ATR family fuel burn performance

There are six main variants of the ATR 42 and 72. Most operators have cycle times that average one hour. The fuel burn performance of these six main variants on a typical sector is analysed.

Analysis of the fuel burn performance of three variants of the ATR42, and three variants of the ATR72, reveals that for a given payload flown over a given distance, the fuel burn per seat is influenced by several factors that include operating empty weight (OEW) per seat, rated engine power, and cruise speed.

Aircraft overview

Six models of the ATR family of turboprops have been evaluated. These are subdivided between the baseline ATR42 and larger ATR72 variants.

Three ATR 42 models are examined: the -300, -320, and -500. The ATR42-300 has a maximum take-off weight (MTOW) of 37,200lbs and is powered by four-bladed PW120s rated at 1,800shp. The ATR42-320, as analysed here, is operated with a lighter MTOW of 37,000lbs and is powered by PW121s each delivering 1,900shp. Meanwhile, the ATR42-500 is operated with an increased MTOW of 41,100lbs, is powered by six-bladed PW127Es and is rated at 2,160shp. With a cruise speed of 303 knots, this aircraft cruises 34 knots faster than the older ATR42-300 series.

As very few examples of the ATR42-200 and -400 series are still in service, these types have not been included in the analysis.

As for the larger ATR-72 series, we have evaluated the -200, -210 and -500 models. The -210 is powered by a four-bladed PW127 with a take-off power rating of 2,475shp, while the -200 is powered by a four-bladed PW124B with 2,160shp. These two have a gross weight of 48,500lbs *(see ATR 42 & 72 specifications, page 4)*. The -500 model has the highest MTOW and is powered by a six-bladed PW127F engine rated at 2,475shp. All three variants have a cruise speed of 277 knots.

Route analysed

The three aircraft are analysed on a route that is typical to many ATR operations: Vienna (VIE) - Venice (VCE). Aircraft performance has been analysed in both directions to illustrate the effects of wind speed and direction on the actual distance flown, which is also referred to as equivalent still-air-distance (ESAD). This airport-pair is typical of many ATR regional turboprop operators, since it has a block time of 75-95 minutes, depending on aircraft type and the direction of travel.

The flight time for each aircraft depends on 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 Jeppesen. The flight plans have also been calculated using Prague as an alternate airport when operating to Vienna, and Milan Malpensa is the alternate when operating to Venice. The performance of the six aircraft has also been analysed using a taxi time of 10 minutes. This adds about 140lbs of fuel to the trip for the ATR 42-300/-320, and 180-190lbs of fuel for the other four models.

The aircraft have been analysed with full passenger payloads: 48 passengers in the case of the ATR42; and 68 passengers for the ATR72. The standard weight for each passenger plus baggage is taken as 220lbs.

The payload for each aircraft is therefore 10,560lbs for the three ATR42 models and 14,960lbs for the three ATR 72 variants.

Operating from Vienna to Venice, the aircraft encounter a headwind of 13 to 14 knots, which increases the 'distance' flown from a tracked (actual) distance of 307nm to an ESAD of up to 320nm *(see table, page 11)*.

This route has a block time of 88-96 minutes, depending on the cruise speed of the aircraft model. For example, the original ATR42-300 with four-bladed PW120s has the slowest cruise speed of 265 knots, while the ATR42-500, which is powered by a six-bladed PW127E, has an enhanced target cruise speed of 303 knots. The ATR 72 variants cruise at around 277 knots.

Meanwhile, for the VCE-VIE route, where there is only a 1-knot headwind, the 267nm tracked distance flown equates to an ESAD range of 267-271nm, depending on the aircraft type. This route has a block time of 74-83 minutes, depending on aircraft type and cruise speed.

The later generation ATR 42-500 and 72-500 were equipped with six-bladed propellers designed to lower specific fuel consumption. While the ATR 42-500 can take advantage of this and operate at a higher cruising speed than the -200 and -210, the -500 still has an overall higher fuel burn.

FUEL BURN PERFORMANCE OF CF6-80C2 SERIES

City-pair variant	Aircraft	Engine model	TOW lbs	Fuel capacity USG	Fuel burn USG	Block time mins	Passenger payload	ESAD nm	Fuel per seat	Wind speed
Vienna-Venice	ATR 42-300	PW120	37,010	1,481	260	96	48	321	5.43	-13
Vienna-Venice	ATR 42-320	PW121	35,490	1,481	250	95	48	320	5.21	-13
Vienna-Venice	ATR 42-500	PW127E	39,670	1,481	305	85	48	318	6.36	-13
Vienna-Venice	ATR 72-200	PW124B	45,917	1,646	303	91	68	319	4.46	-14
Vienna-Venice	ATR 72-210	PW127	46,523	1,646	321	88	68	318	4.72	-14
Vienna-Venice	ATR 72-500	PW127F	48,552	1,646	362	88	68	318	5.33	-14
Venice-Vienna	ATR 42-300	PW120	37,200	1,481	227	83	48	271	4.72	1
Venice-Vienna	ATR 42-320	PW121	35,715	1,481	219	82	48	268	4.56	1
Venice-Vienna	ATR 42-500	PW127E	39,860	1,481	267	74	48	267	5.55	1
Venice-Vienna	ATR 72-200	PW124B	46,316	1,646	267	80	68	267	3.93	1
Venice-Vienna	ATR 72-210	PW127	46,910	1,646	281	76	68	267	4.13	1
Venice-Vienna	ATR 72-500	PW127F	48,248	1,646	317	78	68	267	4.66	1

Source: Jeppesen

ATR 42 fuel burns

The fuel burn for each aircraft and the consequent burn per passenger are shown *(see table, this page)*. To remain consistent when comparing the three aircraft models, the outward leg (VIE-VCE) is used as the basis for the fuel burn analysis.

At first glance, the data show that the fuel burn per passenger increases for higher gross weight aircraft models and actual take-off weights. There are several other factors at play here, however. Among these is OEW, which is the manufacturer's empty weight plus the operator's items, and does not include useable fuel and payload. In short, the higher the OEW, and all other things being equal (such as passenger counts), then the higher the actual take-off weight. To compound this, more fuel has to be burned to carry the additional structural weight over a given distance.

The ATR42-300 has an OEW which is 1,320lbs more than the ATR42-320's. In turn, the -300's actual take-off weight is 1,520lbs heavier on the same sector (and with virtually identical ESAD), and with the same number of passengers as its lighter sibling *(see table, this page)*.

The ATR 42-500 makes things more interesting, since the aircraft has higher performance. The -500's OEW is 2,200lbs and 3,520lbs higher than the -300 and -320 models. In turn, the -500 also has a take-off weight which is about 4,000lbs higher than the others. Part of this increase, however, is to provide greater payload-range performance.

The other important factor is the -500's 38-knot faster cruise speed, which is afforded by its more powerful 2,160shp rated six-bladed turboprop engines. This speed accounts for the 10-minute shorter block time compared to the older variants. By flying faster, however, there is an unavoidable aerodynamic drag penalty, since airframe-induced drag increases with the square of the speed, when all other variables are equal. The -500's engine has a lower specific fuel consumption than the engines powering the -300/-320, but this advantage is offset by the aircraft's faster speed. The overall difference is the -500's higher fuel burn per passenger.

This penalty of faster cruise speed performance (even though the -500 operates at a lighter all-up weight than its maximum) is that its fuel burn per passenger, at 6.36 US Gallons (USG), is 17-22% higher than the -300/-320 which have fuel burn rates of 5.43USG and 5.21USG per passenger. At a fuel price of $2 per USG, these fuel burn rates equate to a fuel cost per passenger of: $13 for the ATR42-500; $10.9 for the ATR42-300; and $10.4 for the ATR42-320.

Airlines should, however, consider the positive economic benefit resulting from the -500's faster cruise speed, which includes additional frequencies. If managed well, the faster aircraft could conceivably squeeze in an extra frequency per day, thereby generating additional revenue and gross profit.

ATR 72 fuel burns

Turning now to the larger 68-seat configured ATR 72 models, it can be seen that (again using the VIE-VCE leg for the following study) the -200, -210 and -500 models used are operating with identical payloads of 14,280lbs and over virtually identical ESADs.

They also share the same design MTOW of 48,000lbs. The two variants, however, as operated here differ from each other in several key aspects. These are actual take-off weight (45,917lbs versus 46,523lbs), OEW (27,940lbs versus 28,380lbs), and engine power (2,160shp versus 2,475shp). It should be noted that the two have the same cruise speeds.

The heavier ATR 72-500 has the same cruise speed as the lighter -200 and -210 variants. The -500's OEW is about 1,000lbs higher than the lighter -200 and -210 models, which results in the -500 having a higher fuel burn.

In terms of fuel burn, the ATR72-200 and the -210 models have block fuel burns of 4.46USG and 4.72USG per passenger, equivalent to a difference of 5.8% between the two. At a fuel price of $2 per USG, this is equal to a fuel cost per passenger of $9.0 for the ATR72-200 and $9.4 for the ATR72-210.

The ATR 72-500 has a fuel burn of 5.33USG per passenger, equal to about $10.6 at current fuel prices. This is up to $1.6 more per passenger than the -200.

It is perhaps worth noting the differences between the ATR42 and its 'stretched' ATR72 sibling, which arise as a function of their respective size-related properties. The larger, 68-seat ATR72 has lower fuel burn compared to the smaller, 48-seat ATR42, equivalent typically to a 21% fuel saving per passenger. This is to be expected, however, since the ATR72 is a stretch, which gives it a minimal drag increase over the ATR42. The ATR72 also uses a similar fuselage and wingbox structure that leads to a lower fuel-burn per seat. AC