A330-200 & -300 fuel burn performance

The operating and fuel performance of the A330-200 & -300 passenger variants with all three engine types are analysed on medium- and long-haul routes. The performance of both variants of the A330-200F are also examined.

The fuel burn and operating performance of the two passenger A330 family members, and also the new A330-200F freighter are analysed and assessed. All three engine families powering these aircraft are represented in this analysis.

Aircraft variants

The A330-200 and A330-300 variants analysed include: the A330-203/-303 powered by the CF6-80E1A3 rated at 68,530lbs thrust; the A330-223/-323 powered by the PW4170, a new variant of the PW4000-100 introduced by Pratt & Whitney, rated at 70,000lbs thrust; and the A330-243/-343 powered by the Trent 772B-60, rated at 71,100lbs thrust. The aircraft chosen are the most recent and most capable versions, and they have the highest take-off weight (TOW) capabilities. These are marketed by Airbus as the '233-tonne' versions, and have a maximum take-off weight (MTOW) of 513,765lbs.

The factory-freighter aircraft analysed comprise four sub-versions: the A330-200F 'Payload' mode powered by the PW4170 rated at 70,000lbs thrust; the A330-200F 'Payload' mode powered by the Trent 772B-60 rated at 71,100lbs thrust; the A330-200F 'Range' mode powered by the PW4170 rated at 70,000lbs thrust; and the A330-200F 'Range' mode powered by the Trent 772B-60 rated at 71,100lbs thrust.

The maximum structural payloads (MSPs) of the 'Payload' mode aircraft are 151,899lbs for the Trent-powered aircraft and 151,330lbs for the PW4000-powered aircraft. The structural payloads of the 'Range' mode aircraft are 140,875lbs for the Trent-powered aircraft and 140,307lbs for the PW4000-powered aircraft *(see A330-200/-300 specifications, page 9)*.

Parameters

Aircraft performance has been analysed in both directions on example routes to illustrate the effects of wind speed and direction on the actual distance flown, also referred to as equivalent still-air distance (ESAD). The flight profiles in each case are based on international Federal Aviation Regulations (FAR) flight rules, which include standard assumptions on fuel reserves, standard diversion fuel, plus contingency fuel, and a taxi time of 20 minutes for the whole sector. This is included in block time. In addition, all sectors presented here are flown using an optimum long-range cruise (LRC) speed of Mach 0.82. This speed has been chosen as the best balance between fuel burn and sector time. 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 produced by Airbus.

The two passenger aircraft analysed have been assumed to have full three-class passenger payloads. These are 253 passengers for the A330-200 and 295 passengers for the A330-300. 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 55,777lbs for the A330-200 series and 65,036lbs for the A330-300 series.

For the freighter analysis, the objective is to carry the maximum possible gross payload for any of the missions. This is constrained by the mission range or ESAD, required fuel load, airport elevation, and the different maximum zero fuel weights (MZFWs) and MTOWs of the 'Payload' and 'Range' variants of the A330-200F.

Routes described

Two city-pairs are used to analyse the A330-200/-300 passenger aircraft. The first is Los Angeles International (LAX) to La Guardia, New York (LGA). This route has a tracked distance of 2,188nm. When flown in an easterly direction to LGA, the aircraft experiences a tailwind of 20 knots. This reduces the tracked distance from 2,190nm to an ESAD of 2,100nm *(see table, page 8)*. In the other direction to LAX, the aircraft faces a headwind of 50 knots which increases the equivalent distance to an ESAD value of 2,420nm.

The same aircraft are also analysed using the longer-range route between LAX and Stockholm Arlanda airport

Fuel burn per seat-mile varies little with different engine types powering the same weight specification variant of the A330-200 and -300. Moreover, fuel burn per seat-mile also varies little mission length.

FUEL BURN PERFORMANCE OF PASSENGER-CONFIGURED A330-200 & -300

City-pair	Aircraft variant	Engine type	Seats	Payload lbs	MTOW lbs	Actual TOW lbs	Fuel burn USG	Block time mins	ESAD nm	USG per seat-nm
LAX-LGA	A330-203	CF6-80E1A3	253	55,777	513,765	385,900	7,641	301	2,100	0.0144
LAX-LGA	A330-223	PW4170	253	55,777	513,765	387,133	7,654	302	2,100	0.0144
LAX-LGA	A330-243	Trent 772B	253	55,777	513,765	386,700	7,638	301	2,100	0.0144
LAX-LGA	A330-303	CF6-80E1A3	295	65,036	513,765	410,016	8,164	301	2,100	0.0132
LAX-LGA	A330-323	PW4170	295	65,036	513,765	411,267	8,185	302	2,100	0.0132
LAX-LGA	A330-343	Trent 772B	295	65,036	513,765	410,840	8,157	301	2,100	0.0132
LGA-LAX	A330-203	CF6-80E1A3	253	55,777	513,765	394,937	8,891	342	2,420	0.0145
LGA-LAX	A330-223	PW4170	253	55,777	513,765	396,266	8,917	343	2,420	0.0146
LGA-LAX	A330-243	Trent 772B	253	55,777	513,765	395,751	8,891	342	2,420	0.0145
LGA-LAX	A330-303	CF6-80E1A3	295	65,036	513,765	419,095	9,396	342	2,420	0.0132
LGA-LAX	A330-323	PW4170	295	65,036	513,765	420,063	9,393	353	2,420	0.0132
LGA-LAX	A330-343	Trent 772B	295	65,036	513,765	419,757	9,385	342	2,420	0.0131
LAX-ARN	A330-203	CF6-80E1A3	253	55,777	513,765	463,268	18,357	653	4,850	0.0150
LAX-ARN	A330-223	PW4170	253	55,777	513,765	464,547	18,371	654	4,850	0.0150
LAX-ARN	A330-243	Trent 772B	253	55,777	513,765	464,369	18,393	653	4,850	0.0150
LAX-ARN	A330-303	CF6-80E1A3	295	65,036	513,765	493,361	19,691	653	4,850	0.0138
LAX-ARN	A330-323	PW4170	295	65,036	513,765	494,398	19,697	653	4,850	0.0138
LAX-ARN	A330-343	Trent 772B	295	65,036	513,765	494,223	19,706	653	4,850	0.0138
ARN-LAX	A330-203	CF6-80E1A3	253	55,777	513,765	473,644	19,801	692	5,160	0.0152
ARN-LAX	A330-223	PW4170	253	55,777	513,765	475,042	19,827	693	5,160	0.0152
ARN-LAX	A330-243	Trent 772B	253	55,777	513,765	474,740	19,837	692	5,160	0.0152
ARN-LAX	A330-303	CF6-80E1A3	295	65,036	513,765	503,718	21,138	692	5,160	0.0139
ARN-LAX	A330-323	PW4170	295	65,036	513,765	504,534	21,101	692	5,160	0.0139
ARN-LAX	A330-343	Trent 772B	295	65,036	513,765	504,543	21,144	692	5,160	0.0139

(ARN). This route has a tracked distance of 4,900nm. Aircraft operating in an easterly direction from LAX to ARN have a small tailwind averaging four knots, which takes the ESAD value down to 4,850nm. Operations in the other direction face a headwind of 14 knots increasing the ESAD to 5,160nm. On all passenger routes outlined above, the aircraft are not payload-restricted, and can therefore carry their maximum passenger load.

The A330-200F has been analysed on two routes. A medium-range route is represented by Bogota (BOG) to Miami (MIA). This route has a tracked distance of 1,314nm. When flown in a northerly direction to MIA, the aircraft experiences a headwind of 18 knots. This increases the tracked distance from 1,314nm to an ESAD of 1,406nm *(see table, page 19)*. In the other direction to LAX, the aircraft faces a headwind of eight knots, which results in an ESAD value of 1,361nm.

In addition, a long-range freight route between London Heathrow (LHR) and Nairobi (NBO) has been analysed. This route has a tracked distance of 3,692nm. When flown in a north-westerly direction to LHR, the aircraft experiences a headwind of 31 knots. This increases the tracked distance from 3,692nm to an ESAD value of 4,013nm *(see table, page 19)*. This distance coincides with the maximum design range of the A330-200F 'Range' variant when carrying its MSP, and is greater than the maximum range of the 'Payload' variant. In the other direction to NBO, the aircraft faces a smaller headwind of four knots which results in an ESAD of 3,826nm. The latter distance is just within the 4,000nm range the 'Range' variant, but beyond the nominal 3,200nm range of the 'Payload' variant. The latter model must therefore reduce payload to fly the distance.

A330 passenger aircraft

The fuel burn for each aircraft/engine combination and the consequent fuel burn per passenger are shown *(see table, this page)*. The data show that for each respective passenger model, the block fuel burns increase in relation to actual take-off weights (ATOWs) and aircraft size. The engine type has very little effect, since they are extremely close in terms of specific fuel consumption (SFC). As an illustration of the small fuel burn difference with respect to engine type, the table shows there is no absolute leader. The Trent has the lowest block fuel burn in three missions, the CF6-80E1 has the lowest fuel burn in four missions, and the PW4100 has the lowest fuel burn in one mission *(see table, this page)*.

On the outward LAX-LGA sector the A330-200s have block fuel burns of: 7,638USG (Trent); 7,641USG (CF6); and 7,654USG (PW4170). Fuel burns per passenger are: 30.19USG (Trent); 30.20USG (CF6); and 30.25USG (PW4170).

In contrast, the larger A330-300s have higher total fuel burns of: 8,157USG (Trent); 8,164USG (CF6); and 8,185USG (PW4100).

Aside from size differences between the passenger A330-200 and A330-300, which affect operating empty weight (OEW) and TOW, other factors influencing fuel burn on any given city-pair are the respective headwind or tailwind component differences (and hence ESAD value) between outbound and return sectors. The A330-200 versions have lower OEWs *(see table, this page)*, the lowest ATOWs, lower total drag, and therefore lower cruise thrust and lower fuel burn compared with the larger A330-300s. However, because the A330-200 carries fewer passengers, the fuel burn per passenger is proportionally higher.

In the LGA-LAX direction, the main

FUEL BURN PERFORMANCE OF FREIGHTER-CONFIGURED A330-200F

City-pair	Aircraft variant	Engine type	ESAD nm	MTOW lbs	Available TOW lbs	Block burn USG	Block time mins	Available payload lbs
BOG-MIA	A330-200F 'Range'	PW4170	1,406	513,677	433,572	5,905	214	140,307
BOG-MIA	A330-200F 'Range'	Trent 772B	1,406	513,677	433,682	5,883	213	140,875
BOG-MIA	A330-200F 'Payload'	PW4170	1,406	500,450	446,118	6,084	214	151,330
BOG-MIA	A330-200F 'Payload'	Trent 772B	1,406	500,450	446,170	6,056	213	151,899
MIA-BOG	A330-200F 'Range'	PW4170	1,361	513,677	432,990	5,971	205	140,307
MIA-BOG	A330-200F 'Range'	Trent 772B	1,361	513,677	433,031	5,942	204	140,875
MIA-BOG	A330-200F 'Payload'	PW4170	1,361	500,450	445,123	6,097	205	151,330
MIA-BOG	A330-200F 'Payload'	Trent 772B	1,361	500,450	445,192	6,072	205	151,899
NBO-LHR	A330-200F 'Range'	PW4170	4,013	513,677	499,200	16,717	546	127,906
NBO-LHR	A330-200F 'Range'	Trent 772B	4,013	513,677	505,900	16,949	545	133,115
NBO-LHR	A330-200F 'Payload'	PW4170	4,013	500,450	499,200	16,717	546	127,906
NBO-LHR	A330-200F 'Payload'	Trent 772B	4,013	500,450	500,449	16,775	545	129,004
LHR-NBO	A330-200F 'Range'	PW4170	3,826	513,677	509,829	16,514	520	140,307
LHR-NBO	A330-200F 'Range'	Trent 772B	3,826	513,677	510,200	16,535	520	140,875
LHR-NBO	A330-200F 'Payload'	PW4170	3,826	500,450	500,450	16,229	521	133,109
LHR-NBO	A330-200F 'Payload'	Trent 772B	3,826	500,450	500,450	16,237	520	133,402

observation is the 14% increase in average block fuel burn across all the aircraft due to the headwind component and higher ESAD *(see table, page 18)*. This increases the block fuel burns per passenger *(see table, page 18)*.

On the longer LAX-ARN route, the most interesting observation is that the average block fuel burn per seat-mile is 4.4% greater on the longer sector (averaging both directions) than for the LAX-LGA city pair (again, averaging both directions). This is despite the fact that the aircraft spends more time at efficient cruise altitude as a proportion of the whole flight. By using the ESAD in the fuel per seat-mile, these calculations factor out any differences arising from headwinds or tailwinds. The principal reason for the higher fuel burn per seat-mile on the longer routes is the heavier weight of fuel carried to fly the extra distance, particularly during the earlier part of the flight. Indeed, this extra fuel load is reflected in the ATOWs which are about 80,000lbs higher on the longer LAX-ARN city-pair.

A330-200F

Two city-pairs have been chosen to illustrate how the fuel burn and aircraft performance of the two A330-200F variants are affected both by the demanding 'hot-and-high' airport Bogota (BOG), and also by the long-range challenges of flying from Nairobi (NBO) to London Heathrow (LHR).

Taking the BOG-MIA sector, with an ESAD to MIA of 1,406nm, the results *(see table, this page)* shows that when taking off from BOG, all the aircraft variants can depart with MSPs, as described earlier. This is regardless of the ambient departure conditions and despite the high airport elevation of 8,361 feet, runway length of 12,467 feet and noon temperature of 17°C.

In this example, the 'Payload' variants are the most suitable aircraft to deploy on this route because they can take advantage of their higher MZFWs to carry higher structural payloads from hot-and-high airports over short ranges, especially as fuel loads are relatively light for this long-range aircraft family. In terms of block fuel burn, there is a slight difference between the 'Payload' and 'Range' versions in either direction *(see table, this page)*. This is due to the higher MSPs carried by the 'Payload' versions, which also increases respective TOWs.

For the NBO-LHR sector, not only must all the aircraft fly a very long range ESAD distance of 4,013nm (just beyond the 4,000nm limit of the 'Range' version, and exceeding the normal 3,200nm mission range of the 'Payload' version), but they must also depart from an airport which has an elevation of 5,330ft, has an ambient noon departure temperature of 23°C, and a runway length of 13,507 feet. From here, three out of the four variants face ATOW restrictions, and all the aircraft variants face significant available payload restrictions *(see table, this page)*. This is due to the severe combination of a hot-and-high departure and very high fuel load required for the 4,000nm mission.

Even from LHR (a sea-level airport from which all aircraft could depart at their full MTOWs if required), only the 'Range' variants can make the trip without payload restrictions. That is, they can carry their MSPs over this long sector as well as the high fuel load required. In contrast, the 'Payload' aircraft in the LHR-NBO direction are still restricted. That is, their available payloads are less than their MSPs. This is mainly because the 'Payload' variants have a lower MTOW than the 'Range' variants.

There is a significant difference in ESAD between the two directions (3,826nm for LHR-NBO versus 4,013nm for NBO-LHR), which is due to the headwinds *(see table, this page)*. The fuel burns are consequently higher in the NBO-LHR direction, despite the lower payloads and take-off weights. When both 'Payload' and 'Range' variants are flying the same NBO-LHR sector, the variation in fuel burns between them is slight because MTOWs in this direction are very close. In the LHR-NBO direction, sea-level ambient conditions allow each aircraft to utilise their full MTOW (which differs between the 'Payload' and 'Range' versions).

In summary, the A330-200F 'Payload' versions have higher MZFWs and are the best choice for operators flying high-density cargo on demanding short-range sectors, whereas on very long-range routes, the 'Range' variants have higher certified MTOWs and can therefore carry the greatest combined payload plus fuel load without compromise. AC