jeppesen

historical average winds for the month of June with 85% reliability. The company also notes that winds vary slightly only if taking historical average winds for the months before May or after July.

The aircraft analysed have been assumed to have typical high-density passenger payloads, which are: 132 passengers for the 737-600; 149 for the 737-700; 189 for the 737-800; and 215 for the 737-900 *(see table, this page)*. The standard weight for each passenger plus baggage is assumed to be 220lbs, and no additional underfloor cargo is carried. The payload carried in both directions by each aircraft is therefore: 29,040lbs for the 737-600; 32,780lbs for the 737-700; 41,580lbs for the 737-800; and 47,300lbs for the 737-900.

On the YYZ-ATL route, the 13-knot headwind increases the tracked distance of 671nm to an ESAD of 691nm. This route has a block time of 116-118 minutes *(see table, this page)*. On the ATL-YYZ route, with a zero net wind component, the 671nm is the same as the ESAD. This route has a block time of 113-114 minutes. On each of the routes, these variations in block duration are accounted for by non-wind-related factors such as differences in take-off, cruise, climb and descent profiles respective to each aircraft model.

Fuel burn performance

The fuel burn for each aircraft/engine combination and the consequent burn per passenger are shown *(see table, this page)*. The fuel burn performance of the different aircraft-engine variants is compared on the YYZ-ATL sector.

The data show that for the respective 737NG models the fuel burn increases in relation to actual take-off weights (ATOWs) and aircraft size. The 737-600, which is the smallest aircraft here in terms of overall length has both the lowest operating empty weight (OEW), of 81,360lbs, and the lowest ATOW, of 126,031lbs. On the YYZ-ATL sector, its resultant fuel burn is 1,482USG. This compares with 1,514USG for the larger 737-700, which has a heavier OEW of 84,000lbs and ATOW of 132,853lbs *(see table, this page)*.

The longer 737-800 has an OEW of 90,710lbs and an ATOW of 149,230lbs. This aircraft exhibits a fuel burn of 1,581USG. The largest of the 737NG models is the stretched 737-900. This has the highest OEW (95,400lbs) and highest ATOW (160,284lbs). On the YYZ-ATL sector its resultant fuel burn is 1,637USG *(see table, this page)*.

In the reverse direction on the ATL-YYZ sector, the fuel burn for each aircraft/engine combination and the consequent burn per passenger are shown *(see table, this page)*. As with the outward sector, the data show that for the respective 737NG models, the fuel burn increases in relation to ATOWs and aircraft size. The 737-600's fuel burn is 1,474USG. This compares with 1,502USG for the 737-700, 1,558USG for the 737-800, and 1,607USG for the 737-900. These fuel burn values are slightly lower than for the corresponding aircraft on the outward sector. This is due to the longer ESAD arising from the lack of a headwind component on the ATL-YYZ sector.

Economics

The results *(see table, this page)* also show fuel burn per passenger and fuel burn per passenger-mile, using the ESAD (rather than the tracked distance). As the aircraft size and weight increases, so too does the required engine thrust, as does the quantity of overall fuel consumed. Conversely, the fuel burn per passenger is nevertheless lowest with the largest aircraft which holds the most passengers: the 737-900.

Taking the YYZ-ATL sector, the CFM56-7B22-powered 737-600 carrying 132 passengers burns the most fuel per passenger: 11.23USG. This compares with the CFM56-7B24-powered 737-700 carrying 149 passengers with a fuel burn of 10.16USG per passenger. Fuel burns per passenger decrease further with the larger models. The CFM56-7B26-powered 737-800 with 189 passengers burns 8.37USG per passenger, while the CFM56-7B27-powered 737-900 with 215 passengers burns the least per passenger, only 7.62USG.

Furthermore, at current jet-fuel prices of about $4 per USG, the cost of fuel burned per passenger averages as follows: $44.6 for the 737-600; $40.4 for the 737-700; $33.2 for the 737-800; and $30.2 for the 737-900.

In summary, the 737-900, as a stretch of the 737-800, delivers the best fuel efficiency and lowest fuel burn per passenger. Meanwhile, the 737-600, which is a fuselage 'shrink' that still shares the same engine hardware, wingbox and landing gear of the larger versions, delivers the highest fuel-burn per passenger.

When considered in terms of fuel burn per passenger per mile, the 737NG family has similar fuel efficiency to the A320 family. This means that the 737-700, -800 and -900 have similar seat numbers to the A319, A320 and A321 similar lower fuel burn per passenger per mile when ESAD is considered *(see CFM56-5A/5B fuel burn performance, Aircraft Commerce, February/March 2007, page 13)*. AC