V2500-A5/-D5 fuel burn performance

The fuel burn performance and economics of the three A320 family members and MD-90 aircraft powered by V2500-A5/-D5 engines are analysed and assessed.

The V2500-A5 series of engines powers three of the four members of the A320 family of aircraft currently in production: the A319, A320 and A321.In addition, a virtually identical but tail-mounted -D5 variant powers the MD-90.

The aircraft and engines

Although each respective A320 family member offers operators a wide variety of maximum take-off weights (MTOWs), maximum landing weights (MLWs) and fuel capacity options, the aircraft and engine hardware (V2500-A5 series) is identical for each version. This is because the capability differences are merely 'paper changes', which depend on the operator-specific contract and certification documentation. Airlines can therefore choose from various aircraft configuration permutations to specify different engine thrust ratings with different specification weights to suit a particular operation. The highest MTOW and thrust options are not specified by all customers as standard because the purchase price of the engine reflects the required thrust level, while the MTOW and MLW capability and the fuel capacity affect the price of the delivered aircraft as well as airport fees. Only where mission demands dictate the highest possible thrust level, such as hot-and-high departure/limited runway profiles, will an operator be willing to pay more for this.

The hull weights or operational empty weights (OEWs) are the same for each specification option for the current production A319-100, A320-200 and A321-200 aircraft. All weight options would therefore exhibit identical actual take-off weights and resultant fuel burns, regardless of their specification MTOW.

The A319 can be powered by either the V2522-A5 rated at 23,040lbs thrust, or the mechanically identical V2524-A5 rated at 24,480lbs (both at or below ISA plus 40°C). Meanwhile, the V2527-A5 is offered for the A320's three MTOW variants and is certified at 24,800lbs thrust (at or below ISA plus 31°C). There are also two supplementary options for the V2527-A5-powered A320: the V2527E-A5 and V2527M-A5. The former is the 'enhanced take-off" model, which provides increased take-off thrust for A320s at high airport elevations relative to the V2527-A5 base model. The largest A320 member, the A321, is offered with the V2530-A5 or V2533-A5, certified at 29,900lbs and 31,600lbs thrust (both at or below ISA plus 15°C). These engines are available for the A321's five different MTOW options.

The MD-90 can be powered either by V2525-D5s rated at 25,000lbs thrust, or V2528-D5 engines rated at 28,000lbs thrust. Both these thrust ratings apply at ISA plus 15°C.

Flight plans for only one base engine for each aircraft model were studied in this fuel burn analysis of aircraft powered by V2500-A5 and V2500-D5. The alternative thrust options are not included because they would make very little difference, if any, to the sector fuel-burn results, given that the aircraft and engine hardware are identical. The aircraft and engine model combinations covered in this analysis are as follows:

- V2524-A5 on the A319-100
- V2527-A5 on the A320-200
- V2530-A5 on the A321-200
- V2525-D5 on the MD-90-30

The A320-200 version incorporates all the latest modifications developed over its 20-year production life. The same applies to the V2500 engines. The first powerplant version was the V2500-A1, but is not included in this analysis.

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 A320 family operators, and would also be applicable to the MD-90, since this sector has a block time of about two hours at Mach 0.76-0.78. In this case the diversion or alternate airports used are Nashville (BNA) when travelling to Atlanta, and Pittsburgh (PIT) 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 Airbus and Jeppesen flight plans.

There are several MTOW variants on the A320 family. These different weights are achieved through 'paper changes'. Fuel burn performance is therefore only affected by differences in actual take-off weights.

FUEL BURN PERFORMANCE OF V2500-POWERED PASSENGER AIRCRAFT

City-pair	Aircraft variant	Engine type	Seats	Payload lbs	MTOW lbs	Actual TOW lbs	Fuel burn USG	Block time mins	ESAD nm	USG per pax-nm
YYZ-ATL	A319-100	V2524-A5	124	27,280	166,450	132,092	1,379	129	722	11.12
YYZ-ATL	A320-200	V2527-A5	150	33,000	169,750	142,850	1,474	132	723	9.82
YYZ-ATL	A321-200	V2530-A5	185	40,700	196,210	166,110	1,709	127	722	9.24
YYZ-ATL	MD-90	V2525-D5	155	34,100	156,000	141,415	1,691	129	728	10.91
ATL-YYZ	A319-100	V2524-A5	124	27,280	166,450	132,005	1,352	127	705	10.90
ATL-YYZ	A320-200	V2527-A5	150	33,000	169,750	142,540	1,427	129	705	9.52
ATL-YYZ	A321-200	V2530-A5	185	40,700	196,210	165,918	1,682	125	704	9.09
ATL-YYZ	MD-90	V2525-D5	155	34,100	156,000	141,146	1,626	127	705	10.49

Departure temperature at YYZ is 18°C, and 24°C at ATL. For an 85% reliability annual wind, a headwind component of 31 knots *(see table, this page)* means that in 85% of cases in June, the headwind component is at least 31 knots. The remaining 15% of the time, the headwind component is weaker, at less than 31 knots. The table shows that in all cases, YYZ-ATL has a headwind component of 31 knots, while ATL-YYZ has a reduced wind component of 20 knots.

The aircraft analysed have been assumed to have full passenger payloads: 124 passengers for the A319; 150 for the A320; 185 for the A321; and 155 for the MD-90 *(see table, this page)*. The standard weight for each passenger plus baggage is assumed to be 220lbs and no additional under-floor cargo is carried. The payload carried in both directions by each aircraft is therefore: 27,280lbs for the A319; 33,000lbs for the A320; 40,700lbs for the A321; and 34,100lbs for the MD-90.

On the YYZ-ATL route, the 31-knot headwind increases the tracked distance of 675nm to an ESAD of between 722nm and 728nm. This route has a block time of 127-132 minutes *(see table, this page)*.

On ATL-YYZ, with the headwind of 20 knots, the 675nm tracked distance flown increases to an ESAD of 704-705nm, depending on the aircraft. This has a block time of 125-129 minutes.

Flight profiles

The flight profiles are based on domestic FAR flight rules, which include standard assumptions on fuel reserves, standard diversion fuel (for the alternate airports mentioned above), 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 275-300lbs, at either end, depending on the specific aircraft-engine combination. All sectors presented here are flown using optimum long-range-cruise (LRC) Mach number. The Airbus aircraft's LRC is Mach 0.78, while the MD-90's is Mach 0.76.

If the aircraft fly any faster than this, the block fuel consumption will increase, due to the exponential onset of transonic drag over the lifting surfaces and also fuselage, especially at the nose.

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 Airbus models the block fuel burn increases in relation to actual take-off weights and aircraft size. The A319-100, the smallest aircraft here by overall length has the lowest OEW (89,000lbs) and the lowest actual take-off weight (132,092lbs). On the YYZ-ATL sector, its resultant block fuel burn is 1,379USG, compared to 1,474USG for the A320-200, with a heavier OEW of 93,500lbs and actual take-off weight of 142,850lbs resulting in a higher block fuel burn of 1,474USG. The other influence is the higher induced drag due to the increased wetted area of the A320's fuselage, which is longer than the A319's. The even larger A321-200 has an OEW of 106,300lbs and an actual take-off weight of 166,110lbs. Unsurprisingly, it has the highest block fuel burn, 1,709USG.

The MD-90 carrying 155 passengers is shown to burn almost as much fuel on the sector (1,691USG) as the largest A321 (1,709USG) carrying 185 passengers. This is especially surprising, given that the MD-90 has the same OEW, 89,500lbs, as the smallest Airbus here, the A319. Engine efficiency is not a factor since the V2500-D5 is virtually the same as the V2500-A5, sharing the same turbomachinery and thermodynamic cycle. Nor is flight profile a factor, since all the Airbus aircraft and the MD-90 are subject to the same ISA/temperature, runway and cruise conditions. They are also flying the same sector, with light payloads, carrying low fuel loads, from runways where they are not constrained, and cruising at their most efficient cruise speed with virtually the same tracked distance, winds and resultant ESADs.

The MD-90's high fuel burn in comparison with the Airbus aircraft can only be due to its older-generation wing aerodynamics. Indeed, the MD-90's wing owes its design heritage to the 1960s-1970s McDonnell Douglas DC-9/MD-80 era. The A320 family wing is a second-generation 1980s supercritical design with a significantly better lift-to-drag ratio. Similar trends are observed in the reverse ATL-YYZ direction. The main differences in fuel burn *(see table, this page)* are due to the reduced headwind component, which proportionally reduces the ESAD on each aircraft by 2-4%.

Economics

Absolute block fuel burn is only part of the story. The critical measure is fuel burn per passenger. As the aircraft size increases, all specification weights and actual take-off weights increase. So too does the required engine thrust, as does the quantity of overall fuel consumed. However, for the A320 family with its different fuselage lengths, the fuel burn per passenger *(see table, this page)*, is nevertheless lowest with the aircraft which holds the most passengers.

The table shows the relative fuel burn efficiencies of the V2500-powered A320 family members, and of the MD-90. On the YYZ-ATL sector, the V2524-A5-powered A319 carrying 124 passengers burns the most fuel per passenger, 11.12USG, while the V2530-powered A321 carries 185 passengers with a fuel burn of only 9.24USG per passenger. The V2525-D5-powered MD-90 carrying 155 passengers, sits between the A319 and A320 in terms of fuel burn per passenger at 10.91USG. AC