737NG fuel burn performance

The fuel burn performance of four CFM56-7B-powered 737NG variants are analysed on five route lengths of between 212nm and 1,483nm.

The CFM56-7B series of engines powers all variants of the 737NG family. This analysis examines fuel burn per sector, per passenger seat and per seat-mile for the four variants over five US routes ranging in length from 212nm to 1,483nm.

For the purposes of this analysis, the 737-600 and -700 are powered by the CFM56-7B22, while the 737-800 and -900ER are powered by the CFM56-7B26.

Flight profiles

Aircraft performance has been analysed both inbound and outbound for each route in order to illustrate the effects of wind speed, and its direction, on the distance flown. The resulting distance is referred to as the equivalent still air distance (ESAD) or nautical air miles (NAM).

Average weather for the month of June has been used, with 85% reliability winds and 50% reliability temperatures used for that month, in the flight plans produced by Jeppesen. The flight profiles in each case are based on International Flight Rules, which include standard assumptions on fuel reserves, diversion fuel and contingency fuel. Nevertheless, the fuel burn used for the analysis of each sector only includes the fuel used for the trip and taxiing. The optimum routes and levels have been used for every flight, except where it has been necessary to restrict the levels due to airspace or airway restrictions and to comply with standard route and Eurocontrol restrictions.

A taxi time of 20 minutes has been factored into the fuel burns and added to the flight times in order to provide block times. The flight plans have all been calculated using long-range cruise (LRC) with an equivalent cruise speed of Mach 0.78. Although other speeds are more likely on shorter routes, LRC has been chosen so that all routes can be equally compared for all variants. LRC allows an aircraft to use the least fuel per nm and per seat-mile. Although this means that block times are longer, this is the economical and operational compromise between fuel consumption and flight times.

The aircraft being assessed are assumed to have passenger loads of 110 passengers on the 737-600, 126 on the 737-700, 162 on the 737-800 and 180 on the 737-900ER. These passenger loads are a realistic average of the numbers carried in the two-class configurations utilised by many operators of the 737NG operators. The standard weight for each passenger and their luggage is assumed, on these short-haul flights, to be 200lbs per person, with no additional cargo carried in the hold. The payload carried is therefore: 22,000lbs for the 737-600, 25,200lbs for the 737-700, 32,400 for the 737-800 and 36,000lbs on the 737-900ER.

Route analysis

Five routes of varying lengths were analysed with tracked distances of 212-1,483nm. The routes were chosen as examples of flights that Delta Airlines is currently operating out of its Atlanta hub. All five routes are in the same general direction to avoid the effect of wind distorting the comparison of different variants over different mission lengths.

The first route is Atlanta, GA (ATL) to Columbus/ Starkville/West Point, known as the Gold Triangle Regional (GTR) airport, MS. For this route there was a headwind, causing the tracked distance of 212nm increase to a longer ESAD of 228nm.

The second route is ATL to Springfield, MO (SGF). Again there are headwinds, which have the effect of increasing the tracked distance of 543nm by at least 35nm to an ESAD of 578nm.

The third route is ATL to Omaha, NE (OMA). There is a strong headwind of 32-36kts, which means that the ESAD has an average increase of approximately 55nm over the tracked distance to 810nm.

The fourth route is ATL to Denver, CO (DEN). Again, this route has a strong headwind, the consequence of which is that the ESAD is 127nm longer at

Analysis shows that as route or mission length increases up to about 600nm, the fuel per per seat-mile for each variant reduces. Fuel burn per seat-mile then remains about constant on all longer mission lengths.

FUEL BURN PERFORMANCE OF THE 737-600, -700, -800 & -900ER

City-pair	Aircraft variant	Engine type	Seats	Payload lbs	MTOW lbs	Actual TOW lbs	Block time min	Wind kt	ESAD nm	Track Dist (nm)	Max Fuel capacity (lbs)	Trip fuel burn (USG)	Fuel per seat (USG)	Fuel per seat-mile (USG)
ATL-GTR	B737-600	CFM56-7B22	110	22,000	143,500	112,576	59	M34	228	212	48,900	535	4.860	0.021
ATL-GTR	B737-700	CFM56-7B22	126	25,200	154,500	118,167	58	M34	226	212	39,600	539	4.274	0.019
ATL-GTR	B737-800	CFM56-7B26	162	32,400	174,200	132,649	62	M29	227	212	40,000	561	3.462	0.015
ATL-GTR	B737-900ER	CFM56-7B2 6	180	36,000	187,600	139,540	59	M34	225	212	52,600	586	3.253	0.014
ATL-SGF	B737-600	CFM56-7B22	110	22,000	143,500	117,730	102	M33	578	543	48,900	1,218	11.073	0.019
ATL-SGF	B737-700	CFM56-7B22	126	25,200	154,500	123,282	102	M33	578	543	39,600	1,225	9.720	0.017
ATL-SGF	B737-800	CFM56-7B26	162	32,400	174,200	137,962	114	M29	582	543	40,000	1,273	7.859	0.014
ATL-SGF	B737-900ER	CFM56-7B26	180	36,000	187,600	145,065	102	M33	578	543	52,600	1,322	7.347	0.013
ATL-OMA	B737-600	CFM56-7B22	110	22,000	143,500	120,569	131	M36	809	752	48,900	1,671	15.187	0.019
ATL-OMA	B737-700	CFM56-7B22	126	25,200	154,500	126,100	132	M36	810	752	39,600	1,679	13.326	0.016
ATL-OMA	B737-800	CFM56-7B26	162	32,400	174,200	140,951	151	M32	815	752	40,000	1,751	10.808	0.013
ATL-OMA	B737-900ER	CFM56-7B26	180	36,000	187,600	148,183	133	M36	809	752	52,600	1,813	10.074	0.012
ATL-DEN	B737-600	CFM56-7B22	110	22,000	143,500	125,228	180	M34	1207	1,126	48,900	2,466	22.419	0.019
ATL-DEN	B737-700	CFM56-7B22	126	25,200	154,500	130,924	180	M34	1209	1,126	39,600	2,476	19.648	0.016
ATL-DEN	B737-800	CFM56-7B26	162	32,400	174,200	145,952	209	M29	1210	1,126	40,000	2,586	15.964	0.013
ATL-DEN	B737-900ER	CFM56-7B26	180	36,000	187,600	153,147	180	M34	1210	1,126	52,600	2,663	14.792	0.012
ATL-SLC	B737-600	CFM56-7B22	110	22,000	143,500	130,190	232	M38	1611	1,483	48,900	3,255	29.593	0.018
ATL-SLC	B737-700	CFM56-7B22	126	25,200	154,500	135,824	232	M38	1610	1,483	39,600	3,270	25.951	0.016
ATL-SLC	B737-800	CFM56-7B26	162	32,400	174,200	151,242	269	M33	1615	1,483	40,000	3,429	21.168	0.013
ATL-SLC	B737-900ER	CFM56-7B26	180	36,000	187,600	158,460	232	M38	1611	1,483	52,600	3,516	19.531	0.012

Source: Jeppesen

1,210nm.

The fifth route is ATL to Salt Lake City, UT (SLC). This is a route that experiences the strongest headwind of up to 38kts, which therefore results in an increase in ESAD of at least 127nm to 1,611nm.

The block times and winds for the 737-600, 700 and -900ER are all very similar on each route, with only two minutes maximum between block times *(see table, this page)*. The -800 on shorter routes shows a small difference compared to other variants in terms of absolute fuel burn, but on longer routes the difference in fuel burn per seat between variants actually widens. For the -800, the winds are weaker, although they are still headwinds, thereby making the ESAD longer than the tracked distance and, in most cases, making it the largest ESAD when comparing variants within a certain route.

Fuel burn performance

The fuel burn for each aircraft variant and the consequent fuel burn per passenger seat are shown *(see table, this page)*. The fuel burn per seat-mile is also shown.

The data shows that the fuel burn increases with larger variants, as the take-off weights increase.

Fuel burn per seat naturally increases as mission length increases. Although the ESAD of the fifth route is just over seven times the ESAD of the first, the fuel burn per seat is actually only just over six times as large for the four variants. This serves to illustrate the beneficial effect that longer mission lengths have on fuel burn economy.

As the number of seats for larger variants increases, however, the fuel per seat decreases, with the lowest fuel burn per seat being for the 737-900ER on the ATL-GTR route, the shortest sector.

The highest fuel burn per seat is on the 737-600 on the ATL-SLC route. This is the longest route and the smallest variant, so a high burn per seat is expected.

The burn per seat-mile takes into account the distances flown and the size of the aircraft. For the same variant the fuel burn per seat-mile reduces with longer stage lengths. For the same route length the fuel burn per seat-mile reduces with increasing aircraft size.

The highest burn per seat-mile is for the -600 on the shortest route. The lowest burn per seat-mile is for the -900ER on all but the first two routes.

Not surprisingly, the 737-600 has the lowest burn per seat-mile on the longest route, which is ATL-SLC. The aircraft is more likely to be seen on shorter routes, however.

All variants perform better with increasing stage lengths, up to about 600nm. For routes that are longer than this, burn per seat-mile does not improve for each variant.

There are large differences, however, in the rates of fuel burn per seat between the four variants on all route lengths. The -600, for example, has about a 50% higher burn per seat than the -900 on all route lengths. This represents a difference of more than $6 per seat at current fuel prices between the two variants on a 550-600nm route. The difference between the -700 and -800 is smaller, but it is still equal to a difference in fuel price per seat of approximately $5.

It is worth remembering that the shorter routes are not likely to be flown with LRC, but will use a faster cruise speed, which will increase the fuel per seat and per seat-mile. This will also reduce the flight time. AC