Airlines have the choice of a mixed 787/777 fleet or the A350 family when selecting 220- to 360-seat widebodies. The all-new A350 offers extensive commonality and lower fuel burn the older 777. The 787 has several attractive features, including carbon fibre, that have helped it win the majority of orders.

Widebody selection: 787/777 versus the A350 family

The combination of constantly rising fuel prices, advances in airframe and engine technology and downward pressure on passenger yields is pushing airlines to make improvements in unit cost per available seat-mile (CASM) and revenue-generating ability on medium- and long-haul networks. The advent of the 787 and A350 families offers airlines improved operating efficiencies and higher qualitative service index (QSI) values over 1980s- and 1990s-generation widebodies. This comes through aircraft families. The 787 and 777 are an alternative to the A350 family in the 210- to 360-seat category.

787 & A350 families

There is an array of medium- and long-haul older types that could potentially be replaced by new generation aircraft. These include a small number of MD-11s, as well as A300-600s, A310-300s, 767-200ERs/-300ERs, A330s, A340s, 777-200s/-300s, and 747-400s. All these aircraft have two-man flightdecks, while most are twin-engined types and certified for 180-minute extended-range twin-engine operations (Etops). Most of them also have long-range capability, but only a few have ultra-long-range performance.

Previous advances in aircraft technologies mean that the only opportunity for new generation aircraft to offer lower direct operating costs (DOC) over these older types is through lower fuel consumption and maintenance costs, and increased levels of pilot, engine and system component commonality. Some of the older types listed, especially the A330 and A340, already have wide-ranging flightdeck and system component commonalities.

In addition to straightforward DOC savings, the 787, 777 and A350 have been developed to provide operators with aircraft that have tri-class configurations of 210-350 seats and range capabilities of 7,500-8,500nm. This combination of seat capacities and range enables the aircraft to operate most city-pairs non-stop, which gives them much greater flexibility than older types. Such capability is increasingly being demanded by airlines that seek to offer at least daily frequencies on all their long-haul routes. They also require aircraft with 220-270 seats to open new long-haul routes with limited demand.

The 787's and A350's passenger appeal and QSI values are further improved by the enhanced cabin comfort that they offer compared to current generation aircraft.

The 787's extensive use of carbon has far-reaching consequences. It saves weight and contributes to lower fuel burn; it permits a lower cabin altitude and higher cabin humidity, improving passenger comfort; and it is resistant to corrosion, contributing to reduced maintenance cost.

777, 787 & A350 SPECIFICATIONS

	777-200ER	777-200LR	777-300ER	787-8	787-9	A350-800	A350-900	A350-1000
Availability	Now	Now	Now	2010	2013	2014	2013	2015
MTOW-lbs	656,000	766,000	775,000	484,000	540,000	540,700	590,800	657,000
Engine	Trent800 GE90 PW4000-112	GE90	GE90	Trent1000 GEnx	Trent1000 GEnx	TrentXWB	TrentXWB	TrentXWB
Thrust-lbs	90,000-93,700	110,000	115,000	64,000	74,000	74,000	83,000	92,000
Tri-class seats	305	301	365	224	250	253	300	350
Cabin width-inches	231	231	231	215	215	220	220	220
Cruise speed	M 0.84	M 0.84	M 0.84	M 0.85	M 0.85	M 0.85	M 0.85	M 0.85
Range-nm	7,770	9,380	7,930	7,650 -8,200	8,000 -8,500	8,300	8,100	8,000
Fuel capacity-USG	45,220	47,890	47,890	33,528		34,082	36,460	41,215

In addition to replacement of older aircraft, airlines also have to consider fleet growth and the types that suit their capacity and range performance requirements.

Although Boeing and Airbus have both been successful in the 200- to 360-seat market, they have nevertheless felt the need to launch new aircraft families in order to meet the airlines' requirement for lower DOCs, longer range performance and improved passenger appeal. Fuel prices may have fallen recently, but this is widely predicted to be only a temporary situation, and airlines remain concerned about the stability of fuel prices in the long term.

787 & 777 families

The 787 family has two variants, the 787-8 and -9, with cabin sizes and seat capacities of about 220 and 260 seats for international operations.

The 787-8 will have tri-class seat capacity of about 220, a maximum take-off weight (MTOW) of 484,000lbs and range of up to 8,200nm. Engines will be rated at 64,000lbs thrust *(see table, this page)*. This variant is due for delivery to All Nippon Airways (ANA) in early 2010.

The 787-9 will have a tri-class capacity of about 260 seats, an MTOW of 540,000lbs, engines rated at 74,000lbs thrust of 74,000lbs and a range of up to 8,500nm *(see table, this page)*.

The 787 will be made of 50% carbon fibre reinforced plastic (CFRP) and other composites, and 20% aluminium, making it lighter than previous-generation aircraft. The fuselage is manufactured in a one-piece section, thereby eliminating the need for as many aluminium sheets and up to 80% fewer fasteners.

The 787's design also features the largest cabin windows so far used on a commercial aircraft. Boeing has employed various measures to ensure the cabin air is superior on the 787. Due to the extensive use of CFRP, the 787 can tolerate high levels of cabin humidity. Its cabin altitude will therefore be 6,000 feet, compared to 8,000 feet on other types. This higher moisture content and atmospheric pressure is one feature that improves passenger comfort, and contributes to reduced effects of jetlag. Cabin air has also been improved through filters that remove ozone, bacteria, viruses, odours and other contaminants. Engine bleed air designs of older types have been replaced with electrically-driven compressors. Passengers' experience will further be improved by the use of a system that reduces the feelings of turbulence and aircraft noise both inside and outside the cabin.

The 787's cabin width is narrower than the A350's. The 787 can accommodate eight-abreast economy class seating with a seat width of 18.5 inches, or nine-abreast seating with a 17.2-inch seat width.

There are two engine options for the 787, the GEnx-1B and the RR Trent 1000, but Boeing say that it is possible for engines to be interchangeable at the wing, depending on the operator's requirements.

The overall effect of the new engines, the aircraft's lighter weight, more efficient systems and aerodynamic designs mean that the 787 is expected to burn 20% less fuel than the 767 and A330.

The 787 is complemented by the larger 777-200 and -300 series. The 777-200ER, 777-200LR and 777-300ER are the 777 variants achieving sales in recent years.

The 777-200ER has average tri-class seat counts of 260-280, and the ultra-long-range -200LR has about 250 seats. The larger 777-300ER has as standard a tri-class seat count of 365. Actual airline seat capacities are closer to an average of about 330. Many airlines have already selected the 777-300ER to replace their 747-400s.

A350 family

The A350 was originally adapted from the A330-200/-300. The two aircraft shared the same eight-abreast fuselage cross-section and material makeup. After further discussions with customers, and fierce competition from the 787, a new design was announced in 2006: the A350 XWB. This features a wider cross-section, a completely new wing and flightdeck, and increased use of composite materials.

The fuselage for all Airbus widebodies has so far used a barrel with an external diameter of 220 inches. This allows a

The three members of the A350 family provide capacities between 250 and 350 seats. This places it as a direct replacement for the MD-11, A330, A340 and 777 families. Besides new technologies that will contribute to lower fuel and maintenance costs, it will also have extensive flightdeck, engine and system component commonality.

standard 2-4-2 configuration in economy class, with a seat width of 18 inches.

The A350 will be the first Airbus widebody to adapt a new fuselage cross-section. This will be a wider external cabin width of 234 inches, and an internal diameter of 208 inches. This will allow a standard economy class configuration of nine-abreast seating, and seat width of 17.7 inches. This cross-section is wider than the 787's, but narrower than the 777's.

Airbus claims that the fuselage will also incorporate the widest aircraft cabin windows in the industry. These will allow more light into the cabin and give passengers a larger view outside, thereby contributing to improved cabin comfort, and helping to limit the effects of jet lag.

Additional options for airlines are several cabin effects, including: light emitting diode (LED) mood lighting; special effects projected on the ceiling; and accent lighting for areas such as overhead lockers, windows and cabin dividers. These all lessen passengers' feelings of jetlag.

The A350 family is offered in three variants: the A350-800 with a tri-class seat capacity of 270; the -900 with 315 seats; and the -1000 with 350 seats. The A350-800 and -900 are direct replacements for the A330-200 and -300, while the A350-1000 is a direct challenge to the 777-300ER. The A350-1000 could also be a replacement candidate for the A340-600 and 747-400.

Moreover, the A350-800 is a close competitor to the 787-9 and a direct replacement for the A340-200 and other similar-sized widebodies. The A350-900 is a direct challenger to the 777-200ER, and a replacement candidate for the A340-300 and -500.

The A350's wing will be made primarily of carbon-composite materials and will involve many concepts to reduce drag and noise. The flight computer will perform in-flight trimming of the inboard and outboard flaps, to create a variable camber wing that adapts to different flight conditions.

Airbus says that the fuselage will be manufactured using many composite materials that could lessen the need for fatigue and corrosion-related structural maintenance inspections by as much as 60%.

The A350-800 will accommodate about 253 passengers in a three-class layout, have engines rated at 74,000lbs thrust, have a MTOW of 546,700lbs, and a range of 8,300nm *(see table, page 19)*.

The A350-900 will be the first variant to be delivered in 2013. It will have an MTOW of 590,800lbs and a range of 8,100nm with 300 passengers *(see table, page 19)*.

The A350-1000, which is due for delivery in 2015, will have about 350 seats, an MTOW of 657,000lbs and range of about 8,000nm.

Pilots that are already type-rated on the A320 family, A330 and A340 will need to attend a shorter differences course for the A350 rather than a full type-rating course. This could mean a large training cost saving to many airlines.

The Rolls-Royce (RR) Trent XWB will exclusively power the A350. RR says that the engine will have the lowest carbon emissions of any widebody engine. Airbus states the A350-900 will have 30% lower block fuel per seat than the 777-200ER.

Maintenance programmes

The A350 and 787 have adopted new maintenance philosophies. The extensive use of composite materials, and new electric and IT systems and procedures means that maintenance checks will have increased intervals, require fewer routine inspections and are likely to have lower levels of non-routine rectifications than current generation aircraft. This will both reduce maintenance costs and downtime for maintenance.

The maintenance planning documents (MPD) of both types give an indication of their likely maintenance costs relative to current types.

Neither the 787 nor the A350 have traditional pre-flight, transit or daily checks for line and ramp maintenance. The 787's lowest check in the MPD is one every three days, while the A350's smallest check is one every 10 days.

While this would deliver many maintenance cost savings, in practice it is unlikely that aviation authorities will allow aircraft to operate without line checks, especially when operating internationally between different countries. Moreover, aircraft will be operating Etops missions, which require specific checks prior to every flight. Airlines are also likely to add in their own line checks into their maintenance programmes in order to maintain operational reliability. These line checks would include items such as tyre pressure and condition inspections, and checking oil and other fluid levels. Non-routine line maintenance will also be required to deal with any component and system failures.

The 787's MPD has its next highest check at 200 flight hours (FH), which is equal to about 14 days *(see The 787's maintenance costs: an initial assessment, Aircraft Commerce, April/May 2007, page 39)*. This check will ultimately depend on the operator's maintenance programme, but will include items that have been deferred, such as brake wear inspection, out-of-phase (OOP) tasks and non-routine work.

The traditional 'A' checks are the next highest maintenance intervals. The 787 requires various combinations of A checks every 1,000FH, with some tasks performed every 2,000FH, 4,000FH or 6,000FH.

The 777-300ER is in a class of its own, and has been selected as a 350-seat workhorse by several airlines. While its twin-engine design, size and range make it more economic than the 747-400; the 777-300ER will be overshadowed by the A350-1000's superior fuel efficiency, commonality with its smaller family members, and maintenance-cost-saving technology.

The A350 is similar, with an 'A' check interval of 1,200FH. Again, this will depend on the choices of the operator and their maintenance programme and combinations of tasks.

The next level of maintenance is the base or 'C' checks. These are in multiples of 36 months or 6,000 flight cycles (FC) for the 787. Airbus is targeting an interval of 36 months for the A350. The A350 will have structural inspections in checks performed at 72- and 114-month intervals.

The base checks will cover items such as system and structural inspections, non-routine rectifications, interior cleaning and refurbishment, airworthiness directives (ADs) and service bulletins (SBs).

The 787's base check cycle will comprise four checks, with the fourth coming due every 12 years. The A350's base maintenance cycle will also last 12 years, with structural inspections at six and 12 years.

The high percentage of composites and carbon-fibre used in the A350 and 787, means that corrosion and fatigue are less likely to occur than in previous aircraft. As a result, structural inspections for corrosion and fatigue will not be needed as often, thereby reducing intervals and maintenance costs. The use of CFRP and composites also means a relatively low ratio of non-routine inspections is anticipated, which will contribute to fewer man hours (MH) being required to complete airframe checks on the A350 and 787 than on current aircraft.

Operating costs

The three main operating cost categories where the 787, 777 and A350 can offer improved efficiencies for airlines are maintenance, fuel burn and flightcrew.

Maintenance costs consist of four main elements: line maintenance; airframe checks; rotable and component maintenance; and engine maintenance.

As described, the 787 and A350 will both have MPDs with the smallest scheduled line checks every three and 10 days. Airlines are likely to add their own scheduled line checks with higher frequencies, but the two aircraft will nevertheless provide lower line maintenance requirements and costs over current types.

As described, both types are expected to have base check cycles that consume fewer MH than types such as the 767 and A330. This will be due to longer check intervals, fewer routine tasks, and lower non-routine ratios. The 767's reserves for base maintenance are in the region of $155 per FH, while for the A330 they are about $130 per FH. While the 787 and A350 can be expected to have reserves lower than the767 and A330, the difference between the older and new types is unlikely to be much more than $50 per FH.

The 787 and A350 have been designed to have higher component reliability, which will reduce the requirement to hold stocks of inventory necessary to maintain operation. The list prices of rotables will be higher than for current types, however, so this will offset gains from more reliable components. The 787's and A350's overall costs for full rotable support are unlikely to differ significantly from those of the 767 and A330.

Engine maintenance costs for the RR Trent 1000, RR Trent XWB and GEnx will be determined by shop visit intervals and costs, and life limited part (LLP) lives and list prices. Reserves for the Trent 700, PW4000-100 and CF6-80E1 powering the A330 are $225-265 per engine flight hour (EFH) when operating at 6-8FH per FC *(see Big engine in-service performance & maintenance, Aircraft Commerce, August/September 2008, page 41)*. Reserves for the Trent 800, PW4000-112 and GE90 powering the 777 are $330-410 per EFH at the same FH:FC ratio.

While RR and GE are aiming to increase shop visit intervals, part and component price inflation may nevertheless offset these effects. The best overall reduction in engine maintenance costs per EFH that can be expected for the 787 and A350 is in the order of 5-15%.

Fuel burn is a cost element where the 787 and A350 can realise the biggest savings for operators. Boeing estimates that the 787-8, which is the smallest of all 787, 777 and A350 family members, will burn 15-20% less fuel than a similar-sized type such as the 767-300ER. The 767-300ER burns about 17,300USG on a 5,000nm sector, so the 787-8 can be expected to burn about 14,700USG. This saving of 2,600USG is equal to about $3,600 and $17 per seat at current fuel prices of $1.40 per USG.

The 787-9 and A350-800 are both similar in size to the A330-200. The A350-800 is expected to have about 12% lower burn than the A330-200, while the 787-9 is expected to have 15-20% lower burn than the 767-400ER and A330-200. The A330-200 burns 18,800-19,000USG on a 5,000nm trip. The 787-9 will therefore be expected to burn 2,800-3,800USG less than the A330-200, representing a saving of $3,900-5,300. The A350-800 would burn about 2,300USG less, equal to about $3,200.

The A350-900 is expected to have 11% lower fuel burn than the A330-300. The A330-300 consumes about 21,000USG on a 5,000nm mission. The A350-900 will therefore have a 2,300USG smaller burn, saving about $3,200 per trip and $10-11 per seat.

By comparison, the 777-200ER burns 24,000-25,000USG on the same trip length, 3,000-4,000USG more than the A330-300 and 5,000-6,000USG more

The A350 family is the first Airbus widebody to offer a wider fuselage cross section than the original design used by the A300B2. The A350's wider fuselage will allow standard nine-abreast seating in economy class. Seat width will be the same as that in the eight-abreast arrangement of the previous Airbus widebody fuselage.

than the A350-900's expected burn. The 777-200ER on average has 10-20 more seats than the A330-300.

The largest aircraft are the 777-300ER and A350-1000. The 777-300ER burns 31,000-32,000USG on a 5,000nm mission. The A350-1000 is expected to offer a 15-20% fuel burn saving, which is equal to 4,600-6,400USG less fuel per trip, and to $6,400-9,000 and $18-26 per seat.

Flightcrew salaries and most associated costs of employment for the 787 and A350 will be similar to those of similar-sized current generation aircraft. The A350, however, has the advantage of a single pilot type-rating over the 787 and 777 combination. A single pilot type-rating for the A350's three family members reduces training costs considerably, compared to a mixed 787 and 777 fleet, which requires two pilot pools with two different ratings. Moreover, airlines which already operate A320s, A330s and A340s will have lower transition training costs when phasing in new A350 fleets, compared to those faced by an existing 777 operator introducing the 787 into service.

Environmental aspects

The main environmental aspects to be considered are the gaseous and noise emissions.

Exact figures have yet to be released in respect of the emissions from both aircraft. Airbus states that the A350's nitrogen oxide (NOx) emissions will be 35% below CAEP6 standards, and its carbon dioxide (CO2) emissions will be up to 25% lower than those of similar aircraft. As a result of automated noise abatement departure procedures and new engine designs, the A350 is 16 decibels below Chapter 4 noise levels.

The 787's noise footprint is forecast to be 60% smaller than that of similar-sized aircraft, while its NOx emissions will be 30% lower than the 767's. The GEnx's emissions are in fact expected to be 95% lower than current regulations.

Summary

The main criteria for an airline to consider in choosing between the 787/777 or A350 family are: seat capacities; range performance; fuel burn; maintenance costs; and levels of commonality.

The 787/777 combination offers a wider range of seat capacities, with the 787-8 starting at 220 and the 777-300ER at up to 360. This compares to 253-350 seats for the A350 family.

Range performance is similar for the Airbus and Boeing counterparts with the exception of the 777-200LR, which has a range of about 9,400nm, and is not matched by the A350-900.

The A350 family fares better overall in fuel burn performance. This is because the A350-900 and -1000, as newer aircraft types, have lower burns than their 777-200ER/-200LR and 777-300ER counterparts. The 787 and A350-800 will have similar fuel burns, although it is not yet possible to say which will be more efficient.

Similarly, the A350 family should overall offer better maintenance costs than a combined 787/777 fleet. Like fuel burn, this is because the A350-900 and -1000 offer new technologies over the 777-200 and -300.

As described, the three-member A350 family will have an advantage in flightcrew training costs.

Overall, the 787/777 combination offers a wider range of aircraft capacities, while the A350 is an all-new aircraft family. Its middle and largest members offer lower DOCs than the two 777 variants.

As the aircraft start to come on line and more operators operate them in different markets and on different routes, some of their true costs will start to become apparent. It will also be only after several aircraft have completed their first base check cycles that an accurate picture of their maintenance costs will be available.

Purchase price and financing costs can still exert the largest influence over an airline choice of aircraft. The 2008 list prices are different for the two aircraft families. The 787-8's average list price is $166.25 million and the 787-9's is $199.75 million. This compares with $209 million for the similar-sized A350 2008.

The A350-900 has a list price of $240.6 million. The 777-200ER and -200LR have list prices of up to $230 million and $260 million.

The A350-1000 has a list price of $269.6 million, while the 777-300ER has a list price of $260-285 million.

Initially, the 787 seems to have won the race with 879 firm orders from 58 airlines. Out of these, 22 are A330/340 customers, which suggests that the 787 could be favoured as a replacement over the A350. There are also 18 787 customers which also operate the 777.

The A350 has 483 firm orders from 29 customers. At least 15 of these are A330/340 customers, while seven of these 15 also operate the 777. This suggests that 777 operators favour neither the 787 or A350. Most other A350 customers are lessors.

The A350 is not due for delivery, however, until 2013 at the earliest. The 787, on the other hand, has gained orders from airlines that are looking for an earlier delivery timescale than the A350's. The 777 will lose to the A350-900/-1000 in the long run. This may trigger a replacement for the 777. AC