The constant rise of fuel prices has amplified the need to replace the 727-200 and other ageing freighters. An examination of the aircraft options in the 15- to 35-ton payload category and their economic performance as express package and general freighters is made.

Fleet planning & economic performance of 15- to 35-ton freighters

The replacement of first generation freighters is overdue, and there is pent-up demand for replacement aircraft. In the case of 15- to 35-ton capacity aircraft, the majority of replacements will come from converted aircraft. The prime candidates in this payload category are the 737-300 and -400, 757-200 and A310-300. The 767-200ER also qualifies at the top end of this capacity scale. The A320F and A321F will also enter this market from 2011. The number of aircraft available for conversion is now increasing as passenger airlines retire larger numbers in the wake of recent rises in fuel prices. This is particularly the case with the 737-300 and -400.

Freight markets

The two main roles for the 737-300 and -400 are express package operations and the carriage of general freight. These two markets have different yield and route lengths, as well as demands on aircraft in terms of utilisation.

Express package markets began in the US, but have since developed in many other regions. A typical route length can be used to illustrate the economic differences between candidate aircraft. Missions in Central America, North America, Western Europe and parts of the Asia Pacific can be 500-800nm in length. Aircraft typically operate one return flight per night, six nights per week over the course of the year, generating 600 flight cycles (FC) annually. A 600nm route has a flight time of about 97 minutes for most aircraft types. Aircraft will therefore accumulate about 1,000 flight hours (FH) per year.

Express packages have a low packing density of about 6.5lbs per cubic foot, and depend on freight being containerised. Candidate aircraft for express package operations therefore need to have containers that interline with other aircraft in the fleet. They also have to be able to maximise the available space in the aircraft's maindeck and underfloor space. The economic suitability of each aircraft depends on its payload capacity, which will be the volumetric payload at a packing density of 6.5lbs per cubic foot.

General freight routes are usually longer, and aircraft utilisations are higher as a result. A 1,200nm mission is representative of some routes, although there is a wide range of sector lengths in this market. This mission has a flight time of about 176 minutes for most aircraft types. An annual utilisation of about 2,500FH is typical, particularly for the 757, A310 and 767-200ER carrying general freight.

The packing density of general freight is higher than for express packages. The density of general freight will be at least 7lbs per cubic foot for most types of carriage, and can be higher. The economic capacity of candidate aircraft in this case is therefore the aircraft's structural payload, net of the tare weight of containers or pallets used to carry the freight.

Candidate aircraft

There are three freighter conversion programmes each for the 737 and 757-200, and each has differences in structural payloads and containerised volumes for carrying freight *(see The costs of acquiring narrowbody freighters, Aircraft Commerce, March/April 2008, page 59)*.

The 737-300F has net structural payloads of 38,262-39,716lbs, and total freight volumes of 4,740-5,028 cubic feet *(see table, page 64)*. The aircraft also has a maximum packing density of 8.2lbs per cubic foot. With freight packed at 6.5lbs per cubic foot, it has a volumetric payload of 30,875lbs.

The 737-400F has net structural payloads of 39,516-44,240lbs, and volumes of 5,683-5,773 cubic feet *(see table, page 64)*. The actual payload and freight volume depend on the conversion programme used. Packing density is 7.7lbs per cubic foot, while volumetric payload for express packages is 37,050lbs.

There is a wider variation in the freight capacities of the 757-200F following different conversion programmes. The Precision Conversions modification provides 15 standard 88-inch X 125-inch maindeck unit load devices (ULDs), and a volume of 8,390 cubic feet. The modification also has two maximum zero fuel weight (MZFW) options of 184,000lbs and 186,000lbs. These result in net structural payloads of 60,360-64,860lbs, depending on engine type and other factors *(see table, page 64)*. These have maximum packing densities of 7.1-7.6lbs per cubic foot, and volumetric payloads of 54,275lbs for express packages.

Precision Conversions is developing a programme that will offer the 757-200F with an MZFW of 194,000lbs or 192,000lbs, depending on engine type. The two MZFWs will give the aircraft a net structural payload of 69,200lbs or

PAYLOAD CHARACTERISTICS OF 15- TO 35-TON FREIGHTERS

Aircraft type	737-300F	737-400F	A320-200F	A321-100F/ -200F	757-200F	757-200F High MZFW	A310-300F	767-200ERF
Net structural payload lbs	39,000	44,000	44,000	47,000/ 56,750	60,000 -64,000	69,000/ 70,000	81,000	84,000
Containerised volume - cu ft	4,750	5,700	5,250	6,950	8,350	8,350	9,650	12,600
Maximum packing density lbs/cu ft	8.2	7.7	8.4	6.7/8.1	7.1-7.6	8.2/8.3	8.4	6.7
Volumetric payload @ 6.5lbs/cu ft	30,875	37,050	34,125	45,175	54,275	54,275	62,725	81,900

70,860lbs respectively *(see table, page 64)*. This higher structural payload version of the aircraft would clearly increase its capability for carrying general freight. It has the same containerised volume as lower-weight converted aircraft, and so has no advantage for express package operations.

Freighter conversion programmes are now under development for the A320 and A321, by a joint venture, formed by EADS-EFW, known as Airbus Freighter Conversions. The first aircraft are due to enter service in 2011, although availability of candidate aircraft for conversion is low, and their values are high.

The A320 has a net structural payload of 43,685lbs, and a containerised freight volume of 5,300 cubic feet *(see table, this page)*. This puts it close to the 737-400, although the A320 has a smaller containerised volume. This results in a higher packing density of 8.4lbs per cubic foot. Volumetric payload for express packages is 34,125lbs.

The lower weight A321-100F has a net structural payload of 47,272lbs, and containerised volume of 6,990 cubic feet *(see table, this page)*. Higher weight -200 models will have a higher net structural payload of 56,750lbs, but the same containerised volume *(see table, this page)*.

The A321-100F has a maximum packing density of 6.76lbs per cubic foot, while the -200F has a maximum density of 8.1lbs per cubic foot. The -100F is clearly only suited for express package operations, but the -200F has a high density that makes it suitable for carrying different types of general freight. The A310-100F and -200F have larger capacities than the 737-400, but are 7,500-13,000lbs smaller than the various lower MZFW options of the 757-200 *(see table, this page)*.

No A310-200s are available for freight conversion, so operators with a possible interest in the A310 have to select the heavier and longer range -300 model. This has a net structural payload of about 81,000lbs, equal to 36.8 tons, and containerised freight volume of 9,650 cubic feet *(see table, this page)*. This gives it a maximum packing density of 8.4lbs per cubic foot, and makes it capable of carrying a variety of general freight types. At a packing density of 6.5lbs per cubic foot, the aircraft has a volumetric payload of 62,725lbs, about 8,450lbs more than the 757-200F.

There are a limited number of 767-200s in operation, some of which are unsuitable as freight conversion candidates. Of the few 767-200s that have been converted, these are used for express package operations by ABX and Maersk subsidiary Star Air.

The 767-200ER has a net structural payload of 84,000lbs and containerised volume of 12,600 cubic feet *(see table, this page)*. This gives it a maximum packing density of 6.7lbs per cubic foot, meaning not all of the aircraft's volume can be utilised if general freight of a higher density is carried. The aircraft still has a slightly higher structural payload than the A310-300F.

Relative economics

The economic performance and selection of aircraft for each operator should be made on the basis of gross margin performance, which means that the aircraft type that generates the highest contribution to non aircraft-related costs and overheads should be selected. The revenue generated for a particular load on each route in the network will clearly not vary between different aircraft types. The issue is therefore one of trip costs and the payload capacities of each type.

The demand or volume of freight on a route will vary. As freight yields are generally low, airlines will want to maximise load factor and use the smallest type possible in relation to demand. If demand exceeds aircraft capacity, operating a larger type will clearly be cheaper than making two trips with a smaller aircraft.

The types analysed here have capacities of up to 84,000lbs. The 737-300F has the smallest capacity, with up to 30,875lbs volumetric payload and 39,000lbs net structural payload. All types can clearly carry payloads of up to the 737-300F's capacity, and will all generate the same revenue for a particular payload. The 737-300F, being the smallest type, would be expected to have the lowest trip cost, and so would generate the highest gross margin. This makes it the most economic type.

As demand levels or payloads rise larger types are required. Where this exceeds the 737-300F's capacity several types can be considered. The next two largest are the 737-400F and A320-200F. With similar payload capacities, the two are suited to virtually the same traffic volumes on a route, so the selection will, in theory, be just an issue of operating economics and trip costs. The A320-200F will not be available, however, until at least 2011. Even then the economics of the aircraft depend on the availability of used passenger aircraft. The cost of conversion and additional maintenance is likely to be $7-8 million, depending on the condition of the aircraft *(see The costs of acquiring narrowbody freighters, Aircraft Commerce, April/May 2008, page 59)*. To be an effective competitor, the A320-200F's lease rate will have to be comparable with the 737-400F's, which is in the region of $150,000 per month. The A320-200F's lease rate would therefore have to be up to $170,000. Given that

lease rate factors on the total investment in the aircraft will be 1.3-1.5%, the limit on the investment will be $11.5-13.5 million, meaning that used passenger aircraft would have to be acquired for no more than $4-6 million. This compares with current values of $9-11 million. The values of the oldest A320s in 2011 will depend on aircraft market conditions. If current fuel prices persist then the oldest A320s will clearly be retired, and will be available in large enough numbers to push values down to the required level. On the same basis, however, large numbers of 737-400s will have been retired by passenger carriers by this stage, and their values will be further depressed from current levels, making them more attractive and cheaper to convert to freighter.

While the 737-400F and A320-200F have similar payloads, the other types are clearly larger and so likely to have higher trip costs. This will make them economic only when freight volumes are high. At the highest level of demand, the largest type is clearly the winner because it is the only one capable of carrying the load for the trip cost of a single operation. There are therefore ranges of freight traffic for which each type is most suited.

As well as the maximum payload of each type, operating performance can affect its economic performance. Weak take-off performance will lead to reduced payloads on particular routes, which may make an aircraft a poorer performer than a competitor which has a smaller maximum payload.

Express package operations

As described, the analysis of aircraft types on express package operations is made on a route length of 600nm and at rates of aircraft utilisation of 600FC and about 1,000FH per year.

The candidate aircraft are the 737-300F, 737-400F, A320-200F, A321-100F, 757-200F and A310-300F. These aircraft are compared on the basis of their volumetric payloads. These range from 30,875lbs for the 737-300F to 62,725lbs for the A310-300F. The 757-200F model is the aircraft with the standard MZFW.

The gross margin performance clearly depends on payload carried, freight yield, and aircraft trip costs. The payloads carried are as described, and a yield of $1 per lb of freight has been used. Although this may be reflective of some express package yield, and different from others, it merely illustrates the relative differences between types. That is, the revenue generated for a given load carried is the same for all types, while only aircraft trip costs differ.

The trip costs of each aircraft analysed comprise fuel, maintenance, flightcrew, navigation and landing charges, and lease rentals.

Fuel has become a more important cost element, with spot prices reaching $4.00 per US Gallon (USG), having steadily risen from about $0.75 per USG in 2001. The generally accepted view of the economics of freight aircraft, especially for express package operations at low rates of utilisation, was that the lowest aircraft capital cost was the most important issue compared to aircraft efficiency and low cash operating costs. The 727-200F has remained a stalwart of freight operations for many years for this reason. Its capital cost and lease rates are a fraction of those of its potential replacements the 737-300F/-400F and 757-200F. High fuel prices now mean that cash operating costs and operating efficiencies of younger types make them more attractive overall. The 727 not only has high fuel burn, but also high maintenance costs, and a three-man flightcrew. Even with a low lease rate of $30,000 per month, the 727-200F's trip costs at current fuel prices exceed both 737 variants, the A320 and the A321. Moreover, the 727-200F's cash operating costs exceed the 757-200F's by about $3,000. It is only the 727-200F's low lease rentals that bring its trip costs in line with the 757's. The 757-200F, of

course, has a higher payload and lower operating costs over the long term. The 727-200F's economic performance is therefore not illustrated.

Fuel burn and cost is by far the most important operating cost element of the six aircraft analysed. In all cases, fuel at $4 per USG accounts for about 50% of the trip cost analysed. While not all operating costs have been included, the most important and largest items are examined.

The 737-300F clearly has a low fuel burn, and will be 1,450-1,550USG for a 600nm route. The A320-200F, however, will have a lower burn of about 1,200USG.

The 737-400F will burn about 100USG more than the -300F. The larger A321-200F, however, will burn about 230USG less than the 737-400F. The 757-200F's burn will be in the region of 1,700USG, and the A310-300F will consume about 2,400USG, a similar amount to the 727-200F.

Maintenance costs account for a relatively low percentage of total costs. These are 18-21% of trip costs, depending on the aircraft type. All aircraft have similar costs of $1,200-1,350 per FH, except for the A310-300F, whose costs exceed $2,000 per FH. This is mainly due to its higher engine reserves, which are particularly high for a short FC operation. The 757-200F's maintenance costs are variable because it has two engine choices, with the PW2037/40 having reserves of $60-80 per engine flight hour (EFH) lower than the RB211-535E4.

The aircraft all benefit from two-man flightcrews. Pilot salaries here are assumed to vary with aircraft size. Captains' salaries for the 737-300F are taken as $65,000 per year, rising to $90,000 per year for the A310-300F. First officers' salaries range from $44,000 to $60,000 per year. Total crew salaries are inflated by 35% to account for all employment costs. Crews are assumed to operate for about 700FH per year. Nevertheless, crew costs per trip are small compared to other cost elements.

Landing fees at $5 per ton of maximum take-off weight (MTOW) are also added, and navigation charges at 20 cents per nm multiplied by the aircraft's MTOW factor are also included.

Total cash operating costs for the 737-300F are just over $9,000; and about $500 higher for the -400F. The A320-200F benefits from its lower fuel burn, with cash operating costs at $7,900. This advantage is only exaggerated, however, by high fuel prices and would be reduced if fuel prices were to decline again in the future. The A320's maintenance costs are relatively high, mainly because its components have higher capital costs than the 737's.

The A321-100F's cash operating costs are about $9,000, so it benefits from fuel efficiency like the A320. The 757-200F's cash costs are $10,350, and the A310-300F's are $15,300.

Despite high fuel prices, aircraft lease rentals are still a pivotal issue in the relative economics of freighters. Lease rentals used here are approximate market rates for each type, while actual financing charges will vary with individual transactions. Lease rentals used for the 737-300F and -400F are $130,000 and $150,000 per month.

Lease rates for the A320-200F and A321-100F are theoretical, since none have been converted and market appetite for them has yet to be established. Rates are $170,000 for the A320-200F and $200,000 for the A321-100F.

A lease rate of $220,000 for a low MZFW variant of the 757-200F is used, and $250,000 per month has been used for the A310-300F. Like the A320 and A321, the A310's lease rate is a theoretical rate that the market may bear, rather than an actual market rate.

These translate into trip costs of $2,600 for the 737-300F, and up to $5,000 for the A310-300F. These are equal to 22-31% of total trip costs, and so are the largest cost element. This portion of total costs is smaller than it used to be in the past with lower fuel costs.

The 737-300F and A320-200F have the lowest trip costs: $11,300-11,600. The 737-400F's total is marginally higher at $12,600. Its unit cost per lb is 34 cents, just one cent higher than the A320-200F. The actual lease rentals that operators will have to pay for the 737-400F and A320-200F will determine which is the most economic aircraft. As described, the

market values of A320-200s will have probably declined by 2011 to levels low enough to make them economic to convert, but values of 737-400s will have also declined by this time, therefore making them cheaper to operate than shown here.

The A321-100F's trip costs are about $12,900, just $400 more than the 737-400F. This gives the A321 a lower cost per lb, given its 8,000lbs higher payload.

The 757-200F's trip cost of $14,800 is almost $2,000 more than the A321-100F's, but the 757 has a 9,000lbs higher payload. The A310-300F has a much higher trip cost of $20,300, but also has an 8,000lbs advantage over the 757.

While the 737-300F, 737-400F and A320-200F all closely compete, the A321-100F, 757-200F and A310-300F are in a class of their own for certain ranges of freight volume. That is, the A321 has no direct competitors when freight volume ranges from 37,000lbs to 45,000lbs *(see first chart, page 68)*. Similarly, the 757-200F has no direct competition between 45,000lbs and 54,000lbs, while the A310-300F is the only option for volumes higher than 54,000lbs.

Carrying up to 30,000lbs of freight volume, the A320-200F has marginally higher gross margin performance than the 737-300F and -400F *(see first chart, page 68)*. In the case of the 737-300F and A320-200F, the difference is only about $350, with the A320-200F's trip cost being lower by the same amount. This difference is highly dependent on lease rentals, and the 737's trip costs are likely to be lower once the A320-200F becomes available in 2011 because of a large number of passenger aircraft retirements. Until 2011, therefore, the 737-300F is the most economic type for freight volumes up to 30,000lbs, and the -400F the most economic aircraft for volumes up to 37,000lbs.

The A321-100F will be the most economic between 37,000lbs and 45,000lbs *(see first chart, page 68)*, but only after 2011 or 2012 when it first becomes available. Until then, the 757-200F will be the most economic between 37,000lbs and 54,000lbs. As with the 737, the market values of used passenger 757-200s could have dropped below current levels, possibly allowing lower lease rates in the future.

The A310-300F holds the advantage with its maximum payload of 54,000lbs to 62,700lbs *(see first chart, page 68)*.

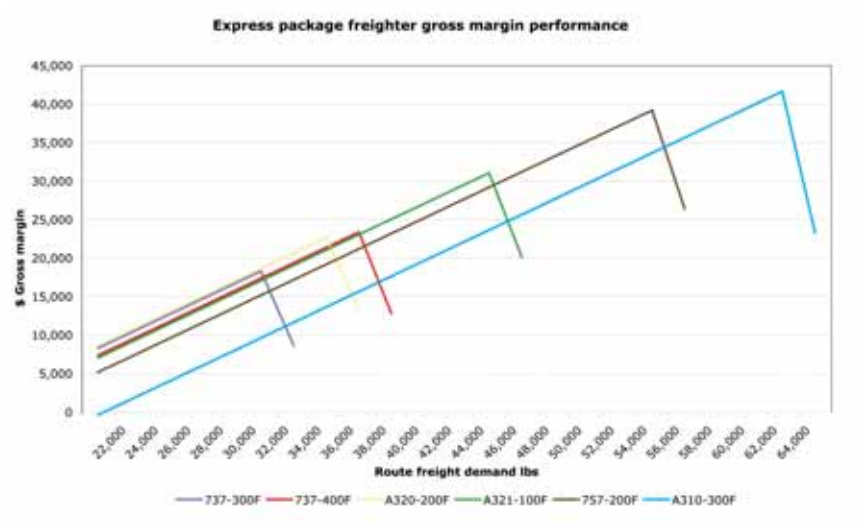
General freight

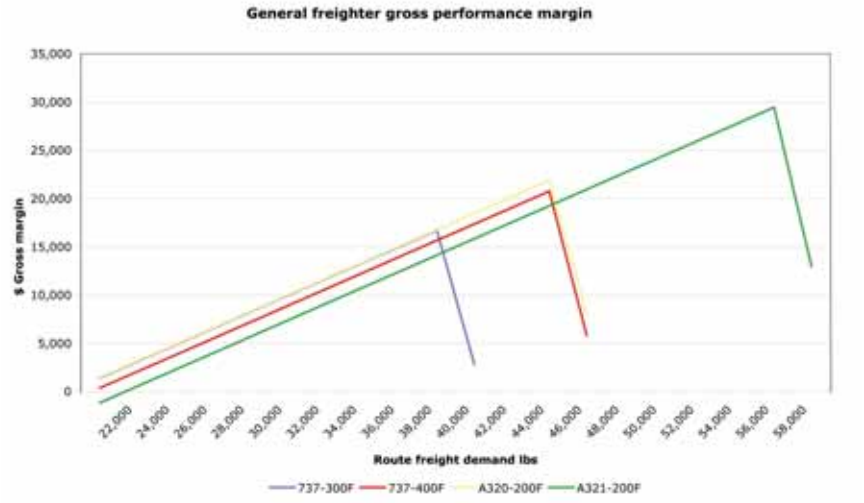
The aircraft analysed for general freight selection are examined on a longer route length of 1,200nm and at a higher annual utilisation of about 2,500FH. Some of the aircraft types differ to those analysed for express package operations.

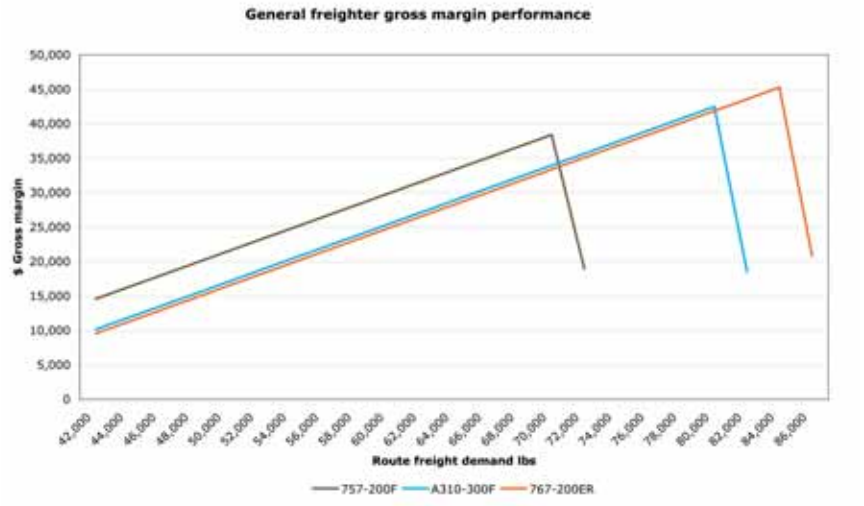
The 737-300F, 737-400F, A320-200F and A310-300F are the same. The 757-200F variant used is the higher MZFW option that provides a net structural payload of 69,000/70,000lbs *(see table, page 64)*. The A321-200F is included, which has a net structural payload of 56,750lbs, and the largest type is the 767-200ER with a payload of 84,000lbs.

The aircraft are analysed with their net structural payloads, and therefore with route freight volume of up to 84,000lbs *(see second chart, page 68)*. An arbitrary freight yield of 85 cents per lb of payload has been used to demonstrate the relative differences between aircraft types.

The higher rates of utilisation allow the aircraft to achieve similar costs per lb to the express package operations. Relative fuel burn differences between the types are similar to the express package analysis. The 767-200ER has a similar







burn to the A310-300F.

The main difference between the general freight and express package operations is that in general freight higher rates of utilisation dilute the lease rentals and finance charges, and increase the relative importance of the cash operating costs. Fuel therefore accounts for an even larger portion of all costs, 54-64%, depending on aircraft type.

The 767-200ER benefits from slightly lower maintenance costs than the A310-300F.

Also importantly, the lease cost per trip is lower than in the case of express package operations, and is therefore less significant. Lease rentals for the 737-300F, 737-400F, A320-200F and A310-300F are as previously discussed. The lease rental for the 757-200F is taken as being $250,000 per month, a higher rate being assumed for the high capability version. The lease rental used for the 767-200ER is $275,000. This is based on the total costs of acquiring a used aircraft, converting it to a freighter, and making it serviceable. A probable lease rate factor is then taken into consideration.

Total trip costs are virtually the same for the 737-300F and A320-200F. This results in the two having virtually the same gross margin performance and profile *(see second chart, this page)*. The A320-200F's payload makes it the most economic up to loads of 44,000lbs. This is dependent, however, on the aircraft being available at the lease rental of $170,000 from 2011. Moreover, it is dependent on the relative differences in lease rentals being the same as used here. Until the A320-200F becomes available, the 737-300F is the best option up to freight volumes of 39,000lbs, and the 737-400F is the most economic aircraft up to freight volumes of 44,000lbs *(see second chart, this page)*.

The A321-200F is in a class of its own between 44,000lbs and 56,000lbs *(see second chart, this page)*, but only when it becomes available from 2012. The 757-200F has a $3,000 higher trip cost of $21,100, but also a 14,000lbs higher payload.

Until the A321-200F becomes available, the 757-200F is in a class of its own for freight volumes ranging from 44,000lbs to 70,000lbs *(see third chart, this page)*. The range of freight volume over which it holds an advantage is widened by its high MZFW option.

The A310-300F has marginally better performance than the 767-200ER, but the difference in trip costs between the two aircraft is only about $500. The 767-200ER has a higher payload than the A310-300. The 767 also offers some pilot commonality benefits with the 757, potentially allowing some savings to be made.

Like the A321 and 757, the difference between the A310-300F and 767-200ER depends on actual lease rentals. The 767 has an advantage of a 3,000lbs higher structural payload and 30% more volume. The 767-200ER overall is the most attractive aircraft when freight volume ranges from 70,000lbs to 84,000lbs. The 767-200ER is also available in larger numbers than the A310-300. Another issue that has to be analysed and considered in detail for these two types is their operating performance on a range of missions. AC