A340-300 fuel burn performance

The A340-200 & -300 are well known for their ultra long-range performance capability. Their fuel burn performances on long-distance routes are analysed.

The fuel burn and operating performance of the A340-200 and A340-300 are analysed. The three different thrust ratings of the CFM56-5C series are represented. The aircraft analysed include: the A340-211 and -311 powered by the CFM56-5C2 rated at 31,200lbs thrust; the A340-212 and -312 powered by the CFM56-5C3 rated at 32,000lbs thrust; and the A340-313 powered by the CFM56-5C4 and CFM56-5C4/P rated at 34,000lbs thrust *(see table, page 16)*.

Passenger routes described

Two city-pairs are used to analyse the aircraft: London Heathrow (LHR) to Los Angeles (LAX); and LHR to Singapore (SIN). Aircraft performance has been analysed in both directions to illustrate the effects of wind speed and direction on the actual distance flown. Wind speed and direction result in an equivalent still-air distance (ESAD).

The first city-pair (LHR-LAX) has a tracked distance of 4,963nm, and is within the payload range of all versions of the A340-200 and -300.

The second route (LHR-SIN) has a tracked distance of 5,879nm. The A340-311 and -312 are at the limit of their payload-range capabilities on this route in both directions. Both reach their maximum take-off weight (MTOW), and both have to be operated with a reduced payload in both directions.

In the flight plans performed by Airbus, 85% reliability annual winds have been used. The aircraft have been assumed to have full passenger payloads, unless limited, and to be carrying no additional belly freight. Tri-class passenger loads are 261 passengers for the A340-200s, and 295 for the A340-300s. The exceptions to these are the A340-311 and -312 on the LHR-SIN route *(see table, page 16)*.

The standard weight used for each passenger plus baggage is 220lbs. The payload for the non-restricted A340-200s is therefore 57,420lbs, and the payload target for the larger A340-300s is 64,900lbs *(see table, page 16)*. The payload for the two MTOW-restricted A340-300s varies according to the operating empty weight (OEW) version and route direction, but is equal to the weight of 18-38 fewer passengers *(see table, page 16)*.

The flight profile used in each case is based on international Federal Aviation Regulations (FAR) flight rules. This includes standard assumptions on: standard diversion plus holding fuel reserves; contingency fuel (based on a percentage of total trip time); a cruise speed of Mach 0.82; 220lbs per passenger; and using taxiing times of 15 minutes out and 10 minutes in. These taxi times and fuel used are included in 'block time' and 'block fuel' respectively. The taxi out is assumed to use 750lbs fuel, and the taxi in is assumed to use 500lbs fuel. In addition, 99lbs of fuel is burned during engine start-up.

LHR-LAX

In the LHR-LAX westerly direction, the aircraft encounter a 39-knot headwind component. This increases the tracked distance by 442nm to give an ESAD of 5,405-5,407nm *(see table, page 16)*. The aircraft maintain fairly uniform block times of 727-729 minutes on this route. The alternate is San Francisco.

These slight differences in ESADs and block times observed are due to differences in the climb profile between the -200s and the larger -300s. All variants have step climbs in their flight profiles. The -200s, however, have higher initial cruising altitudes.

On this route, the A340-200s burn less fuel than the longer -300s because of the lower actual take-off weight caused by the -200s' shorter fuselage and lower absolute airframe weight, which contribute to a smaller passenger count, and therefore a lower payload. However, even though the fuel burn in absolute terms is lower, the fuel burn per passenger is actually higher *(see table, page 16)*.

LAX-LHR

In the reverse direction, the aircraft are assisted by a 4-knot tailwind. This results in a reduced ESAD of 4,921-4,922nm, compared with the tracked distance of 4,963nm. All the aircraft maintain fairly similar block times to each other, but because of the wind strength and direction the flight times are reduced by almost one hour compared to the westerly sector. The alternate airport for LHR is London Gatwick (LGW).

LHR-SIN

For the LHR-SIN route, where there is an assisting tailwind component of 6 knots, the 5,879nm tracked distance flown compares with an ESAD of 5,806nm *(see table, page 17)*. Block times are 777-779 minutes in this direction. The slight differences in ESAD and block time observed *(see table, page 16)* are again due to differences in the step-climb profile between the -200s and the larger -300s. The alternate airport for SIN is Ho Chi Minh City (SGN).

SIN-LHR

On the SIN-LHR sector in a westerly direction, the aircraft are hindered by a large 35-knot headwind component. This results in an increased ESAD of 6,345-6,348nm, compared with the tracked distance of 5,879nm. All the aircraft maintain similar block times. The headwind results in varying flight times, however, and these can be up to 70 minutes longer than the outbound sector.

Aircraft fuel burns compared

There are two A340-200 models and four A340-300s variants compared *(see table, page 16)*. On the LHR-LAX and LAX-LHR round trip, all aircraft easily operate within their respective payload-range capabilities. That is, there are no restrictions on take-off weight, fuel capacity, or structural payload uplift.

The smaller -200's shorter fuselage means that its OEW is lower than the -300's by about 5%. The -200 also has lower airframe-induced drag. The A340-200s consequently burn less total fuel. This difference is about 7% for the LHR-LAX sector. However, because the -200s carry fewer passengers than the -300s, the block fuel burned per passenger by the -200s is higher than the -300s. The -200s burn 92 US Gallons (USG) per passenger compared to about 87 USG per passenger for the -300s. A similar pattern is observed for the other sectors *(see table, page 16)*.

In the easterly direction of LAX-LHR, all the aircraft burn proportionally less fuel *(see table, page 16)* for two main reasons. The first is because the ESAD is shorter due to a tailwind component, and second because less reserve fuel needs to be loaded due to the close proximity of the alternate airport (LGW).

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FUEL BURN PERFORMANCE OF A340-200/-300

City-pair variant	Aircraft	Engine model	MTOW lbs	TOW lbs	Fuel burn USG	Block time mins	Passenger payload	ESAD nm	Fuel per seat	Wind speed
LHR-LAX	A340-211	CFM56-5C2	566,588	527,710	24,028	729	261	5,406	92	-39
LHR-LAX	A340-212	CFM56-5C3	566,588	527,710	24,028	729	261	5,407	92	-39
LHR-LAX	A340-311	CFM56-5C2	573,201	556,094	25,610	728	295	5,405	97	-39
LHR-LAX	A340-312	CFM56-5C3	573,201	555,193	25,409	727	295	5,406	86	-39
LHR-LAX	A340-313	CFM56-5C4	606,271	563,818	25,688	727	295	5,406	87	-39
LHR-LAX	A340-313	CFM56-5C4/P	609,578	562,511	25,509	727	295	5,406	86	-39
LAX-LHR	A340-211	CFM56-5C2	566,588	497,430	21,004	668	261	4,921	80	4
LAX-LHR	A340-212	CFM56-5C3	566,588	497,430	21,004	668	261	4,922	80	4
LAX-LHR	A340-311	CFM56-5C2	573,201	524,138	22,391	667	295	4,922	76	4
LAX-LHR	A340-312	CFM56-5C3	573,201	523,603	22,301	667	295	4,922	76	4
LAX-LHR	A340-313	CFM56-5C4	606,271	532,011	22,552	666	295	4,922	76	4
LAX-LHR	A340-313	CFM56-5C4/P	609,578	530,887	22,386	666	295	4,922	76	4
LHR-SIN	A340-211	CFM56-5C2	566,588	556,257	26,806	779	261	5,806	103	6
LHR-SIN	A340-212	CFM56-5C3	566,588	544,639	26,146	779	261	5,806	100	6
LHR-SIN	A340-311	CFM56-5C2	573,201	573,202	27,937	779	257	5,806	109	6
LHR-SIN	A340-312	CFM56-5C3	573,201	573,202	27,751	778	259	5,806	107	6
LHR-SIN	A340-313	CFM56-5C4	606,271	594,278	28,615	777	295	5,806	97	6
LHR-SIN	A340-313	CFM56-5C4/P	609,578	592,530	28,381	777	295	5,806	96	6
SIN-LHR	A340-211	CFM56-5C2	566,588	551,224	28,529	849	261	6,347	109	-35
SIN-LHR	A340-212	CFM56-5C3	566,588	538,534	27,767	849	261	6,348	106	-35
SIN-LHR	A340-311	CFM56-5C2	573,201	573,202	29,985	847	272	6,346	110	-35
SIN-LHR	A340-311	CFM56-5C3	573,201	573,202	29,786	846	277	6,346	108	-35
SIN-LHR	A340-312	CFM56-5C4	606,271	588,116	30,412	846	295	6,345	103	-35
SIN-LHR	A340-313	CFM56-5C4/P	609,578	586,590	30,192	845	295	6,345	102	-35

longer LHR-SIN/SIN-LHR route on the absolute trip fuel burns, and fuel burns per passenger can clearly be seen *(see table, this page)*.

Interestingly, the A340-311 and -312 are both the 573,202lbs MTOW certified version, so they reach their MTOW limits on this long-range mission, and have a reduced passenger payload. In these cases, the reduced passenger count results in a higher fuel burn per passenger *(see table, this page)* compared to the other aircraft. For example, on the LHR-LAX sector, the CFM56-5C2-powered A340-311 carries 257 passengers and has a block fuel burn per passenger of 109USG. The A340-313s, which are not payload restricted on the same route, have a lower block fuel burn per passenger of only 96-97USG.

There are small fuel burn variations across the four A340-300 variants. These are partly due to differences in actual take-off weight and take-off thrust powerplant turbomachinery between the CFM56-5C2, -5C3, 5C4, and -5C4/P.

Although the A340-311 and A340-312 both carry the same payload and also have the same airframe MTOW and OEW specification, they nevertheless have different engine thrusts: 31,200lbs for the CFM56-5C2-powered A340-311; and 32,500lbs for the CFM56-5C3-powered A340-312. The table shows that the A340-312 with its higher thrust actually burns less block fuel than the A340-311 which is identical in all respects, except for its lower engine thrust. According to Benoit Machefert, spokesperson for the long-range marketing team at Airbus, the main reason for this is that the more powerful -5C3 engines allow the A340-300 to climb to cruise altitude more efficiently than with the -5C2. A similar fuel burn situation is evident for the A340-211 compared to the A340-212, both of which have identical OEWs and payloads. Importantly, the A340-212 has the more powerful CFM56-5C3s which allow it to adopt a more efficient climb to cruise, thereby resulting in a lower overall fuel burn.

At the other extreme of model variants, the most capable A340-313 is powered by the /P engine. This improves on-wing life over the standard -5C4 by means of 3D-aero and single-crystal hot-section blades. Another feature of the /P engine is a small fuel burn improvement of up to 1%, and this probably reflects the observed 0.8-0.9% differences in the actual block fuel burn between the -5C4/P powered A340-313 and the standard -5C4-powered aircraft on both routes, and in both directions *(see table, this page)*. The aircraft also manages this fuel burn improvement, despite the fact that the CFM56-5C4/P-powered A340-313 has an OEW that is about 250lbs higher than that of the regular CFM56-5C4-powered A340. It is not surprising that the CFM56-5C4/P-powered A313 has the best fuel burn per passenger because the aircraft is not payload-restricted, its engines are the most fuel efficient, and the CFM56-5C4/P's high continuous thrust capability ensures the most rapid climb performance to optimum cruising altitude. AC