The 747-400 has been in operation for 18 years. The A380 that is about 150 seats larger and the 777-300ER which is about 50 seats smaller seem to be the only available replacement candidates. Airlines need a wider range of replacement options, but this will not be for up to another eight years.

Assessing 747-400 replacement options

Many operators of the 747-400 are now considering replacing it. There is no aircraft of similar size available, with the nearest in size to the 747-400 being smaller or larger by 30-50 seats. Smaller aircraft are suitable for operators that find the 747-400 too big, or wish to increase service frequency. A few carriers require larger types like the A380 or 747-8 to replace at least some of their 747-400s.

Replacement options

There are 492 passenger- and combi-configured 747-400s in operation with 37 airlines, most of which are the original customers. These aircraft range in age from two to 18 years old.

The only disposals of 747-400s to date include 17 aircraft by Singapore Airlines, seven by Air Canada, and 12 by United Airlines. All Nippon Airways (ANA) has ordered 777-300ERs to replace its 747-400s. A small number of airlines have converted their -400s to freighters.

There is a shortage of all aircraft types. Although a large number of 747-400s have passed their third D check, replacement options are only just becoming available.

The 500- to 550-seat A380 will soon enter service, but this is suitable as a replacement for only a few 747-400s, most of which are configured with about 360 seats. The 467-seat 747-8 programme has only recently been launched, with Lufthansa being the only customer for 10 aircraft. This aircraft will not enter service until 2010.

There are two smaller alternatives in operation: the 777-300ER with a standard capacity of 365 seats, and the four-engined A340-600 with a standard capacity of 360 seats. The A340-600 has had limited success, however, with only 126 firm orders from 13 customers. It has now virtually stopped selling. The 777-300ER has won 270 firm orders from 21 customers.

The 350-seat, twin-engined A350-1000 has yet to be launched, but it is intended to replace the A340-600 and compete directly with the 777-300ER. The A350-1000 is expected to enter service in 2015.

Some 747-400 operators may wish to replace some of their fleets with smaller aircraft, and have the 777-200ER/-200LR and A350-900 as options. Downsizing from the 747-400's capacity by 80-100 seats is only appealing for a few operators.

Basic economics

The past 20-30 years have seen a gradual rise in the size of twin-engined widebodies, leaving the 747-8 and A380 as the only new generation quads.

The gradual increase in the size of twinjets has been made possible by the development of higher thrust turbofans. Extended range twin-engined operations (Etops) have become less of an issue in limiting flight operations. While twin-engined designs have been a major factor in reducing operational costs, the increasing use of new materials, more efficient maintenance programmes, more electronics in aircraft systems, and more sophisticated on-board maintenance computers have all further reduced aircraft operating costs. On the 777 and later the 787, for example, these have enabled the provision of similar seat-mile costs to the 747-400. Airbus is following the same general strategy with the A350 family to allow airlines to operate more long-haul routes with aircraft that are more closely matched to demand levels.

Total aircraft operating costs fall into two main categories: fuel, maintenance and flightcrew; and aircraft financing charges and depreciation. New replacement alternatives are all designed to lower cash operating costs, but they will have higher financing or depreciation charges. Selecting 747-400 replacements will depend on the improvement in overall seat-mile costs and aircraft performance they provide.

Size requirements

Replacements for the 747-400 depend in the first instance on the size of aircraft airlines require. This is determined by levels of passenger demand on airline route networks, and how the frequency of service they offer compares to the one required. Operating long-haul routes is also linked to payload-range performance.

The 747-400 is used in many cases to provide just four to seven weekly services. Only the arrival of the A340-300 and 777-200ER made more routes and higher frequencies possible.

The A340-600 and 777-300ER have become been launched more recently, and have also been used to provide more frequencies on the same routes as the 747-400. New types like the A350-1000 will add to the choice available to airlines.

Analysis of the world's routes that have the highest levels of capacity reveal consistent trends in how capacity increases to cater for growth have been provided over the past five years. Aircraft size has changed little, while increases in total capacity to meet greater demand

FEATURES OF 747-400 & CLOSEST SIZED REPLACEMENT OPTIONS

Aircraft type	747-400	777-300ER	A340-600	A350-1000	747-8	A380
MTOW lbs	870,000	750,000	805,000	650,000	970,000	1,235,000
Fuel capacity USG	57,065	47,890	56,750	40,000	64,000	82,000
Engines	4 X CF6-80C2 4 X PW4056/4060 4 X RB211-524G/H	2 X GE90-115	4 X Trent 560	2 X GEnx	4 X GEnx	4 X Trent 1,000 4 X GP 7200
Standard tri-class seats	417	370	380	350	467	555
Range with full passenger load-nm	7,260	7,700	7,900	8,300	8,000	8,200
Typical/probable tri-class seats	360	320	320	335	440	520
Comments	Most aircraft had second or third D check, and maintenance costs rising.	More orders than A340-600. Competitive design.	Aircraft suffers from high weight & fuel burn.	Aircraft light & fuel efficient. Not available until 2015.	Only 1 customer to date. Available from 2010.	Only suitable for busiest routes. High weight per seat. Available from late 2007.

have been supplied by a rise in frequencies *(see Where & when will the A380 & 747-8 be required? Aircraft Commerce, June/July 2006, page 36)*. Average aircraft size has actually decreased by a few per cent in most markets, and has increased only in the Europe-Middle East market. The average aircraft size in all markets is 280-350 seats.

The majority of city-pairs have fewer than seven weekly frequencies. Most airlines would like to offer at least one daily frequency, and preferably two. In most cases traffic will have to more than double, or frequencies become limited by airspace or airport congestion, before aircraft size has to increase. Many long-range routes from most European cities and transatlantic city-pairs are operated by aircraft in the 250- to 300-seat category. This indicates that large numbers of 747-8s and A380s will not be required for another 10 years.

An example of this is Taiwan's EVA Air, which has selected the 777-300ER to replace its 747-400s through to 2010. It uses the 777-300ERs on routes previously operated by the 747-400 at the same frequency of service. This strategy has been followed to match capacity closer to levels of passenger demand.

The 747-400 is now only dominant on the world's busiest routes, or those limited to single daily services. It is also used extensively on some Japanese domestic and intra-Asia-Pacific routes.

The 467-seat 747-8 and 550-seat A380 are more likely to be used by airlines operating on the world's busiest routes and from the world's busiest hubs.

An obvious example is Singapore Airlines (SIA), particularly with its services to London Heathrow, on which it will utilise the A380 when this is delivered in late 2007. Qantas has high frequency operations from several Australian cities to London and Los Angeles with the 747-400 and -400ER. "Because of the mixed effect of airport curfews and time zone differences we fly our four daily flights to and from London at very close departure times," explains Barry Phair, general manager fleet and network planning at Qantas. "This is why we require a large aircraft. One daily return service to London requires the equivalent of two and a half aircraft, so four daily services need 10. We will use the 20 A380s we have on order to operate to London and Los Angeles."

Virgin, Air France and Lufthansa have all also ordered the A380 to operate on their busiest routes from London, Paris and Frankfurt.

Most A380 operators, with the exception of Emirates, operate large fleets of 747-400s. It remains to be seen whether they will replace the 747-400 with the 747-8 on the remainder of their networks, select smaller aircraft, or opt for a mixed fleet.

Many 747-400 operators are now finding they require, or prefer, a replacement option that provides several long-haul aircraft with a range of sizes. This will give them the flexibility to operate routes with varying levels of passenger demand at frequencies of at least one daily service. "Our fleet of 30 747-400s is two to 18 years old, and includes the world's only six -400ERs. These and other aircraft that are displaced by the A380 will be put on to routes with lower traffic densities," says Phair. "Our fleet plan is complex, however. We have also ordered 65 787-8/-9s, which will be used on point-to-point services. The 787s will effectively replace some of the 747-400s from the bottom up. We could also replace some with A350-1000s or 777-300ERs. We have also been pushing for larger versions of the 787, because we need something larger than the proposed -10 variant. Boeing has no data on the -10, however. This leaves a gap between the 787 and the A380, so we will wait to see what mid-sized aircraft are available."

747-400 economic performance

The 747-400's operating cost performance is a standard against which replacement candidates have to be measured. The 747-400's seat-mile costs can be assessed. This depends on seat numbers. Analysis shows an average of 360 for several major operators. About 5% of seats are first class, 15% business class and the remainder economy.

The 747-400 burns 19,500 US Gallons (USG) on a 3,000nm trip, which increases up to 38,000-39,000USG on a 5,500nm trip *(see 747-400 fuel burn performance, Aircraft Commerce, April/May 2007, page 12)*. At current fuel prices of $2.25 per USG, this means $44,000 for trip fuel and $122 per seat for a 3,000nm trip, and $85,000-88,000 for trip fuel and $235-245 per seat for a 5,500nm trip.

The 747-400's maintenance costs

have been analysed and examined *(see 747-400 maintenance analysis & budget, Aircraft Commerce, April/May 2007, page 14).* The main elements are line and light airframe checks, base maintenance, engine maintenance, heavy components, and rotable support.

Costs for line, ramp and A checks are $230-290 per flight hour (FH), depending on annual utilisation, average flight cycle (FC) time and cost of labour.

The 747-400 has a cycle of three C checks and a D check in its base maintenance cycle. The checks have an interval of 18 months, so the cycle's maximum interval is six years. The cycle of checks is therefore likely to be completed every 26,000FH. Maintenance programmes vary, but a total of 78,000-85,000 man-hours (MH) can be used in these four checks for an aircraft in its third base check cycle, together with $1.2-1.4 million in materials and consumables. This is equal to $5.3-5.7 million at typical labour rates, and a reserve of $210-220 per FH.

This element of maintenance costs is likely to increase as the aircraft ages. The D3 check, for example, will consume 60,000MH in a maintenance programme that has a high workscope for D checks. This compares to 54,000-55,000MH for a D1 check. The labour required for successive D checks will rise, so operators can expect base maintenance reserves to rise with age to $280-300 per FH.

Other maintenance elements include $400-450 per FH for heavy components and rotable support packages. Full reserves for its four engines are $760-860 per FH, depending on engine type, taking total costs to $1,600-1,800 per FH. This is equal to a trip cost of $11,000 and $31 per seat for a 3,000nm trip, and a trip cost of $18,000 and $50 per seat for a 5,500nm sector.

Flightcrew is the third major cost element. Annual remuneration can be linked to aircraft size, but also varies globally and between airlines. Examples of 747-400 flightcrew salaries are $170,000 per year for captains and $120,000 for first officers. These have to be increased by 50% to arrive at the total annual cost of employment. Since many long-haul trips require one or two supernumerary crew, crew costs will have to be doubled in some cases.

Crew productivity does not vary much between aircraft types, but it should be considered. Annual crew hours of 700 block hours result in a flightcrew cost per hour of $1,200 for a crew of four, and $900 for a crew of three.

This would add $6,000 for a 3,000nm trip, and $13,500 for a 5,500nm trip.

Total cash operating costs for fuel, flightcrew and maintenance are therefore $60,000-63,000 and $167-175 per seat for a 3,000nm trip, and $118,000-120,000 and $328-333 per seat for a 5,500nm trip.

Most 747-400s are now more than 10 years old, and the oldest are 16-18 years old. This means that some aircraft will be fully depreciated and actually have zero charges. Current market lease rates for medium-aged 747-400s are $800,000-1,000,000.

Typical annual rates of utilisation are 5,000FH and 450-750FC. Lease rentals will be $14,000 for a 3,000nm trip, and $23,000-24,000 for a 5,500nm trip.

The total for the four cost elements is $76,000 and $210 per seat for a 3,000nm trip, and $142,000 and $395 per seat for a 5,500nm trip *(see table, page 43).*

The majority of 747-400 have passed their second or third D check. It is well established that the 747 experiences large increases in the labour required for C and D checks as it ages, and so the -400's base check reserves will rise. There are a limited number of replacement options, and a wider range of aircraft will not come available until up to 2015.

Replacement economics

The increasing age and maintenance costs of 747-400s make their replacement inevitable. Operators of 747-400s will be particularly interested in smaller aircraft that can deliver comparable available seat mile (ASM) costs. The probable operating cost performance of the 777-300ER, A340-600, A350-1000, 747-8 and A380 is examined on a trip cost and per seat seat basis for two missions of 3,000nm and 5,500nm. Complete operating cost data does not exist for all aircraft types, and only approximate fuel burns and probable or possible maintenance cost elements are available. The calculated costs, at 2007 levels for all types, are therefore only approximate and indicative only of the probable performance of each type.

777-300/-300ER

While the tri-class capacity of 747-400s averages 360 seats by most carriers, the 777-300ER's comparable configuration is about 320 seats.

The 777-300ER has won 270 firm orders since 2000. A large number have been placed by operators of large 747-400 fleets. These include Air France with 29 orders for the 777-300ER, Air India (16), ANA (16), Cathay Pacific (14), EVA Air (13), JAL (13) and SIA (19). These airlines all have similar-sized or larger 747-400 fleets.

The 777-300ER burns about 16,000USG of fuel on a 3,000nm sector. At current fuel prices this is equal to $36,000 or $112 per seat.

Fuel burn for a 5,500nm sector is 33,000USG, and equal to $74,000 and $232 per seat. This is only marginally better than the 747-400's fuel costs.

The 777-300ER can offer an advantage over the 747-400 in several elements of maintenance costs. These are base and engine-related maintenance.

The 777 benefits from an efficient maintenance programme. It has a base check cycle of eight checks, each with an interval of 5,000FH. Actual intervals mean the cycle will be completed in 36,000FH, and inputs for young aircraft are 45,000MH and $2.0-2.3 million in materials *(see Evaluating the 777's base check costs, Aircraft Commerce, October/November 2007, page 45).* This takes reserves for base maintenance to

TRIP & SEAT-MILE OPERATING COSTS OF 747-400 & CLOSEST SIZED REPLACEMENT OPTIONS

Aircraft type	747-400	777-300ER	A340-600	A350-1000	747-8	A380
Typical tri-class seats	360	320	320	335	440	520
Trip length-nm	3,000	3,000	3,000	3,000	3,000	3,000
Trip cost-$	75,394	70,500	84,498	62,472	91,492	114,927
Cost per seat-$	209	220	264	186	208	221
Unit cost per seat-mile-cents	7.0	7.3	8.8	6.2	6.9	7.4
Trip length-nm	5,500	5,500	5,500	5,500	5,500	5,500
Trip cost-$	142,099	134,453	148,370	118,206	169,636	198,359
Cost per seat-$	395	420	464	353	386	381
Unit cost per seat-mile-cents	7.2	7.6	8.4	6.4	7.0	6.9

$120-130 per FH.

The second main difference lies with engine reserves. Most engines are maintained under fixed rate contracts, at $360-380 per engine flight hour (EFH) based on average removal intervals of 16,000EFH, totalling $720-760 per FH.

Line, ramp and A checks cost a total of $240-270 per FH. Rotables and heavy components total $320-370 per FH.

This takes total maintenance costs to $1,400-1,530 per FH, compared to $1,600-1,760 per FH for the 747-400. The 747's costs will also rise with age to $1,700-1,850 per FH.

The 777-300ER can offer a saving. Maintenance costs are $9,950 and $31 per seat for a 3,000nm trip, and $15,800 and $50 per seat for a 5,500nm trip.

Flightcrew salaries can be expected to be lower for the 777-300ER than the 747-400. Annual captains' salaries would be $140,000, and first officers' about $100,000 on a comparative basis. Using the same assumptions as for the 747-400, the 777-300ER would have flightcrew costs of $1,000 per FH for a crew of four, and $770 per hour for a crew of three.

The aircraft are only one to six years old, and market lease rates for aircraft acquired at typical discounts will be $1.25 million per month, and equal to $19,000-20,000 per trip for a 3,000nm sector, and $33,000 per trip for a 5,500nm sector.

The total of the four cost elements for a 3,000nm trip will be $70,000-71,000, and equal to $220 per seat. This is similar to the 747-400's performance *(see table, page 43)*.

Total costs for a 5,500nm trip would be $134,000-135,000, and equal to $420 per seat. This is about $25 per seat higher than the 747-400's performance, and is explained by the 777-300ER's higher lease rate. The 747-400 will experience rising maintenance costs, however.

A340-600

The A340-600 has had less success than the 777-300ER, with 126 firm orders from 13 airlines. It has suffered mainly due to its four-engined design, which has given it a higher hull and 55,000lbs higher maximum take-off weight (MTOW) than the 777-300ER. The A340-600 is close in size to the 777-300ER, and has an average of 320 seats.

The A340-600, however, has higher fuel burn. The aircraft consumes about 23,000USG on a 3,000nm trip, equal to $52,000 and $162 per seat at current fuel prices. Fuel consumption for a 5,500nm trip is 40,000-41,000USG and equal to $90,000-92,000 and $285 per seat.

The A340 family's airframe maintenance costs are well-established. A large number of A340-300s have completed base check cycles using 88,000-92,000MH and $3.1-3.3 million in materials and consumables over an interval of 50,000FH *(see A340 maintenance analysis & budget, page 17)*.

The A340-600 should benefit from escalated maintenance intervals, and so complete its cycle in 55,000FH. The -600 can be expected to consume a similar number of MH and materials. Although it will not require some of the same modifications as the -300 series, the -600 is larger and will use more MH for structural tasks. The reserve for base checks will thus be about $140 per FH, rising in the second base maintenance cycle between 11 and 22 years.

Engine reserves are the other major element of maintenance costs, and are high because the A340-600 has four engines. These are $230-240 per EFH for the Trent 556 and 560, based on an average shop visit interval of 15,500EFH. This is equal to $940-960 per FH.

Remaining costs for line maintenance and A checks are $240-270 per FH and $320-370 per FH for rotables and heavy components. This takes total maintenance costs to $1,740 per FH for operations averaging 7.0FH per FC, and $1,605 per FH for aircraft on longer cycles. Maintenance costs are therefore $200 per FH higher than the 777-300ER's.

Maintenance costs for a 3,000nm trip are therefore $11,300 and $36 per seat, and $18,100 for a 5,500nm trip and $57 per seat.

Flightcrew salaries and remunerations will be the same as for 777-300ER crews, resulting in similar trip rates and costs per seat.

Monthly lease rates for A340-600s up to four years old are $900,000-1,200,000. These are $44-60 per seat for a 3,000nm trip, and $75-99 per seat for a 5,500nm trip.

Total costs per seat for a 3,000nm trip are $256-272, and costs per seat for a 5,500nm trip are $450-461 *(see table, page 43)*. These are higher than for the 777-300ER and 747-400, with the A340-600 being disadvantaged by its high fuel burn and engine maintenance costs.

A350-1000

The yet-to-be-launched A350-1000 is pitched as a 777-300ER competitor. Only basic information about the A350-1000 is available, making detailed evaluations difficult. "The A350-1000 may meet our requirements to carry a full payload in both directions from Sydney and Melbourne to beyond the West Coast of the US. Our interest will depend on what its performance will be, but it is still not completely defined," says Phair.

The A350-1000's standard capacity is 350 seats, including 24 first- and 62 business-class passengers. The 777-300ER has a smaller cabin floor area, implying the A350-1000's actual seat

The 777-300ER has already been selected by some airlines as a 747-400 replacement. Smaller aircraft that have long-haul range performance and unit operating costs that can match the 747-400 suit some carriers' needs. The proposed A350-1000 will have a similar size and range capability, but will be lighter and have lower fuel burn than the 777-300ER.

number could come close to 350. The aircraft is assumed here to have 335 seats with a configuration equal to the 777-300ER's standard.

The A350-1000's performance suggests it will be a big improvement on the A340-600 and also a better performer than the 777-300ER. With similar payloads of 350 to 380 passengers, the 777-300ER has a range of 7,700nm, the A340-600 a range of 7,900nm and the A350-1000 a range of 8,300nm. The A350-1000's expected efficiency is illustrated by its lower MTOW and fuel capacity, which allow it to perform the same mission as its two counterparts. The A350-1000's MTOW at 650,000lbs is 125,000lbs lower than the 777-300ER's. Fuel capacities are 52,000USG for the A340-600, 48,000USG for the 777-300ER and 40,000USG for the A350-1000.

Interestingly, the A350-1000 has a similar MTOW to the 777-200ER. The A350-1000 can, however, carry more passengers a longer distance.

The A350-1000's light weight and low fuel capacity suggest it will be able to offer a significant fuel burn saving over the 777-300ER. The A350-1000's MTOW is 16% less than the 777-300ER's, while the GEnx has 17% lower installed thrust than the GE90-115's. Once the GEnx's lower specific fuel consumption and the A350's probable superior aerodynamics are considered, Airbus's claim of 25% lower fuel burn per seat appears realistic. On this basis, the A350-1000 would burn 12,000USG on a 3,000nm route and 25,000USG on a 5,500nm sector.

The A350-1000's other main cost advantage will be related to maintenance. Possible savings over the 777-300ER and A340-600 will come mainly from base and engine maintenance.

A modern maintenance programme would allow longer check intervals and require fewer MH to complete checks. A base maintenance reserve of $120 per FH would be required to make a significant contribution to lower maintenance costs.

The A350-1000 would be able to realise large reductions in engine reserves through its twin-engined design. As with base maintenance reserves, the A350-1000's GEnx engines would be rated at 95,000lbs thrust, and would have to offer reserves at $275-290 per EFH, or at least $80-90 per EFH lower than the 777-300ER's GE90-115s.

Line and A checks and rotable costs would also contribute to lowering costs.

Overall, the A350-1000's maintenance costs could be $1,230-1,320 per FH. This is $400 per FH less than the A340-600 and $200 per FH less than the 777-300ER.

Flightcrew costs would be unchanged, leaving finance and leasing costs to influence total operating costs. At 2007 rates, lease rentals are likely to be $100,000-200,000 higher than the 777-300ER's because of the A350-1000's superior performance.

Total costs would be $63,000 and $186 per seat for a 3,000nm trip, and $118,000 and $353 per seat for a 5,500nm trip.

747-8

The 747-8 followed on the heels of the larger A380. It was initially proposed as a shorter and lighter variant of its freighter counterpart. The -8 had a standard tri-class capacity of 450, an MTOW of 960,000lbs, a fuel capacity of 61,000USG, and range capability of 8,270nm.

An increase in fuselage length of seven feet to take the 747-8 to the same length as the freighter version has increased its standard seat numbers to 467, but reduced its range to 8,000nm. This is despite an increase in MTOW to 970,000lbs and fuel capacity to 64,000USG. "Emirates reportedly pushed for a stretch, which would help to bring down the seat-mile cost, but the resulting reduction in range now makes the aircraft marginal in a westerly direction on Los Angeles-Melbourne, which is an important route for us," says Phair. "The longer freighter fuselage on the 747-8 makes it too heavy, and range performance is also lost once new engines have deteriorated and fuel burn increases by 1-2%. This can be up to 3 tons more fuel for a 747 on a trans-Pacific flight, which has to come out of payload."

The 747-8's performance will be sufficient for most 747-400 operators, however, with the -8's range being about 800nm longer.

The -8 can be expected to have 440 tri-class seats compared to its standard seat count of 467. This is 80 seats more than the -400 series, and 80 fewer than the A380.

Boeing claims the 747-8 will have about 15% lower fuel burn per seat than the -400. On this basis, the -8 would burn 22,000USG on a 3,000nm trip and 42,500USG on a 5,500nm trip.

Like the A350-1000, the 747-8 would have to effect competitive maintenance costs through lower base check and engine reserves.

The 737NG has benefited from its efficient maintenance programme, and consequently has lower base reserves than the 737 Classics. If the 747-8 could benefit in the same way it could have reserves of about $200 per FH. Target engine reserves would be $190-200 per EFH, equal to $760-800 per FH.

Some improvements could be made on line maintenance and rotable-related costs, leading to a target maintenance cost similar to the 747-400's.

Fuel and maintenance would therefore contribute to the 747-8 having lower costs per seat than the 747-400.

It is assumed the 747-8 would have higher flightcrew salaries of $200,000 for captains and $150,000 for first officers.

Lease rates in 2007 would be $1.4-1.5

The A380 does gain from economies of scale in some aspect of its operating cost performance. It has a high weight per seat, however, and so a relatively high fuel burn per passenger carried. Moreover, the aircraft is only suited to international routes with the highest traffic densities and which cannot be operated with smaller aircraft due to various operational constraints.

per month, resulting in costs per seat of $53 for a 3,000nm trip and $90 for a 5,500nm trip.

On this basis, total costs per seat would be $208 on a 3,000nm trip and $386 on a 5,500nm trip *(see table, page 43)*. These are similar to the 747-400's performance.

A380

The A380's size is intended for it to deliver competitive seat-mile costs. The aircraft is likely to be configured with an average of 520 seats. It has an MTOW of 1,235,000lbs, 27% heavier than the 747-8. This compares to the A380's 18% higher seat count. The aircraft's high weight relative to its seat count is due to its design having the potential for further stretch developments with higher seat counts.

The A380 will burn 30,000USG of fuel on a 3,000nm trip and 51,000USG on a 5,500nm trip. This will be equal to $130 per seat on a 3,000nm trip, and $220 on a 5,500nm trip.

In terms of maintenance costs, the A380 should have similar costs per FH for line and A checks as similar-sized aircraft at $270-330 per FH. FH rates for rotables and heavy components can be expected to be marginally higher than smaller types at $450-500 per FH.

The A380 will gain in base and engine maintenance and from the economies of scale provided by its size. A target of $220-250 per FH for base check reserves and $230-250 per EFH would allow the A380 to have total maintenance costs of $1,900-2,000 per FH. This would result in costs of $26 per seat for a 3,000nm trip and $40 per trip for a 5,500nm trip.

Proportionate rises in flightcrew salaries would see similar costs per seat to the 747-8 on the same trip lengths.

Monthly lease rates are predicted to be $1.6-1.7 million per month, although they could be as low as $1.3 million for aircraft with the highest purchase discounts.

These lease rentals equate to $50 per seat for a 3,000nm trip, and $84 per seat for a 5,500nm trip.

Total costs per seat are $221 for a 3,000nm trip, about $10 higher cost per seat than the 747-400 and -8. This difference is small, however, and the

calculated costs are only approximate and based on probable or possible performance for illustrative purposes.

Total costs per seat are $381 for a 5,500nm trip, similar to the 747-8 and $15 lower than the 747-400 *(see table, page 43)*.

Summary

The analysis of operating cost performance is only approximate, and costs per seat and per seat-mile are sensitive to actual seat numbers and costs of operation. The costs shown nevertheless indicate the relative differences in costs for six types in 2007 dollars. The largest influence on relative cost differences is lease rate or financing charges.

For airlines that simply require smaller types than the 747-400, the 777-300ER offers similar costs per seat. This relies on a seat capacity of 320 for the 777-300ER, however. As might be expected of smaller aircraft, the A340-600 has a higher cost per seat than the 747-400. The A340-600, however, has clearly suffered in the market due to a combination of factors that have provided it with high fuel burn characteristics. Its four engines also contribute to higher maintenance costs.

It appears that the A350-1000 will be an impressive replacement. With an MTOW similar to the 777-200ER's, the A350-1000 provides a higher capacity and longer range, indicating that it can be expected to be fuel-efficient. This also contributes to the aircraft needing lower engine thrust, which in turn will mean it has lower engine maintenance reserves. Overall, the A350-1000 will provide competitive operating cost performance, with unit costs lower than the 747-400's *(see table, page 43)*. The A350-1000 will not be available until at least 2015, however.

Airlines that require higher capacity than the 747-400's can select either the 747-8 or A380 without any significant increases in unit costs, and be able to realise savings in most cases.

Neither the 747-8 or A380 provide large reductions in unit costs, as might be expected from the economies of scale that larger types provide. Costs relative to the 747-400 mainly depend on lease rates and financing costs, and actual rates could be higher or lower than those used in the analysis. Relative differences in flightcrew charges could also be different to those used.

The differences between the 747-8 and A380 are also small, so selection of either type should mainly be influenced by financing terms and capacity requirements.

Overall, airlines will be able to replace 747-400s with both smaller and larger types that provide similar unit costs to the 747-400's current performance. This will not be possible for a minority of carriers until at least 2010 or 2011, when the 777-300ER, 747-8 and A380 are all available. The complete range of aircraft will not be available until the arrival of the A350-1000 in 2015. The current tight supply of widebodies of all sizes and capacity requirements on most long-haul routes is likely to favour the 777-300ER until then. AC