A320 family fuel burn performance

The fuel burn performance of the most numerous of the airframe-engine combinations in the A320 family variants are analysed.

The A320 family has a large number of airframe-engine combinations. This is because each family member has several maximum take-off weight (MTOW) variants, as well two or three fuel capacity options. The A321, for example, has up to five different MTOW variants. Airbus also offers between two and four variants of the CFM56-5B and V.2500-A5 for each family member, which means that there can be more than 20 airframe-engine combinations for each family member.

The fleet, however, is dominated by several engine types *(see table, page 17)*. The CFM56-5B and V.2500-A5 series both use the same basic engine and hardware and have up to eight different thrust ratings. These are controlled by the engine's full authority digital engine control (FADEC) system, which allows thrust ratings to be easily changed. Each thrust rating has a different list price, and upgrades to a higher rating incur a cost.

Airbus offers the CFM56-5B8 and -5B9 rated at 21,600lbs and 23,300lbs on the A318 *(see A320 family specifications, page 6)*. It similarly offers the -5B5, -5B6 and-5B7 on the A319. These three variants are rated at 22,000lbs, 23,500lbs and 27,000lbs. The -5A1, -5A3 and -5B4 are available on the A320 at between 25,000lbs and 27,000lbs thrust, and the -5B4, -5B1, -5B2 and -5B3 are available on the A321 rated between 27,000lbs, 30,000lbs and 33,000lbs thrust.

A similar scenario exists with the V.2500 on the A319, A320 and A321. The V.2522-A5 and V.2524-A5 rated at 22,000lbs and 23,500lbs are offered on the A319. Only the V.2527-A5 rated at 26,500lbs thrust is available on the A320's three MTOW variants. The V.2530-A5 and V.2533-A5 rated at 31,000lbs and 33,000lbs are available for the A321's five different MTOW options.

While airlines may usually combine a high-rated engine with a high-MTOW airframe variant, there is still the option of using a lower-rated engine for an aircraft with one of the higher MTOWs. Engine and thrust rating influence field and operating performance, while MTOW and fuel capacity affect range. A higher-rated engine will offer better field performance, but have higher fuel burn.

Fuel burn performance

The differences in fuel burn between the different engine types powering the same MTOW variant of a family member have been examined. Only a few examples of the A319, A320 and A321 have been studied, but these demonstrate the differences in fuel burn of some of the V.2500-A5, CFM56-5A and CFM56-5B series variants on each model.

The present study has been conducted on a typical European route representative of many operated by these aircraft: London Heathrow-Munich. To illustrate the effects of wind strength and direction the aircraft have been analysed for operations in both directions.

The tracked distance for this sector is 536nm. The flight performance and plans for each aircraft have been calculated using historical winds and temperatures for January, with 85% reliability for winds and 50% reliability for temperatures. The flightplans for all aircraft have been examined with the aircraft cruising at a speed of Mach 0.80. In all cases, the aircraft have been studied with payloads of a full two-class passenger layout. The A319 has been analysed with 124 passengers, the A320 with 150, and the A321 with 185. The standard weight for each passenger has been taken as 220lbs. The payload for the A319 is therefore 27,280lbs, for the A320 33,000lbs and for the A321 40,700lbs *(see table, page 17)*.

The aircraft experience a small headwind of only 2 knots flying south from London to Munich, so the equivalent still air distance is almost equal to the tracked distance, and the flight time is 78-80 minutes.

The aircraft experience a 60-knot headwind flying north from Munich to London, which increases the tracked distance from 549nm to 628nm *(see table, page 17)*. This subsequently increases flight time to 90-92 minutes.

Two A319 variants with an MTOW of 154,330lbs (70 tonnes) and 166,450lbs (75.5 tonnes) have been studied with four different engine types: the V.2524-A5, the CFM56-5B5 *(see table, page 17)*. The two MTOW variants have the same fuel capacity of 6,300 US Gallons (USG).

The first point from the analysis on the A319 is that aircraft powered by the V.2524-A5 burn less fuel than their CFM56-powered counterparts. In the case of the A319, with an MTOW of 154,300lbs (70 tonnes), flying from London to Munich, the CFM56-5A5 is the least fuel-efficient, burning 2.4% more fuel than the V.2500-powered aircraft. Aircraft powered by the CFM56-

In most cases, the V.2500 is more fuel efficient than the CFM56-5A/-5B in the order of 0.5-5%.

FUEL BURN PERFORMANCE OF A319, A320 & A321

City-pair	Aircraft variant	MTOW lbs	Engine model	Fuel USG	Flight time	Passenger payload	Fuel USG per passenger	ESAD nm	Wind speed factor
London-Munich	A319	154,330	V.2524-A5	1,030	1:18	124	8.31	536	-2
	A319	154,330	CFM56-5B5	1,037	1:18	124	8.36	536	-2
	A319	154,330	CFM56-5B6	1,048	1:19	124	8.45	536	-2
	A319	154,330	CFM56-5A5	1,055	1:16	124	8.51	536	-2
	A319	166,450	V.2524-A5	1,030	1:18	124	8.31	536	-2
	A319	166,450	CFM56-5B5	1,037	1:18	124	8.36	536	-2
	A319	166,450	CFM56-5B6	1,048	1:19	124	8.45	536	-2
	A319	166,450	CFM56-5A5	1,055	1:16	124	8.51	536	-2
	A320	166,450	V.2500-A1	1,027	1:19	150	6.85	536	-2
	A320	166,450	CFM56-5A1	1,031	1:17	150	6.87	536	-2
	A320	166,450	CFM56-5B4	1,144	1:20	150	7.63	536	-2
	A320	169,800	V.2527-A5	1,078	1:20	150	7.19	536	-2
	A320	169,800	CFM56-5A3	1,094	1:19	150	7.29	536	-2
	A320	169,800	CFM56-5B4	1,144	1:20	150	7.63	536	-2
	A321	196,200	V.2530-A5	1,297	1:19	185	7.01	536	-2
	A321	196,200	CFM56-5B2	1,256	1:19	185	6.79	536	-2
Munich-London	A319	154,330	V.2524-A5	1,153	1:32	124	9.30	627	-60
	A319	154,330	CFM56-5B5	1,160	1:31	124	9.36	627	-60
	A319	154,330	CFM56-5B6	1,167	1:31	124	9.41	627	-60
	A319	154,330	CFM56-5A5	1,175	1:30	124	9.48	627	-60
	A319	166,450	V.2524-A5	1,153	1:32	124	9.30	627	-60
	A319	166,450	CFM56-5B5	1,160	1:31	124	9.36	627	-60
	A319	166,450	CFM56-5B6	1,167	1:31	124	9.41	627	-60
	A319	166,450	CFM56-5A5	1,175	1:30	124	9.48	627	-60
	A320	166,450	V.2500-A1	1,139	1:33	150	7.60	627	-60
	A320	166,450	CFM56-5A1	1,144	1:29	150	7.62	627	-60
	A320	166,450	CFM56-5B4	1,270	1:33	150	8.46	627	-60
	A320	169,800	V.2527-A5	1.192	1:33	150	7.95	627	-60
	A320	169,800	CFM56-5A3	1,204	1:33	150	8.03	627	-60
	A320	169,800	CFM56-5B4	1,270	1:33	150	8.46	627	-60
	A321	196,200	V.2530-A5	1,390	1:32	185	7.51	627	-60
	A321	196,200	CFM56-5B2	1,365	1:31	185	7.38	627	-60

Source: Jeppesen

5B5 and -5B6 burn 0.7% and 1.7% more fuel respectively *(see table, this page)*.

These differences are reduced when flying in the other direction, which increases the travelled distance by about 17%. In this case the CFM56-5A5-powered aircraft burns 1.9% more fuel than that powered by the V.2524-A5. The CFM56-5B6 burns 1.2% more fuel and the -5B5 0.6% more *(see table, this page)*.

The second point is that an aircraft with an MTOW of 166,450lbs (75.5 tonnes) burns the same amount of fuel as that with a lower gross weight and equipped with the same engines. This is because the actual take-off weight of the two aircraft is the same despite the higher gross-weight variant being used.

The A320 has been analysed with MTOWs of 166,450lbs (75.5 tonnes) and 169,800lbs (77 tonnes). The aircraft with a gross weight of 166,450lbs have been analysed with the V.2500-A1, CFM56-A1 and CFM56-5B4 engines.

In this case the V.2500-A1 has the lowest fuel burn, with the CFM56-5B4 burning 11.4% more fuel. This engine was developed for higher gross weight variants of the A320, however, and also for all other models of the A320 family. The V.2500-A1 was only used on early-production aircraft with lower gross weights. Aircraft with the CFM56-5A1 burn less than 1% more fuel than those with the V.2500-A1 *(see table, this page)*. Similar differences in fuel burn are seen with aircraft operating in both directions.

The A320 with the higher gross weight of 169,800lbs was analysed with V.2527-A5, CFM565-5A3 and CFM56-5B4 engines. This is more representative of later-built aircraft, which are also currently being ordered by airlines.

As with all other cases, aircraft with the V.2500 engine are the most fuel-efficient. The CFM56-5B4 has a 6.1-6.5% higher fuel burn, while the CFM56-5A3 has a 1.5-5.5% higher burn *(see table, this page)*, despite the V.2527-A5-equipped aircraft having a 4,000lbs higher operating empty weight (OEW).

Of the five MTOW variants of the A321 the highest is 206,130lbs (93.5 tonnes). The variant analysed here has an MTOW of 196,200lbs (89 tonnes), and a fuel capacity of 7,040 USG. This variant has been analysed with V.2530-A5 and CFM56-5B2 engines. In this case, the V2527-equipped aircraft has a marginally higher fuel burn of 1.8-3.3% *(see table, this page)*.

Besides differences in fuel burn between different engine types on the same aircraft, the analysis also shows that the A321 is the most fuel-efficient family member in terms of fuel burn per seat *(see table, this page)*. The A319 burns about 1.5 USG more per passenger than the A321, equal to about $2.4. AC