CFM56-5A/5B fuel burn performance

There are a large number of CFM56-5A and -5B variants. The fuel burn performance of the four A320 family members, each with several engine variants, is examined here.

The CFM56-5A and -5B series power all four members of the A320 family of aircraft: the A318, A319, A320 and A321. The A320 family offers operators the advantage of a wide variety of maximum take-off weights (MTOWs) and fuel capacity options.

The fuel burn performance of A320 family aircraft powered by CFM56-5A and -5B engines is analysed. The aircraft and engine model combinations covered in this analysis are as follows:

- CFM56-5A1 and -5A3, on the A320.
- CFM56-5B1/P, -5B2/P, and -5B3/P on the A321.
- CFM56-5B4/P on the A320 and A321.
- CFM56-5B5/P and -5B6/P on the A320 and A319.
- CFM56-5B7/P on the A319.
- CFM56-5B8/P and -5B9/P on the A318.

The CFM56-5B1 to -5B9 series engines have a common basic hardware and turbo-machinery and provide operators with up to eight different thrust ratings to suit different MTOWs. Similarly, the CFM56-5A1 and -5A3 on the A320, and the -5A5 on the A319, also use similar hardware to provide a range of different thrust ratings.

The CFM56-5B8 and -5B9 are rated at 21,600lbs and 23,300lbs on the A318. The -5B5, -5B6 and-5B7 on the A319 are rated at 22,000lbs, 23,500lbs and 27,000lbs thrust. The -5A1, -5A3 and -5B4 are rated on the A320 at 25,000lbs and 27,000lbs thrust, and the -5B4, -5B1, -5B2 and -5B3 are rated on the A321 at 27,000lbs, 30,000lbs and 33,000lbs thrust.

Airlines have the option of combining different thrust ratings with different MTOWs.

Route 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 A320 family operators, since it has a block time of about two hours. In this case the diversion or alternate airports used are Nashville when travelling to Atlanta, and Pittsburgh when travelling to Toronto.

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 Airbus Industrie. It should be noted that for an 85% reliability annual wind, a wind component of minus 28 *(see table, page 14)* means that in 85% of all cases during this month of the year, the headwind component is at least 28 knots. The remaining 15% of the time, the headwind component is weaker, up to 28 knots.

The YYZ-ATL sector has a headwind component of 28 knots, while the ATL-YYZ sector has a headwind component of 18 knots.

The aircraft have been assumed to have full passenger payloads. These are 106 passengers for the A318, 124 for the A319, 150 for the A320, and 185 for the A321 *(see table, page 14)*. The standard weight for each passenger plus baggage is 220lbs. No additional underfloor cargo is carried. The payload carried by each aircraft is therefore 23,320lbs for the A318, 27,280lbs for the A319, 33,000lbs for the A320, and 40,700lbs for the A321.

The flight profiles in each case are based on domestic FAR flight rules, which include standard assumptions on fuel reserves, standard 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.

Taxiing typically accounts for a fuel burn of 240-255lbs, at either end, depending on the specific aircraft-engine combination.

On the YYZ-ATL route, the 28-knot headwind increases the tracked distance of 675nm to an ESAD of up to 722nm. This route has a block time of 125-129 minutes *(see table, page 14)*. Since all aircraft in the sample are assumed to have a cruise speed of Mach 0.80, the differences in flight times are mainly due to wind differences.

On the ATL-YYZ route, with the headwind of 17 or 18 knots, the 675nm tracked distance flown increases to an ESAD of 703-705nm, depending on the aircraft type. This route has a block time of 125-127 minutes.

Despite there being large differences in the size of the four A320 family members, there is little difference in fuel burn per seat between the aircraft when equipped with CFM56-5B engines.

FUEL BURN PERFORMANCE OF CFM56-5A/5B SERIES

City-pair variant	Aircraft	Engine model	MTOW lbs	TOW lbs	Fuel capacity USG	Fuel burn USG	Block time mins	Passenger payload	ESAD nm	Fuel per seat	Wind speed
YYZ-ATL	A318-100	CFM56-5B8/P	130,073	125,844	6,303	1,377	127	106	721	12.99	-27
YYZ-ATL	A318-100	CFM56-5B8/P	135,580	125,844	6,303	1,377	127	106	721	12.99	-27
YYZ-ATL	A318-100	CFM56-5B8/P	138,890	125,844	6,303	1,377	127	106	721	12.99	-27
YYZ-ATL	A318-100	CFM56-5B8/P	142,200	125,844	6,303	1,377	127	106	721	12.99	-27
YYZ-ATL	A318-100	CFM56-5B8/P	142,500	125,844	6,303	1,377	127	106	721	12.99	-27
YYZ-ATL	A318-100	CFM56-5B8/P	149,900	125,844	6,303	1,377	127	106	721	12.99	-27
YYZ-ATL	A319-100	CFM56-5A5	141,100	132,314	6,303	1,439	127	124	721	11.61	-27
YYZ-ATL	A319-100	CFM56-5B5/P	149,920	132,868	6,303	1,433	127	124	721	11.55	-28
YYZ-ATL	A319-100	CFM56-5B6/P	154,330	132,868	6,303	1,433	127	124	721	11.55	-28
YYZ-ATL	A319-100	CFM56-5B7/P	166,450	135,437	7,884	1,457	127	124	721	11.75	-28
YYZ-ATL	A320-100	CFM56-5A1	145,504	140,568	4,185	1,519	129	150	722	10.13	-28
YYZ-ATL	A320-200	CFM56-5A1	162,040	143,289	6,303	1,551	129	150	722	10.34	-27
YYZ-ATL	A320-200	CFM56-5A3	166,450	143,289	6,303	1,551	129	150	722	10.34	-27
YYZ-ATL	A320-200	CFM56-5B5/P	162,050	143,759	6,303	1,536	129	150	722	10.24	-27
YYZ-ATL	A320-200	CFM56-5B6/P	166,450	143,759	6,303	1,536	129	150	722	10.24	-27
YYZ-ATL	A320-200	CFM56-5B4/P	169,750	143,759	6,303	1,536	129	150	722	10.24	-27
YYZ-ATL	A321-200	CFM56-5B4/P	183,000	167,241	6,261	1,793	125	185	721	9.69	-28
YYZ-ATL	A321-200	CFM56-5B1/P	187,400	167,241	6,261	1,793	125	185	721	9.69	-28
YYZ-ATL	A321-200	CFM56-5B2/P	196,200	168,496	7,040	1,802	125	185	721	9.74	-27
YYZ-ATL	A321-200	CFM56-5B3/P	206,130	206,130	7,842	1,768	127	185	722	9.56	-28

Source: Airbus Industrie

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 shows that for the respective models the fuel burn per passenger increases in relation to actual take-off weights, rather than the certified MTOW of the aircraft. Higher MTOW capabilities, however, can in some cases mean that aircraft are physically stronger and so have a higher hull weight. In other cases, such as the A318s listed, the family sub-variants' operational empty weight (OEW) are the same, and they have identical actual take-off weights and fuel burns. Successive MTOW increases and thrust differences are simply 'paper changes'. The A318 comes with six MTOW specifications from 130,073lbs to 149,900lbs. In all cases the fuel used for this sector is identical at 1,366 US Gallons (USG) *(see table, this page)*. Most variants have the potential to carry higher payloads and fly longer distances than the YYZ-ATL sector analysed.

The effect is the same with three of the four A319 variants analysed, but the variant with the highest MTOW specification burns more fuel *(see table, this page)*.

For the A320, being the 'original' baseline variant, there are significant physical differences between the models analysed, and also the engines powering them. Not surprisingly, the fuel burn varies widely for each model. The first A320 model to be listed *(see table, this page)* is the earliest -100 model with CFM56-5A1 engines, and this was quickly superseded by the improved -200 which featured fuel-saving wingtip fences, among other changes. The -100 has an MTOW of 145,504lbs, an OEW of 90,422lbs, and fuel capacity of 4,185USG. In contrast, the subsequent -200 model, powered by the same engine, has an increased MTOW of 162,040lbs, a higher fuel capacity of 6,303USG due to larger tankage, and a higher associated OEW of 92,815lbs. This -200 model has a fuel burn of 1,551USG, while the -100's fuel burn is 1,519USG. This is explained by the -200's higher structural weight and OEW, which caters for its higher MTOW capability.

On the other A320-200 models equipped with -5B engines, their fuel burn decreases from 1,551USG to 1,536USG. This decrease is due to the CFM56-5B series' higher fuel burn efficiency over the older -5A1 and -5A3 models.

Moreover, the -5B's lower fuel burn also has to be considered in relation to aircraft with this engine having a higher OEW (93,432lbs versus 92,815lbs for the -5A1-powered aircraft). Interestingly, successive A320-200s (powered by -5B4/P, -5B5/P and -5B6/P engines) have higher specified MTOWs. These higher weights have no effect on their respective block fuel burns, however, which in all three cases are identical at 1,536USG. Correspondingly, the respective OEWs for these versions are 93,432lbs.

An interesting trend can be observed when considering fuel burn per passenger. As the aircraft grow in size (from the A318 through to the A321) all specification weights and actual take-off weights increase. The required engine thrust increases in line with higher take-off weights, as does the quantity of fuel consumed. Fuel burn per passenger *(see table, this page)*, is lowest with the largest aircraft. Fuel burns per passenger shown illustrate the relative fuel burn efficiencies of the A320 family members. The A318s all report the highest fuel burn per passenger at 12.99USG. This compares with the best A321 figure of 9.56USG per passenger. This equates to a fuel cost per passenger of $24 for the A318 and $18 per passenger for the A321. This is explained by only a 28% increase in fuel consumed for a 43% increase in the number of passengers carried. AC