The A340-600 & 777-300ER are positioned to provide 300-seat capacity for new long distance routes and as 747-200 & MD-11 replacements. How do the A340-600 & 777-300ER compare in terms of passenger limitations, freight capacity and fuel burn on a long-haul network?

360-seaters in performance test

Prime candidates for replacing the 747-100/-200 or providing additional capacity on routes served by 250 to 300-seat aircraft are the A340-600 and 777-300. Selection of either type will depend heavily on revenue generating capacity, anticipated operating costs and gross profit potential.

The A340-600 is a 380-seat aircraft with a 7,500nm standard range, while the 777-300ER has 365 seats and a 7,200nm capability.

The markets and route networks for which the A340-600 and 777-300 will be considered by most potential customers are high-density intra-Asian sectors, the trans-Atlantic market, and shorter distance city-pairs between the Asia-Pacific and Europe or across the Pacific.

Many sectors which require the A340-600's and 777-300ER's capacity will have equivalent still air distances (ESADs) on the edge of their payload-range envelope. Performance limitations such as long ESADs, high departure airport temperatures or airfield elevations can all combine to restrict the payload and revenue generating potential of either type on each route in one or both directions. These limitations can damage an aircraft's revenue generating capacity across the network, and so limit its appeal for selection. Revenue-generating potential must also take into account seat numbers, relative cabin sizes and belly freight capacity.

To assess the revenue-generating capacity and appeal of the A340-600 and 777-300ER, the operating performance in terms of seat and belly freight capacity, allowable take-off weight, permitted payload and fuel burn have to be calculated and compared for a selection of routes, or specific city-pairs in an airline's route network. The most testing routes will be those with ESADs close to the standard range capability of the aircraft, or those originating from hot and high airfields.

A340-600 & 777-300ER

To compare the A340-600's and 777-300ER's operating performance, the aircraft will have to be treated on an equal basis. Many factors will be the same irrespective of type. These include diversion airfields, catering weight per passenger, en-route wind direction and strength, and runways used.

Other factors will vary between type, and these will be actual seat numbers in each cabin, seat and galley weights and various operational items on the aircraft. An airline assessing two similarly-sized types will attempt to make aircraft configurations and these factors as similar as possible.

The A340-600 is the largest A340 variant, with a standard tri-class configuration of 380 seats. This is with 12 first, 54 business and 314 economy seats. The aircraft also has capacity for 42 LD-3 containers. Maximum take-off weight (MTOW) is 804,700lbs and range with a full passenger payload is 7,500nm *(see table, page 21)*.

The A340's full payload is 138,700lbs and, after deducting a full passenger payload, it has an additional freight capacity of 58,900lbs *(see table, page 21)*. Range with maximum payload is 5,700nm.

The 777-300ER, with a MTOW of 750,000lbs, has a tri-class capacity of 365. This is with more emphasis on first- and business-class seats than the A340-600. The 777-300ER has 22 first, 70 business and 273 economy seats. Range with a full passenger payload is 7,200nm *(see table, page 21)*. It also has capacity for 44 LD-3 containers.

The 777's maximum payload is about 11,300lbs higher than the A340's at 150,000lbs. As a consequence the 777's additional freight payload capacity is 73,350lbs *(see table, page 21)*. Range with maximum payload is about 4,850nm.

The two types therefore have similar seat capacities and standard operating range and freight capacity. Actual differences will be reflected in operating performance on a range of routes.

Range

Most aircraft are not operated to their full range capability. A few of the long-distance routes have ESADs close to the maximum passenger range of long-haul aircraft. Examples are London-Singapore, which has an ESAD of about 6,700nm. This compares to the 747-400's range of 7,200nm. High ambient temperatures mean little additional freight can be carried, and the aircraft may experience limitations on allowable take-off weight. This means 747-400 operations from Singapore to London will have MTOWs limited to the point where a full passenger payload can only just be carried.

The A340-600 and 777-300ER have 500-900nm longer ranges than the highest MTOW 747-200 variant. This means the A340-600 and 777-300ER will have additional performance capability to operate current 747-100/-200 routes with less restricted payloads and will also be able to operate longer routes.

As previously mentioned, the

performance capability of the A340-600 and 777-300ER allows them to operate many Europe-Asia Pacific and trans-Pacific routes. Examples are New York-Hong Kong (ESAD of 7,415nm), San Francisco-Hong Kong (7,024nm), Frankfurt-Buenos Aires (6,734nm) and Johannesburg-New York (7,456nm). In a few cases payload will be restricted.

The test between the A340-600 and 777-300ER will be the level of payload and revenue limitation. Ideally the type selected by an airline will not have any payload limitations on all the routes on which it would like to operate the type. Each aircraft, however, is likely to have a passenger payload limitation on a few routes. A larger number of sectors will not be able to completely utilise the aircraft's additional belly freight capacity. This is because their ESADs will be longer than the aircraft's full payload range.

The issue is therefore which aircraft has the least restrictions. This can only be exposed by analysing the aircraft on routes longer than 5,000nm; the 777-300ER's maximum payload range.

The longest or most challenging routes will be those with ESADs longer than 7,000nm, or which depart from airports such as Johannesburg and Dubai.

Routes

First, a group of routes were selected that have great circle distances between 5,275nm and 7,139nm *(see table, page 25)*. The actual ESAD would then be altered by actual airline routing and en-route wind strength and direction.

Airline routings will have to take into account airways and in some cases the need to circumnavigate mountain ranges or particular countries for political reasons. Other considerations for the 777-300ER will be possible extended range twin-engine operations (ETOPs) routing limitations. The 777's 180 minutes ETOPs clearance will, however, make it unnecessary to increase ESAD on a route.

Fourteen routes were studied, and most are Europe-Asia or trans-Pacific routes *(see table, page 25)*. A few routes originating from Johannesburg and Dubai were also included to see the effect of high airfield elevation and ambient temperatures.

The performance of aircraft were studied in both directions so the effect of tail and head winds could be analysed. The resulting ESADs vary between 5,243-7,456nm *(see table, page 25)*.

The A340-600 and 777-300ER will also be operated on trans-Atlantic and intra-Asian routes, but these are unlikely to impose performance limitations on them. Also no trans-Atlantic or intra-Asian city-pairs have been included in this analysis. Routes with ESADs up to 6,000nm, such as Paris-Singapore (5,721nm) or Beijing-Auckland (5,554nm) will illustrate the relative differences between the A340-600 and 777-300ER on the longest trans-Atlantic routes.

The longest routes will be those with ESADS longer than 7,000nm. That is, those which are likely to experience a passenger payload limitation, since this is close to the 777-300ER's and A340-600's maximum passenger range. This includes San Francisco-Hong Kong and Los Angeles-Taipei *(see table, page 25)*. The longest routes are New York-Hong Kong (7,415nm) and New York-Johannesburg (7,456nm).

Only Hong Kong-New York has a problem with 180 minute ETOPs routing limitations. This will have the effect of increasing the tracking distance and ESAD.

A340-600 & 777-300ER CONFIGURATION

Aircraft	A340-600	777-300ER
Seat capacity	380 (12/54/314)	365 (22/70/273)
MTOW (lbs)	804,700	750,000
MZFW (lbs)	529,100	524,000
OEW (lbs)	390,390	374,000
Structural payload (lbs)	138,700	150,000
Range with structural payload (nm)	5,700	4,850
Range with full passenger payload (nm)	7,500	7,200
Additional freight payload (lbs)	58,900	73,350
Freight containers	42 x LD-3	44 x LD-3

SUMMARY OF AIRPORT PARAMETERS FOR A340-600 & 777-300ER PERFORMANCE ANALYSIS

Airport	Runway	Temperature (degrees C)	Elevation (feet)	Diversion airport
Auckland (AKL)	23	24	23	Christchurch
Beijing (PEK)	18L	31	108	Taiyun
Buenos Aires (EZE)	29	29	62	Montevideo
Dubai (DXB)	12	38	13	Muscat
Frankfurt (FRA)	18	24	325	Hanover
Hong Kong (HKG)	25R	31	23	Guangzhou
Johannesburg (JNB)	03L	24	5,558	Gaborone
Los Angeles (LAX)	25R	27	95	Las Vegas
Manchester (MAN)	24R	21	249	London
New York (JFK)	31L	29	13	Boston
Paris (CDG)	08L	25	338	Brussels
San Francisco (SFO)	10L	21	3	Reno
Singapore (SIN)	02L	30	23	Kuala Lumpur
Sydney (SYD)	16R	29	7	Canberra
Taipei (TPE)	05L	32	72	Makung
Tokyo (NRT)	34L	30	141	Nagoya

Aircraft configuration

Aircraft specification weights have an influence on available payload and operating performance. The difference in maximum zero fuel weight (MZFW) and operating empty weight (OEW) determines maximum available payload.

The 777-300ER has a higher additional freight capacity and a 14-17% lower fuel burn on most routes than the A340-600. Despite these advantages the A340-600 is able to use a higher proportion of its additional freight capacity and can carry more freight than the 777-300ER on long distance routes. This might give it an overall economic advantage, although Boeing claims the A340-600 will have 42 less seats than the 777-300ER on an equal configuration basis.

While MZFW is fixed, OEW will vary according to an airline's specification and configuration.

A higher OEW will reduce available payload and increase fuel burn. It is therefore important that the configurations of the A340 and 777-300ER should be consistent so as to result in comparative OEWs and thus performance data.

There are four basic categories of items that affect OEW. The first is manufacturer's empty weight (MEW). This is the weight of the aircraft with the manufacturer's standard interior and fuel tanks.

First, there will be changes to the MEW because of customer changes to the aircraft's configuration, such as altering the numbers of first, business and economy seats from the manufacturer's standard layout.

While the 777-300ER's standard configuration is 15 seats less than the A340-600's, Boeing argues that on a basis of the two aircraft having equal proportions of first, business and economy seating, the A340 will have a seat count as low as 323. This is because the A340's first and business class seat numbers have been raised from 12 and 54 to 18 and 60. The economy class then gets reduced from 314 to 245. These are equal to percentages of total seats of 5.6%, 18.6% and 75.8% for first, business and economy class. This compares to ratios of 6%, 19.2% and 74.8% for the 777-300ER.

This would give the 777-300ER a 42 seat advantage over the A340-600.

The addition of pilot and flight attendant rest bunks and other options, such as in-flight entertainment equipment will also affect MEW.

The weight of standard operating items also has to be added. These items include unusable fuel, oil and oxygen equipment, but the majority of this extra weight is accounted for by galley structures.

The largest addition is for operating items. These are crew and their baggage, catering, passenger service equipment, water, emergency equipment and cargo pallets and containers.

The 777-300ER's MEW is 332,966lbs. This is with 22 first, 70 business and 273 economy seats. An extra 4,905lbs is added for crew rest bunks and customer options allowance. This takes MEW to 337,871lbs.

The A340's MEW is 349,521lbs, which includes standard items.

Standard items on the 777-300ER account for another 8,440lbs. These do not vary much for customer configuration, except for galley structure. The galley configuration will depend on seat numbers and customer's preference. A high ratio of first- and business-class seats to economy seating will result in larger galley structures. A higher catering allowance and meal service will also increase galley size, as well as reducing seat numbers.

Operational items will vary more than other additions to MEW. Flight and cabin crew numbers used reflect typical airline operations. One supernumerary pilot will be rostered by most airlines on the routes being studied here. Indeed, on the longer routes a fourth crew member would be carried. Three flight crew are, however, assumed for every route. These have a weight allowance of 220lbs each.

Considering the number of seats on each aircraft, 16 flight attendants would be carried, thus taking total crew numbers on each type to 19. Flight attendants have a weight allowance of 165lbs each.

Catering for a two-meal service is 110lbs for first class, 44lbs for business class and 22lbs for economy, adding 11,506lbs for the 777-300ER. Operator items total 26,472lbs, and takes OEW for the 777-300ER to 374,000lbs.

Operator items and freight containers and pallets add 35,693lbs and 5,181lbs to the A340-600, taking OEW up to 390,394lbs.

Operating conditions

Besides aircraft configuration, and specification, there are other factors that can affect performance. These can be divided into the en-route and airport weather conditions and other aircraft physical parameters.

Remaining aircraft parameters are fuel density, passenger payload and average weight and mission rules.

Mission rules, such as taxi time, cruise altitude and cruise speed, for this analysis have been made in accordance with Boeing's standard long-range rules. They also concern the departure and arrival runways used and alternate airports for each city-pair. The runways and alternate airports used are listed *(see table, page 21)*.

Standard passenger and baggage weight is 210lbs and fuel density is 6.7lbs per US Gallon. En-route winds and temperatures of departure airports used are 85% annual. These result in the ESADs for each city-pair *(see table, page 25)*.

The permitted payload is up to 100% passenger load factor plus any additional freight that can be carried on each route. This payload and the ESAD then determines fuel burn, and the ESAD and cruise speed partially determine flight time.

Performance results

There are three basic parameters of aircraft performance that should be compared: passenger numbers; allowable additional freight payload; and fuel burn.

The 777-300ER is restricted in take-off weight from Johannesburg (JNB) by

ROUTE PERFORMANCE OF A340-600 & 777-300ER

Route	Great circle distance (nm)	ESAD (nm)	A340-600 Fuel (USG)	A340-600 Pax	A340-600 Cargo (lbs)	777-300ER Fuel (USG)	777-300ER Pax	777-300ER Cargo (lbs)
NRT-CDG	5,275	5,686	39,647	380	58,900	33,433	365	49,810
CDG-NRT	5,275	5,243	36,618	380	58,900	31,300	365	61,991
PEK-AKL	5,611	5,554	40,510	380	50,984	32,848	365	44,449
AKL-PEK	5,611	5,995	42,244	380	51,767	34,923	365	35,278
SIN-CDG	5,792	6,257	42,976	380	46,956	36,174	365	30,919
CDG-SIN	5,792	5,721	40,123	380	58,900	33,656	365	47,326
PEK-JFK	5,945	6,045	42,186	380	52,149	35,216	365	36,774
JFK-PEK	5,945	6,161	43,373	380	44,339	35,716	365	29,842
LAX-TPE	6,012	7,028	46,861	380	21,390	39,757	365	6,099
TPE-LAX	6,012	5,694	40,474	380	58,483	33,532	365	46,562
SIN-MAN	6,030	6,485	44,130	380	39,360	37,251	365	23,726
MAN-SIN*	6,030	5,968	41,788	380	54,766	34,624	365	35,572
DXB-JFK	6,055	6,752	45,784	380	28,478	38,494	365	14,159
JFK-DXB	6,055	5,897	41,631	380	55,804	34,513	365	40,480
HKG-SFO	6,125	5,847	41,342	380	57,699	34,273	365	42,785
SFO-HKG	6,125	7,024	46,472	380	23,950	39,741	365	9,668
PEK-JNB	6,307	6,798	45,689	380	29,102	38,743	365	12,778
JNB-PEK*	6,307	6,230	43,485	380	43,602	32,689	260	184
FRA-EZE	6,331	6,734	45,313	380	31,574	38,404	365	16,274
EZE-FRA	6,331	6,279	43,443	380	43,879	36,321	365	29,237
LAX-SYD	6,448	6,966	46,379	380	24,560	39,475	365	8,116
SYD-LAX	6,448	6,305	43,940	380	40,603	36,442	365	26,584
DXB-SYD	6,493	6,440	43,989	380	40,285	37,069	365	24,729
SYD-DXB	6,493	6,892	46,411	380	24,350	39,140	365	8,576
JNB-JFK*	6,917	7,456	48,836	380	8,391	37,774	109	5
JFK-JNB	6,917	6,805	46,144	380	26,107	38,780	365	12,522
HKG-JFK	7,139	7,244	48,223	380	12,421	40,716	359	87
JFK-HKG	7,139	7,415	48,473	380	10,781	41,489	353	87

* 777-300ER take-off weight is limited by tyre speed at JNB and by field length at MAN.

tyre speed, and by field length at Manchester on the route to Singapore. The 777-300ER's passenger numbers are limited on departures from JNB on shorter routes to New York and Beijing, and from Dubai to Miami, but not on the return flights. This is because of airport elevation.

The A340-600 has the advantage of being a four-engined aircraft, and so does not suffer the passenger limitations of the 777 at JNB.

On most routes the 777-300ER has a 15-65% smaller available freight payload than the A340-600.

The 777's allowable freight payload becomes more limited not only where passenger numbers are restricted, but also on routes from the US west coast to the Asia Pacific and routes where ESAD exceeds about 6,700nm; close to the full passenger payload range.

The A340 only suffers freight payload restrictions on routes from JNB because of route length rather than take-off weight limitation. The A340-600, however, is not able to use such a high proportion of its additional freight capacity as the 777-300ER can.

On most routes studied here the A340-600 has 17-21% higher fuel burn than the 777-300ER *(see table, page 25)*. This is partially because of the A340's four-engined design, but the A340 also has a 54,700lbs higher maximum take-off weight.

This means the 777's lower fuel burn reduces the difference it has in additional belly freight capacity with the A340-600.

On most routes the A340-600 is able to use a higher proportion of its additional belly freight capacity of 58,900lbs compared to the 777-300ER; which has an additional capacity of 73,350lbs. This is explained by the A340-600 having a longer range with both maximum payload and full passenger payload.

The 777's main disadvantage over the A340-600 is not a performance shortfall, but a standard smaller seat count of 15. The A340 therefore has a higher passenger and freight revenue capacity, but higher fuel burn.

Taking fuel price at 65 cents per US Gallon and belly freight yields of 50 cents per lb, the A340-600 is able to counter its higher fuel burn with higher freight revenue. On this basis the net difference between fuel and freight would give the A340-600 an advantage over the 777-300ER of $4,000-10,000 per trip on most routes.

Additional passenger revenue for its 15 extra seats could then be added to this. Considering the A340's 15 extra seats are in economy, the yields most airlines are likely to attract for discount fares on these routes are likely to low.

Taking Boeing's argument of a 42 lower seat count for the A340-600 would make a large change. A lower seat count would give the A340 a further 8,820lbs additional freight payload. While this would give it additional freight revenue to further counter its higher fuel burn, the A340-600 would have a large passenger revenue disadvantage.

Ultimately, the difference is decided by customer seat configurations with respect to first, business and economy class numbers. A lower proportion of first and business class seating would favour the A340-600. AC