The 787 & A350 have been developed as high technology aircraft, but can the gains in operational efficiency be enough to justify the high finance charges that will result from their capital costs? Yong Qiu analyses how these aircraft could change the economics of long-haul operations.

Can the 787 & A350 transform the economics of long-haul services?

The 787 series is a proposed replacement for the 767 series, A310-300 and A300-600, the A340-200 and even the A330-200. The A350 has been launched to compete against the 787, so how much of an advantage could the 787 and A350 provide operators of these old types if they were to replace their fleets? Which new type offers airlines the best overall solution: the A350 or 787?

787 family

The 787 series includes the -3, -8, and –9. The 787-3 seats 289 in a dual-class arrangement, and has a range of 3,500nm. Its maximum take-off weight (MTOW) remains unannounced.

This aircraft's range makes it ideal for medium-haul operations and a suitable replacement for the 767-300, A310-300 and A300-600. Customers of 787-3s include Japan Airlines and All Nippon Airways (ANA), which are expected to use the 787-3s for Japanese domestic routes.

The 787-8 has 217 seats in a tri-class configuration, a range of 8,500 nm and a MTOW of 480,000 lbs. The 787-8 is a replacement candidate for the 180-seat 767-200ER, 220-seat 767-300ER and 190-seat A310-300.

The 787-9 has 257 seats in three classes, a range of 8,300nm and MTOW of 500,000 lbs. This is 50,000lbs more than the 245-seat 767-400ER. The 787-9 has a similar size but 2,600nm longer range than the 767–400ER.

The 787-9's size and range make it a replacement candidate for the 767-400ER, 253-seat A330-200 and 260-seat A340-200, as well as older types still in mainline passenger service DC-10-30.

A350

Airbus has launched the A350 in response to the 787. The A350 is based on the A330 and shares the same fuselage and fuel capacity as the -200 and -300. The A350's main difference is that it uses carbon fibre in its wing structure and employs the General Electric (GE) GENX.

The A350-800 has a MTOW of 533,000lbs and 245 seats, eight fewer than the same-sized A330-200. The A350-800's MTOW is 46,000lbs higher than the A330-200's, but this gives the A350-800 a range of 8,600nm. This aircraft is in direct competition with the 787-8.

There is also the larger A350-900, which has the same fuselage as the A330-300. The A350-900 has the same MTOW and fuel capacity as the smaller -800, and so the -900 has a shorter range of 7,500nm. It also has a seat capacity of 285, so it is not a direct competitor of any 787 family variant. The A350-800 is therefore the only aircraft to directly compete with the 787.

787 & A350 markets

The most notable feature of the 787-8/-9 and A350-800 is that their range capability is 2,000-4,000nm longer than the similar-sized, older aircraft types it could potentially replace.

The 787 has this capability without being significantly heavier than these older types. The 787-8's MTOW, for example, is only 68,000lbs more than the 767-300ER, while the 787-8 has a 2,400nm longer range.

The 787-9's MTOW is 500,000lbs which is 7,000lbs less than the A330-200 and 69,000lbs less than the A340-200.

The A350-800 is relatively heavy, with a similar seat capacity and range to the 787-9, but having a MTOW that is 33,000lbs higher.

The small MTOW increase, substantial range increase over older aircraft, and incorporation of modern technology in the 787 and A350 suggest they could provide airlines with large savings in cash direct operating costs (DOCs), while increasing operating flexibility and providing airlines with the opportunity to add currently unserved low-traffic-density, ultra-long-distance routes to their networks. Not only could the 787 and A350-800 replace the remaining A310-300s, A300-600s, 767 series and even A330-200s in service over an extended period, but the potential sales volume could be larger for the new aircraft if they transform the long-haul market with their long-range capability.

There are about 420 passenger-configured A300-600s, 767-200s and 767-300s in operation. These aircraft are used in short- and medium-haul operations, and are potential replacement candidates for the 787-3. There are also 155 remaining A310-300s, which are also used for mainly short- and medium-haul services.

There are nearly 700 767-200ERs, -300ERs and -400ERs in service, which are primarily used on long-haul services. These aircraft are a clear potential market for the 787-8/-9 and A350. Other current and older generation types such as the A330-200, A340-200 and DC-10-30 also provide further possible sales. Moreover, demand for more 787s and A350s would be generated if their ultra-long-range capability stimulated the opening of new long-haul routes.

The 767-300ER is the most numerous of 767 models and widebody twin aircraft types. The 787-8 has a similar seat capacity to the 767-300ER, but the 787-8 has a 2,300nm longer range and will have lower airframe-related maintenance costs and 20% lower fuel burn, and so overall provide an aircraft that could transform the economics of long-haul services.

787 advantages

So far Air New Zealand, ANA and Blue Panorama Airlines have confirmed a total order of 56 787s, and seven other airlines have booked another 135 787 orders. All 787 customers are 767 operators.

"We are going to replace 767s with 787s in 2010, and the three 767s will be returned to lessors. The 787's capital cost is marginally higher than the 767's, but its fuel burn is 20% lower than the 767's," says Gary Palin, aircraft leasing manger at First Choice Airlines.

"We will keep flying 767s, but the 787 can save up to 30% of the operating cost for us," says Sigthor Einarsson, general manager at Icelandair.

"Compared with equivalent size aircraft, the 787 is expected to save 20% in direct operating cost," says Mike Flanagan, general manager regional airlines at Air New Zealand.

This predicted saving is derived from some new technologies applied to the aircraft. The first noticeable feature of the 787 is that its primary structure will be about 82% carbon fibre, which is significantly higher than for any other civil aircraft to date, and explains why the 787 has a much longer range capability than similar-sized older aircraft. This carbon fibre technology will significantly reduce the 787's weight and lengthen its life. "The carbon fibre fuselage will have no erosion and fatigue. Also the 787's C check interval will be doubled to 36 months from the 767's interval of about 18 months, so the 787's maintenance cost will be reduced by about 15%, compared to the 767," says Flanagan.

The 787's second main feature is that the 787 will have two new engines: the General Electric GENX and Rolls-Royce Trent 1000. Both engines will have a high bypass ratio: the GENX 9.5:1; and the Trent 1000 11.0:1. In addition to several other technologies, a traditional air bleed system from the engine to the airframe will be absent. These features will combine to give the 787 a 15-20% lower fuel burn than equivalent-sized aircraft.

The third feature is the use of piezoelectric sensors in the aircraft's structure, which will monitor it for physical damage. These technologies will naturally reduce the aircraft's maintenance cost and bring considerable benefits to the operators. A further consequence of the application of these new technologies is that the aircraft's economic life and residual value will probably change. The cost of financing this aircraft could thus also be significantly reduced.

The 787 is not intended only to replace older aircraft types and save costs. "We are going to use these new aircraft to create new markets, for example from London to San Francisco, South America and Indonesia," says Palin.

As an example of Palin's routes, the great circle distance from London to Bali is 7,565nm, which cannot be operated non-stop by any 767 series.

Icelandair provides other examples. "The 787 will be used to fly from Iceland to South America and Asia," says Einarsson. "We are also going to use the 787s to fly to Hong Kong and North Asia. The 747 and 777 are too big for these routes, and the 787 is an ideal aircraft for these markets," says Flanagan.

The 787-8/-9's design has two purposes: to serve the 200- to 250-seat market, and to serve an ultra-long-range city-pair whose distance is about 8,500nm. Moreover, a third objective is to operate on routes where these two parameters can be combined. Boeing has identified more than 200 routes in the world suitable for the 787-8/-9. Although the technology advantages of the 787 over the 767 seem apparent, are the benefits offered by the 787 and A350 enough to prompt airlines to replace their 767 series, A310-300s, A300-600s or A330-200s?

Economic performance

Although new generation aircraft provide airlines with the opportunity to reduce cash operating costs, they also have high financing charges. Despite new aircraft enjoying a maintenance 'honeymoon' for their initial years of operation, airlines often find that their high finance charges make their total unit costs higher than the older aircraft they are replacing.

The 787 employs technology that could, however, provide airlines with a large enough reduction in cash operating costs to equal or outweigh the likely increase in finance charges an airline will have to bear when using it to replace 767s, A310-300s and A300-600s. The 787 might therefore provide airlines with an aircraft that has a unit cost per available seat-mile (CASM) close to their current fleet, but also provide the bonus of an opportunity to transform their long-haul networks through its ultra long-range capability.

Economic analysis

Although it will be several years before the 787 and A350 are operational, some information about their probable operational and economic performance is known. In addition, maintenance costs for the 767 series, A310-300, A300-600 and A330-200 are known, and allowing the 787's and A350's maintenance costs to be extrapolated. The 787's and A350's list prices are known, so probable financing charges can be estimated.

It is therefore possible to compare the economics of the 787 and A350 with the aircraft they are aimed at replacing.

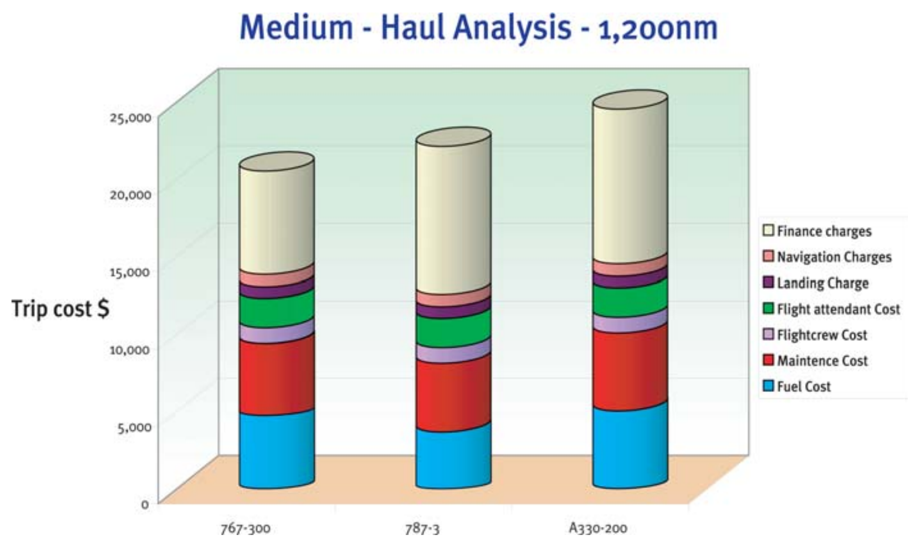
The DOCs analysed include: fuel; direct maintenance (including line, airframe, engine overhaul reserves, components and LRU inventory charges); flightcrew and flight attendant employment costs; navigation and landing fees; and aircraft leasing or financing charges.

Given the 787's three variants and the different routes and markets it could serve, three different scenarios have been examined.

The first is a medium-haul operation with an average route length of 1,200nm. This might be typical of longer US domestic routes or operations in the Asia Pacific region. This scenario analyses the 787-3, as well as the 767-300 and A330-200, which are all analysed in a two-class configuration.

The second is a long-haul operation with an average sector length of 3,500nm, which would be typical of some transatlantic operations. This compares the 787-8 with the A310-300, 767-200ER and 767-300ER, all in a tri-class layout.

The third scenario is an ultra-long-haul operation with an average route length of 5,500nm. This would be representative of many trans-Pacific or Europe-Asia Pacific operations, as well as some other unserved markets. This analyses the 787-9, 767-400ER, A330-200 and A350-800.



Medium-haul: 1,200nm

The 767-300 has a dual class capacity of 261, and the A330-200 has a two-class seat capacity of 290.

These compare with the 787-3's capacity of 289 seats, and range of 3,500nm.

The 787-3 is assumed to complete 950 flight cycles (FC) per year, while the 767-300 and A330-200 will fly 900. The block time for the 787-3 and A330-200 on this trip length is about 200 minutes, and a few minutes more for the 767-300. The 787 will generate about 3,130 block hours (BH) and 330 million available seat-miles (ASMs) per year, the A330-200 about 316 million ASMs, and the 767-300 about 290 million ASMs.

A 767-300 will burn about 4,200USG on a 1,200nm sector. Since the 787-3 is expected to save 20% on fuel, a fuel burn of 3,360USG has been used. The A330-200's fuel burn on this route is about 4,600USG.

Given that the fuel cost is about $1.10 per USG, the 787-3 can save $900 of fuel per trip compared to the 767-300, and $1,240 compared to the A330-200.

The 767-300's airframe and component maintenance costs except for line replaceable units (LRUs), are about $645 per flight hour (FH) for aircraft operating an average FC time of 3.0FH *(see 757 & 767-200/-300 maintenance costs, Aircraft Commerce, June/June 2004, page 22)*.

The 787 will have a carbon fibre fuselage and will also use piezoelectric sensors, which will initially have limited use, but the 787 is still expected to have longer intervals for base checks. The use of carbon fibre means that the ratio of non-routine man-hours will be smaller than for conventional aircraft, thereby providing a saving in base maintenance costs. The portion of the $645 per FH for airframe and component maintenance that is accounted for by base checks on the 767 is $160 per FH. Line maintenance and heavy component repairs are assumed to have the same costs as the 767 in this analysis. Overall, the 787 is therefore assumed here to have a $95 per FH lower cost.

The cost per FH for the 787-3's LRUs, which mainly depends on the reliability, and capital and repair costs of its components, is now impossible to estimate. The cost is thus assumed to be the same as the 767-300's, at $250 per FH *(see 757 & 767-200/-300 maintenance costs, Aircraft Commerce, June/July 2004, page 22)*.

The 787's engines are likely to have longer intervals between shop visits. Like other modern engine types, material costs are expected to be higher than the PW4000 and CF6-80C2 powering the 767-300, and so the 787-3's engine maintenance reserves are assumed to be similar to 767-300's, at $275 per engine flight hour (EFH). The A330-200's engines have the same reserve in this analysis.

These three elements of maintenance costs result in a total of $1,445 per FH for the 767-300, $1,530 per FH for the A330-200 and $1,350 per FH for the 787-3.

These FH rates translate into maintenance costs per trip of $4,800 for the 767-300, $5,050 for the A330-200 and $4,455 for the 787-3. The 787 can thus realise a saving of $400-550 *(see chart, this page)*.

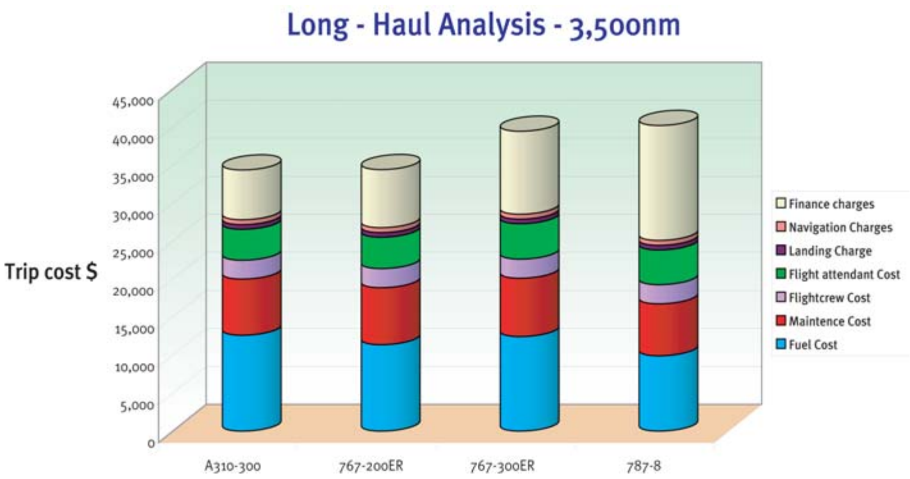
The aircraft's flightcrew cost is dependent on various factors: pilot salaries; additional costs for allowances, subsistence, accommodation and training; average crew size or use of supernumerary crew; and annual pilot productivity. Annual salaries for a standard crew of two are taken as $160,000 for all three aircraft, and no supernumerary crew are used. Salaries are inflated by 25% to account for additional costs, and pilots are assumed to complete about 650BH per year. This results in crew costs per trip of about $1,000 for all aircraft types *(see chart, this page)*.

All three types are assumed to use nine flight attendants. Annual cost per aircraft for flight attendants is about $400,000, which is equal to about $1,900 per trip.

Landing and navigation charges are small and similar for all three aircraft types.

The 787-3's total cash DOC for these cost elements is $12,600. This compares to $13,886 for the 767-300 and $14,558 for the A330-200. The 787-3 provides a saving of $900-2,000 over the aircraft it may replace *(see chart, this page)*. The largest savings the 787-3 offers are derived from fuel and maintenance costs.

The 787-3's lower cash DOC must be considered against the higher financing charges it will have. While assumptions can be made for a price discount and monthly lease rate factor, the 767 and A330 will have a wide range of finance



charges depending on operator, aircraft age and how the aircraft are financed.

The 787's $120 million list price is assumed to be discounted by 30%, and its monthly lease rate factor to be 0.9%. This translates to a monthly lease rate of $756,000, which is equal to $9,550 per trip.

The A330-200 is assumed to have a similar monthly financing charge of $750,000, since all examples are relatively young. A lease rate, or monthly financing or depreciation charge of $500,000 has been used for the 767-300. Some 767-300s will, however, have monthly finance or depreciation charges in the region of $300,000-400,000.

Based on these assumptions, the 787-3's total trip costs would be $22,150. This compares to $20,550 for an ageing 767-300, and $24,600 for an A330-200 *(see chart, page 25)*. While the 787-3's trip costs are about $1,500 more than the 767-300's, the 787-3 has 26 more seats.

On this basis, therefore, the 787-3 is able to offer similar trip costs to the aircraft it is aimed at replacing. These trip costs translate into CASMs of 6.4 cents for the 787-3 and 767-300, and 7.0 cents for the A330-200.

Long-haul: 3,500nm

The 217-seat 787-8 is compared with the 191-seat A310-300, 181-seat 767-200ER and 217-seat 767-300ER in this scenario.

The flight time per trip for these aircraft will be 460-470 minutes. The 787, however, would be expected to complete about 600 FCs per year (50 more than older types). This results in annual utilisations of about 4,800BH per year for the 787, and 4,400BH per year for the older types. This translates to 456 million ASMs for the 787-8, but lower productivities of 348-418 million ASMs for the three older types.

The A310-300 burns about 11,460USG of fuel, which is the highest consumption among these four aircraft.

The 767-200ER and 767-300ER use 10,330USG and 11,300USG respectively.

The 787-3 is expected to burn 20% less than the 767-300ER, using about 9,000USG.

At the fuel price of $1.10 per USG, the 787-3's fuel trip cost would be $9,900, $2,706 lower than the A310-300's; $1,463 lower than the 767-200ER's; and $2,530 lower than the 767-300ER's *(see chart, this page)*.

The 767-200ER's and 767-300ER's airframe and component maintenance costs, excluding LRUs, are about $415 per FH. As previously described, the 787-8 is expected to have lower costs for base checks, and so a maintenance cost of $330 per FH for airframe and component maintenance, excluding LRUs.

It is too early to predict the 787's cost per FH for LRUs, and so it is assumed to be the same as the other three types at $215 per FH.

As with the medium-haul scenario, the 787 is assumed to have equal engine reserves to the 767-300ER, at $155 per EFH. Engine reserves are taken as $145 per EFH for the A310-300 and 767-200ER.

The 787–8's total maintenance cost is $855 per FH, which compares to $920 per FH for the A310-300 and 767-200ER and $940 per FH for the 767-300ER.

A standard flightcrew complement of two pilots has been assumed for this analysis.

The A310-300 and 767-200ER would use eight flight attendants, and the 767-300ER and 787-8 nine. The two larger types will have a flight attendant trip cost about $450-500 higher than the A310 and 767-200ER.

The 787-8's total cash DOC per trip will be $25,080; $2,800 lower than the A310-300; $1,700 lower than the 767-200ER; and $3,500 lower than the 767-300ER.

The A310-300, 767-200ER and 767-300ER have been analysed with monthly finance charges of $300,000, $350,000 and $500,000 respectively. These are representative of younger examples of these three types. This translates into a finance cost per trip of $6,500 for the A310, $7,600 for the 767-200ER and $10,900 for the 767-300ER.

The 787-8's purchase price would be about $84 million with a 30% discount. The 787–8's monthly finance charge will be $756,000, and the lease rate per trip is $15,120.

Overall, the 787-8 has a total cost per trip of $40,200 for all cost categories *(see chart, this page)*. This is almost the same as the 767-300ER. The 787-8's lower fuel and maintenance charges offset its higher financing charges.

The smaller A310 and 767-200ER have trip costs of $34,350 and $34,400.

These trip costs are equal to CASMs of 5.1-5.3 cents for the four types, clearly illustrating that the 787-8 can offer similar costs to the older types it is pitched to replace.

Ultra long-haul: 5,500nm

This scenario compares the 787-9 and A350-800 with the 767-400ER and A330-200.

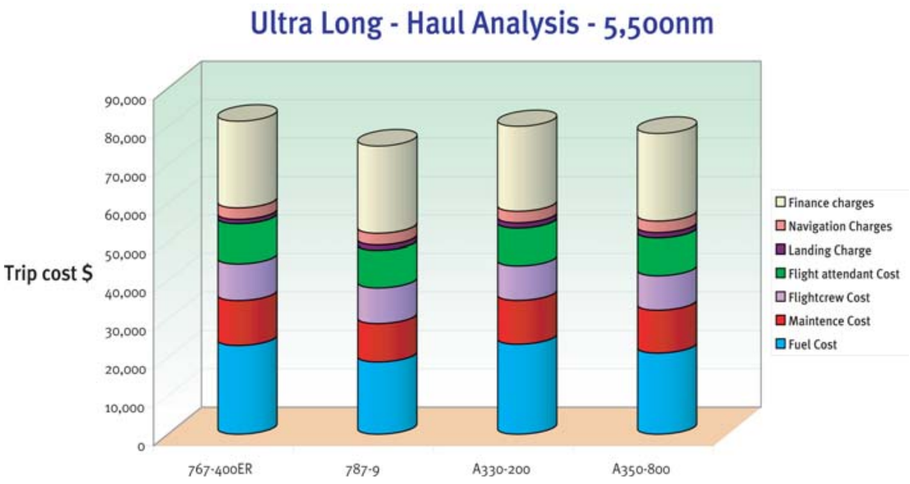
The flight time for the 787-9, A330-200 and A350-800 is 695 minutes, or more than 11 hours. The 767-400ER's flight time is 740 minutes because of its slower cruise speed.

The 787-9 and A350-800 would be expected to generate about 450FC per year and the other two 425FC per year.

The 767-400ER's fuel burn is 21,000USG for this route length, and the 787-9's fuel consumption is about 20%, so its fuel burn will be in the region of 17,100USG.

Although it is not yet clear how the A350-800 will compare with the A330-200, the A350-800's fuel burn may only be be 10% less. Based on the A330-200's fuel consumption of 21,300 USG, the A350-800's fuel burn would be 19,200USG.

A fuel price of 110 cents per USG will give the 787-9 a trip fuel cost of $18,810 *(see chart, page 30)*. This is about $1,300 lower than the A350-800's, about $4,300 lower than the 767-400ER's, and $4,600



lower than the A330-200's.

The 767-400ER will have the same airframe and component maintenance costs per flight hour as the 767-300ER in the long-haul analysis: $415 per FH. The 787-9 is assumed to have a rate $85 per FH lower.

The A330-200 has an airframe and component maintenance cost per FH of $435 when used on long-haul operations *(see A330-200/-300 maintenance cost analysis, Aircraft Commerce, August/September 2003, page 25)*.

Although the A350-800 will also utilise carbon fibre, the material will only be used in its wingboxes and wing skins, and the aircraft will still have a metallic fuselage. The limited application of carbon fibre cannot effectively reduce the –800's weight and increase its resistance to erosion and fatigue. The A350–800's maintenance cost is thus estimated to be at $415 per flight hour, just $20 per FH lower than the A330-200's.

The LRU costs for the 787-9 and A350-800 are assumed to be the same as for their counterparts. Hence, the 787-9's and 767-400ER's LRU cost is $215 per FH. The A330-200's is $230 per FH *(see A330-200/-300 maintenance cost analysis, Aircraft Commerce, August/September 2003, page 25)*, and the same rate is used for the A350-800.

The engine reserves of the four aircraft are equal, at $150 per EFH.

With these assumptions, the 787-9's total maintenance is $845 per FH, about $120 lower than the 767-400ER's. The A350-800 has a total maintenance cost of $945 per FH, about $20 lower than the A330-200's.

Consequently, the 787-9's maintenance trip cost is about $1,700 lower than 767-400ER's. The A350-800's is similar to the A330-200's.

The aircraft will use two supernumerary flightcrew on these ultra-long-range missions. The escalation factor for total employment costs will be high, since airlines will have higher costs for pilot allowances and hotel accommodation. Annual costs for flightcrew will be the same, however, for all four types if the same basic salaries are paid. Flightcrew costs per trip are $9,000-9,500. All aircraft will also use a complement of 12 flight attendants, and so have similar flight attendant costs per trip of $9,800-10,400.

The total cash DOC per trip for the 787-9 is about $52,200, which is about $6,600 lower than the 767-400ER's. The A350-800 has a cash DOC of $55,400, about $4,500 less than the A330-200. The A350-800, however, has a $3,000 higher cash DOC than the 787-9, based on the assumption that the A350-800 will not have the same reduction in fuel burn over its older counterpart that the 787 has over the 767-400ER.

Finance charges for all four aircraft are based on a 30% discount of list price and a monthly lease rate factor of 0.9%, as the 767-400ER and A330-200 are relatively young aircraft. The finance charge per trip for the 787-9 and A350-800 is about $22,600 for both aircraft; while it is about $1,000 lower for the 767-400ER and A330-200.

Overall, the 787-9 has the lowest total trip cost at about $75,000 *(see chart, this page)*. This compares to $81,200 for the 767-400ER, giving the 787-9 a 0.70 cents lower CASM.

The 787-9's trip cost is also about $5,000 less than the A330-200's, while the A350-800 has a trip cost of $78,000 *(see chart, this page)*: $3,000 more than the 787-9, and $1,800 less than the A330-200.

Discussion

The 787's cost-saving advantage over other aircraft mainly comes from its maintenance costs and fuel burn. While some may doubt whether this aircraft can reach the saving, an insider at one of the six Chinese airlines that have ordered 60 787s, disclosed that Boeing had guaranteed the cost saving in the contracts. Hence the comparisons above are based on what 787 customers can expect from the aircraft.

Once the carbon fibre and sensor technology is mature, the 787's maintenance costs could decline and so the cost saving will be higher than the 15% assumed. One uncertain element of the 787's maintenance cost is the cost of LRUs.

One of the assumptions for the comparisons is a fuel price of 110 cents per USG. A higher fuel price of 130 cents per USG would increase the 787's advantage.

The 787's lease rate and financing cost are another uncertain issue. An aircraft's lease rate is affected by the financing term, interest rate and debt balloon permitted by the debt provider, and the debt balloon is in turn influenced by the aircraft's residual value and useful economic life. Thanks to carbon fibre technology, the 787's life is expected to double and so its financing terms and lease rate may be lower than for conventional aircraft.

In the economic analyses, the 787's monthly lease rate factor is assumed to be 0.9%, the same as for current generation aircraft. This is conservative for the 787. Should the 787's monthly lease rate factor reduce by 0.1% to 0.8%, then the 787-3/-8's monthly financing charge will be $84,000 lower and 787-9's charge be $94,000 lower than the rates used. This would thus give the 787 a clear advantage in total operating costs.

The analysis shows that, with a small reduction in base maintenance-related costs and known or probable fuel burn savings, the 787 and A350-800 have similar unit CASMs to their current aircraft types. This is combined with the bonus of the 787 and A350 having an additional 2,000-4,000nm range capability over the longer-range variants of the 767, A310 and A300-600. Airlines can thus operate the similar-sized 787 and A350 and transform their long-haul route network potential, without incurring any significant increase in operating costs while gaining the bonus of a fleet with longer range performance that increases revenue potential. AC