Dash 8 & Q400 fuel burn performance

The fuel burn performance of the four main Dash 8/Q Series variants are analysed in routes of 110-425nm.

Analysis of the fuel burn performance of four main members of the Dash 8 and Q Series reveals that for a given distance, the fuel burn per seat-mile is influenced by several factors that include, but are not limited to: operating empty weight (OEW), engine power rating, weather, and cruise speed.

Aircraft variants

There are four main variants of the Dash 8 and Q Series: the Dash 8-100, Dash 8-200, Dash 8-300 and Q400. Standard models are used to analyse each one. All the aircraft variants are powered by the same family of engines, with more powerful engines being used for the larger aircraft type. The Dash 8-100/Q100 is powered by the PWC-120A, the Dash 8-200/Q200 and -300/Q300 by the PWC-123C, and the Q400 by the PWC150A.

The increase in engine thrust for these aircraft is echoed in their higher OEW, maximum payload and maximum take-off weights (MTOW). The MTOWs rise from 34,500lbs for the Dash 8-100 to 64,000lbs for the Q400. The fuel capacity is the same for all variants except the Q400, which has over double the smaller variants' 841 US Gallon (USG) capacity.

Many different thrust and MTOW variants are used by different airlines, but the basic specifications, as pre-loaded in Jeppesen and stated by the manufacturer, have been used for these calculations.

Flight profiles

Aircraft performance has been analysed on inbound and outbound legs for four routes to illustrate the effects of wind speed and direction on the distance flown. The resulting distance is referred to as the equivalent still air distance (ESAD), or nautical air miles (NAM).

Average weather for the month of June has been used, with 85% reliability winds and 50% reliability temperatures used in the flight plans produced by Jeppesen. The flight profiles are based on International Flight Rules, which include standard assumptions on fuel reserves, diversion fuel and contingency fuel, but the fuel burn used to analyse each sector just includes the fuel used for the trip and taxiing. The optimum routes and levels have been used for every flight, except where it has been necessary to restrict the levels due to airspace or airway restrictions and to comply with standard routes and Eurocontrol restrictions.

A taxi time of 20 minutes has been factored into the fuel burns and added to the flight times to provide block times. Jeppesen says this equates to additional fuel of 200lbs on the Dash 8-100/Q100 & Dash 8-200/Q200, and 250lbs on the Dash 8-300/Q300 & Q400.

Two cruise speeds were listed in the system: high-speed cruise (HSC) and long-range cruise (LRC). Although HSC is more likely on shorter routes, LRC has been chosen so that all routes can be equally compared for all variants without the need to adapt payload figures. LRC allows an aircraft to use less fuel per NAM, meaning longer block times, but this is the economical and operational compromise between fuel consumption and flight times.

The aircraft being assessed are assumed to have a single-class cabin with a full passenger load of 37 on the Dash 8-100/Q100 & Dash 8-200/Q200, 56 on the Dash 8-300/Q300 and 78 on the Q400. The standard weight for each passenger and their luggage is assumed to be 200lbs per person, with no additional cargo in the hold. The payload carried is therefore: 7,400lbs for the Dash 8-100/Q100 & Dash 8-200/Q200; 11,200lbs for the Dash 8-300/Q300; and 15,600lbs on the Q400.

Route analysis

Three routes of varying lengths were analysed with tracked distances of 111-386nm. All three routes are within Europe and were picked to examine how fuel burn per seat-mile changes with increasing mission lengths. All routes are typical of the operators of the Dash 8 and Q Series, which tend to have average FC times of roughly 1.0FH. All routes have been analysed in both directions, to gain a better picture of each aircraft's fuel burn and the effect of wind.

The first route to be analysed, and the shortest, is Southampton, UK (SOU) to Jersey, UK (JER). This has a tracked distance of 111nm on both the outbound and return sectors and is typical of the routes on which Flybe uses its Q400s. There were headwinds of 9-12kts on the outbound sector (increasing the ESAD to 113-116nm) but very light, almost non-existent headwinds on the return (so that the tracked and the ESAD distances were

Despite being larger than the Dash 8-300, the Q400 does not have lower fuel burn per seat-mile. The Q400 nevertheless has almost the same fuel economy, and the two are superior in fuel burn to the Dash 8-100 and -200.

FUEL BURN PERFORMANCE OF DASH 8 & Q400

City-pair variant	Aircraft	Engine model	MTOW lbs	TOW lbs	Fuel burn USG	Block time mins	Passenger seats	ESAD nm	Fuel per seat	Fuel per seat-mile	Wind speed
SOU-JER	Dash 8-100	PWC-120A	34,500	32,464	117	52	37	113	3.15	0.0284	-9
	Dash 8-200	PWC123C	37,000	33,137	119	50	37	114	3.22	0.0290	-10
	Dash8-300	PWC123C	43,000	40,808	129	51	56	115	2.31	0.0208	-9
	Q400	PWC150A	64,000	54,693	191	52	78	116	2.45	0.0221	-12
JER-SOU	Dash 8-100	PWC120A	34,500	32,450	115	52	37	111	3.11	0.0280	-1
	Dash 8-200	PWC123C	37,000	33,132	117	50	37	111	3.17	0.0286	-1
	Dash 8-300	PWC123C	43,000	40,801	128	51	56	111	2.29	0.0206	-1
	Q400	PWC150A	64,000	54,688	190	52	78	111	2.43	0.0219	0
VIE-VCE	Dash 8-100	PWC120A	34,500	33,275	234	99	37	315	6.32	0.0217	-20
	Dash 8-200	PWC123C	37,000	34,197	246	95	37	318	6.64	0.0228	-18
	Dash 8-300	PWC123C	43,000	41,861	259	100	56	313	4.62	0.0159	-18
	Q400	PW150A	64,000	56,228	370	94	78	314	4.75	0.0163	-18
VCE-VIE	Dash 8-100	PWC120A	34,500	33,236	211	88	37	265	5.70	0.0216	-3
	Dash 8-200	PWC123C	37,000	34,147	221	88	37	265	5.97	0.0226	-2
	Dash 8-300	PWC123C	43,000	41,727	234	90	56	265	4.18	0.0158	-2
	Q400	PW150A	64,000	56,193	330	84	78	266	4.24	0.0160	-3
SZG-DUS	Dash 8-100	PWC120A	34,500	33,591	295	127	37	426	7.97	0.0209	-29
	Dash 8-200	PWC123C	37,000	34,503	306	121	37	425	8.27	0.0216	-24
	Dash 8-300	PWC123C	43,000	42,112	325	128	56	420	5.81	0.0152	-25
	Q400	PW150A	64,000	56,647	466	117	78	418	5.97	0.0156	-21
DUS-SZG	Dash 8-100	PWC120A	34,500	33,851	285	120	37	390	7.70	0.0199	-5
	Dash 8-200	PWC123C	37,000	34,777	300	116	37	390	8.10	0.0210	-5
	Dash 8-300	PWC123C	43,000	42,423	328	123	56	391	5.85	0.0152	-
	Q400	PW150A	64,000	57,145	443	110	78	387	5.68	0.0147	-5

Source: Jeppesen

the same). The winds had no effect on the resulting block times, which did not vary between each variant's two sectors. The resulting flight times, for all four variants, were close at 50-52 minutes.

The second route was Vienna, Austria (VIE) to Venice, Italy (VCE), which is operated by Austrian Arrows' Dash 8 and Q Series aircraft. The tracked distance is 291nm outbound and a shorter 264nm on the return sector; the difference coming from longer flight routings outbound. The outbound sector had headwinds of 18-20kts that increased the ESAD to 314-318nm. The return sector still had headwinds but not as strong at just 2-3 knots, meaning the ESAD remained similar at 265-266nm.

Block times on the outbound sector were 94-100 minutes with a 10-minute block time improvement of 84-90 minutes on the return, as a result of the shorter routing and weaker headwinds.

The third and longest route is Salzburg, Austria (SZG) to Dusseldorf, Germany (DUS), which is also typical of routes operated by Austrian Arrows. The outbound distance is 382nm, but, with a large headwind of 21-29kts, the ESAD rises to 418-426nm. The return sector has a tracked distance of 386nm, and lighter headwinds of 5kts mean that the ESAD only increases slightly to 287-391nm.

Fuel burn performance

The fuel burn performance of the four Dash 8 and Q Series variants is shown for all three routes, both outbound and inbound *(see table, this page)*. The data also include the associated fuel burn per passenger and per passenger-mile for both sectors on each route. The fuel burn increases on all sectors as the power and size of aircraft increase, but this is not necessarily the case for fuel burn per passenger or passenger-mile.

On all six sectors, the performance is similar, with the Dash 8-100/Q100 always taking third place and the Dash 8-200/Q200 always performing the worst. Even so, the Dash 8-100/Q100 & Dash 8-200/Q200 are not far behind the Dash 8-300/Q300 and Q400, so the smaller variants would still be cost-effective. This would be the case if operators intended to carry no more than 37 passengers, with economies of scale being generated only when carrying larger payloads. The Dash 8-300/Q300 is the best fuel-per-passenger performer for the shortest and middle routes, but the Q400 performs better on the longest *(see table, this page)*.

The lowest fuel burn per passenger is predictably found on the shortest route, particularly with the Dash 8-300/Q300 on the return sector. The highest fuel burn per passenger was on the longest route, and on the outbound sector in particular, with the Dash 8-200/Q200 *(see table, this page)*.

To compare the routes fairly, the fuel burn per passenger-mile was examined. The best results were on the longest sector and the worst on the shortest. For the first and shortest route the Dash 8-300/Q300 performed best, with 0.0206-0.0208 USG per passenger-mile, followed by the Q400, Dash 8-100/Q100 and the Dash 8-200/Q200 with 0.0286-0.0290 USG per passenger-mile. For the second route, the best performer was the Dash 8-300/Q300 with 0.0158-0.0159 USG per passenger-mile, followed by the Q400, Dash 8-100/Q100, and then the Dash 8-200/Q200 with 0.0226-0.0228 USG per passenger-mile *(see table, this page)*.

On the last and longest route the performance order differs for each sector. On the outbound, the Dash 8-300/Q300 performs best with 0.0152 USG per passenger-mile (which it also burns on the return sector). On the return the Q400 performs better with 0.0147 USG per passenger-mile. On both sectors, the Dash 8-200/Q200 performs worst with 0.0210-0.0216 USG per passenger-mile. AC