CFM56-3 fuel burn performance

Analysis of the fuel burn performance of six MTOW variants of the 737-300, six variants of the 737-400 and five variants of the -500 reveals consistent fuel burn rates per seat.

The CFM56-3's sole application is the 737-300/-400/-500. The -3C1 can be utilised for all three aircraft, and the -3B1 and -3B2 on two *(see CFM56-3 series specifications, page 10)*. There are six maximum take-off weight (MTOW) and fuel-capacity variants of the 737-300 and -400 models, and five variants of the -500 model. The range of different engine types for each main aircraft variant means that there are several airframe-engine combinations.

The fuel-burn performance of the main airframe-engine combinations that dominate the fleet has been analysed. The MTOW, engine variant and actual take-off weight of the aircraft analysed are summarised *(see table, page 16)*.

Aircraft analysed

Five models of the 737-500 have been evaluated. There are three gross weights, all of which have been analysed with the CFM56-3B1 rated at 18,500lbs thrust. Aircraft with the two higher gross weights of 124,500lbs and 133,500lbs have been analysed with the CFM56-3C1 rated at 20,000lbs thrust *(see table, page 16)*.

Six models of the 737-300 have been analysed. Aircraft with the three lower gross weights have been analysed with the CFM56-3B1 rated at 20,000lbs. The aircraft with the intermediate MTOW of 137,000lbs has been analysed with CFM56-3B2 engines rated at 22,000lbs thrust, while aircraft with the two highest gross weights of 138,500lbs and 139,500lbs have been analysed with the CFM56-3C1 engines also rated at 22,000lbs thrust *(see table, page 16)*.

Six MTOW variants of the 737-400 have been examined. The three aircraft with the lowest MTOWs have been analysed with the CFM56-3B2 engine rated at 22,000lbs thrust, while the three with the highest MTOWs of 142,500lbs, 143,500lbs and 150,000lbs have been analysed with the CFM56-3C1 engine rated at 23,500lbs *(see table, page 16)*.

Route analysed

The route used to analyse these different aircraft is London Heathrow (LHR)-Munich, and 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 LHR-Munich route is typical of many 737 operations, since it has a flight time of 85-100 minutes, depending on direction of travel.

Actual flight time depends on wind speed and direction, and 85% annual Boeing winds and temperatures for the month of April have been used in the flight plans performed by Navtech. The flight plans have been made for the aircraft with a long-range cruise speed of Mach 0.74. The aircraft have been assumed to have full passenger payloads of: 108 for the 737-500; 128 for the -300; and 138 for the -400 *(see table, page 16)*. The standard weight for each passenger plus baggage is 220lbs. The payload for each aircraft is therefore: 23,760lbs for the 737-500; 28,160lbs for the -300; and 30,360lbs for the -400.

On the LHR-Munich route the aircraft experience a small headwind of 2 knots *(see table, page 16)*, which increases the distance flown from a tracked distance of 525nm to an ESAD of 528nm *(see table, page 16)*. This route has a flight time of 86 minutes for the -500 and -300, and 85 minutes for the -400. A taxi time of 20 minutes has been added as standard, and this section of the trip has a fuel burn of 2,000lbs. Block time is 103-106 minutes *(see table, page 16)*.

On the Munich-LHR route the aircraft experience a 53-knot headwind, which increases the distance flown to an ESAD of 630nm. In this case the flight time is 100 minutes for the -500, 97 minutes for the -300 and 99 minutes for the -400. Block times are correspondingly about 20 minutes longer.

The 737-300 and -400 have similar fuel burns per passenger. There are six MTOWs for each variant, the rate of fuel burn per seat for each is similar.

FUEL BURN PERFORMANCE OF CFM56-3 SERIES

Aircraft variant	MTOW lbs	Take-off weight lbs	Engine model	Block Fuel USG	Block time mins	Passenger payload	Fuel USG per passenger	ESAD nm	Wind speed
London-Munich									
737-500	115,500	90,842	CFM56-3B1	1,258	106	108	11.65	528	-2
737-500	124,500	97,564	CFM56-3B1	1,306	106	108	12.10	528	-2
737-500	133,500	104,254	CFM56-3B1	1,351	106	108	12.51	528	-2
737-500	124,500	96,850	CFM56-3C1	1,302	107	108	12.05	528	-2
737-500	133,500	102,989	CFM56-3C1	1,348	107	108	12.48	528	-2
737-300	124,500	100,671	CFM56-3B1	1,345	103	128	10.50	528	-2
737-300	130,000	103,730	CFM56-3B1	1,365	103	128	10.66	528	-2
737-300	135,000	106,121	CFM56-3B1	1,381	103	128	10.79	528	-2
737-300	137,000	110,397	CFM56-3B2	1,394	105	128	10.89	528	-2
737-300	138,500	108,451	CFM56-3C1	1,387	104	128	10.84	528	-2
737-300	139,500	109,552	CFM56-3C1	1,397	104	128	10.92	528	-2
737-400	138,500	115,719	CFM56-3B2	1,438	105	138	10.42	528	-2
737-400	142,400	117,141	CFM56-3B2	1,458	105	138	10.57	528	-2
737-400	150,000	122,501	CFM56-3B2	1,512	105	138	10.96	528	-2
737-400	142,500	116,690	CFM56-3C1	1,472	105	138	10.67	528	-2
737-400	143,500	114,149	CFM56-3C1	1,448	105	138	10.49	528	-2
737-400	150,000	121,244	CFM56-3C1	1,506	105	138	10.91	528	-2
Munich-London									
737-500	115,500	91,813	CFM56-3B1	1,414	120	108	13.10	631	-53
737-500	124,500	98,541	CFM56-3B1	1,464	120	108	13.55	631	-53
737-500	133,500	105,209	CFM56-3B1	1,515	120	108	14.03	631	-53
737-500	124,500	97,789	CFM56-3C1	1,456	121	108	13.48	631	-53
737-500	133,500	103,920	CFM56-3C1	1,506	121	108	13.94	631	-53
737-300	124,500	101,599	CFM56-3B1	1,495	117	128	11.68	628	-53
737-300	130,000	104,579	CFM56-3B1	1,513	117	128	11.82	628	-53
737-300	135,000	107,008	CFM56-3B1	1,541	117	128	12.04	628	-53
737-300	137,000	111,325	CFM56-3B2	1,557	119	128	12.16	630	-53
737-300	138,500	109,447	CFM56-3C1	1,551	118	128	12.12	630	-53
737-300	139,500	110,526	CFM56-3C1	1,560	118	128	12.19	630	-53
737-400	138,500	116,555	CFM56-3B2	1,617	119	138	11.72	630	-53
737-400	142,400	117,873	CFM56-3B2	1,631	119	138	11.82	630	-53
737-400	150,000	123,126	CFM56-3B2	1,683	119	138	12.19	630	-53
737-400	142,500	117,380	CFM56-3C1	1,638	119	138	11.87	630	-53
737-400	143,500	114,953	CFM56-3C1	1,622	119	138	11.76	630	-53
737-400	150,000	121,973	CFM56-3C1	1,679	119	138	12.16	630	-53

Source: Navtech

Aircraft fuel burns

The fuel burn for each aircraft, and the consequent burn per passenger, are shown *(see table, this page)*. The data show that for all three aircraft variants the fuel burn per passenger increases for higher gross weight aircraft models and actual take-off weights. Although none of the aircraft under consideration had an actual take-off weight equal to their MTOW, take-off weights were higher for the aircraft with higher certified MTOWs. The higher fuel burns for these aircraft are explained by their higher operating empty weights (OEWs), which contribute to the higher actual take-off weights.

Although the fuel burn per passenger is higher for aircraft with higher take-off weights, the increase in fuel used per passenger for heavier aircraft compared to lighter aircraft is smaller than the increase in take-off weight.

The fuel used varies from 10.42 to 10.96 USG per passenger for the 737-400. This is equal to about $20-22 per passenger at current fuel prices. The difference in fuel used on the heaviest 737-400 with CFM56-3C1 and lightest -400 model with -3B2 engines *(see table, this page)* is only about 0.5 USG, equal to about $1 in fuel cost.

Unsurprisingly, the 737-500 has the highest fuel burn per passenger compared to the -300 and -400 models. The -500's fuel burn is 11-15% higher than the -300 and -400, which have close fuel burn performance. This puts the 737-500's fuel cost per passenger about $2-3 higher than for the 737-300/-400. This is explained by the -500's high weight per passenger. The 737-300 has almost identical fuel burns per passenger to the -400.

This clearly demonstrates that the CFM56-3 series has consistent fuel burn and consumption for all its three main variants, and four thrust ratings across the various MTOW models of the three aircraft types it powers. The only major variable affecting fuel burn per passenger carried is the actual take-off weight, which is most influenced by the aircraft's OEW. AC